UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
501 West Ocean Boulevard, Suite 4200
LONG BEACH, CA 90802

November 12, 2024

Dear Recipient:

In accordance with provisions of the National Environmental Policy Act (NEPA), we announce that the *Draft Programmatic Environmental Impact Statement (DPEIS) for the Identification of Aquaculture Opportunity Areas (AOAs) in Federal Waters of Southern California* is available for review.

The federal action proposed in the DPEIS is to identify one or more locations (referred to as AOAs) in federal waters off of southern California that may be suitable for multiple future offshore aquaculture projects and to evaluate the impacts of siting aquaculture in those locations. The proposed action is a planning initiative and does not propose any aquaculture facilities or permits. The DPEIS was prepared in furtherance of Section 7 of the Executive Order (E.O.) on Promoting American Seafood Competitiveness and Economic Growth (E.O. 13921). The cooperating agencies on this DPEIS are the United States Army Corps of Engineers (USACE) Los Angeles District, the United States Coast Guard (USCG) District Eleven, and the Environmental Protection Agency (EPA) Region 9.

The document is accessible electronically through the following website https://www.fisheries.noaa.gov/west-coast/aquaculture/west-coast-region-southern-california-aquaculture-opportunity-area". Copies of the document may also be obtained from the comment coordinator, Celia Barroso, at the contact information provided below.

Comments may be submitted to NOAA's National Marine Fisheries Service during the public-comment period using any of the following:

- Email at socalaoa.wcr@noaa.gov, or
- www.regulations.gov, search for "NOAA-NMFS-2022-0051 and click "Comment Now,"
- during virtual public meetings (visit https://www.fisheries.noaa.gov/west-coast/aquaculture/west-coast-region-southern-california-aquaculture-opportunity-area for more information, including dates, times and registration), or
- mailing the comment coordinator at the address below.

Comments must be received no later than February 20, 2025.

Comment Coordinator: Celia Barroso
Regional Aquaculture Coordinator, California
National Marine Fisheries Service
West Coast Region
501 W. Ocean Blvd., Ste. 4200
Long Beach, CA 90802
562-432-1850
socalaoa.wcr@noaa.gov

Thank you in advance for your input in finalizing the Programmatic Environmental Impact Statement.

Sincerely,

Jennifer Quan
Regional Administrator

Draft

Programmatic Environmental Impact Statement for the Identification of Aquaculture Opportunity Areas in U.S. Federal Waters off of Southern California

Prepared by:

National Marine Fisheries Service

West Coast Region

501 W. Ocean Blvd., Suite 4200

Long Beach, California 90802

Date: November 15, 2024

PEIS-006-48-1WC-1728044280

COVER SHEET

Title of Proposed Action:	Draft Programmatic Environmental Impact Statement for the Identification of Aquaculture Opportunity Areas in U.S. Federal Waters off of Southern California
Subject:	Draft Programmatic Environmental Impact Statement
Lead Agency:	National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS)
Cooperating Agencies:	U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers (USACE) and U.S. Coast Guard (USCG)
Public Comment:	November 22, 2024 to February 20, 2025

Abstract: The National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NOAA Fisheries) West Coast Region is developing a programmatic environmental impact statement (PEIS), in accordance with the National Environmental Policy Act (NEPA),that analyzes the potential impacts to the human environment that could result from identifying Aquaculture Opportunity Areas (AOAs) in federal waters in the Southern California Bight (SCB) and evaluates the impacts of siting aquaculture in those locations. The intent of this PEIS is to support long-term planning for offshore aquaculture. This PEIS considers a long-term planning effort that is not a regulatory or permitting action and does not propose to authorize or permit any specific aquaculture-related activities or propose to approve any individual aquaculture projects.

For information, contact:

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https://www.fisheries.noaa.gov/about/west-coast-region

If reasonable accommodation is needed to read or listen to the document(s) at this link, please contact Celia Barroso at socalaoa.wcr@noaa.gov and allow five business days for a response. Alternate formats may include, but are not limited to, Braille, ASCII text, large print, recorded audio, and electronic formats that comply with this part. Alternate methods may include, but are not limited to, voice, fax, relay service, TTY, Internet posting, captioning, text-to-speech synthesis, and audio description.

Table of Contents

List of Acronyms

AB	Assembly Bill
AFS	American Fisheries Society
AIS	Automated Identification Systems
AOA	Aquaculture Opportunity Area
AOI	Area of Interest
APT	Aquaculture Planning Team
AQF	Aquaculture Farm
ARA	Assistant Regional Administrator
ASBS	Areas of Special Biological Significance
BES	Baseline Environmental Survey
BGA	Biogeographic Assessment
BIA	Biologically Important Area
BOEM	Bureau of Ocean Energy Management
BSA	Biologically Significant Area
BSEE	Bureau of Safety and Environmental Enforcement
CA	State of California
CAA	Clean Air Act
CAAP	Concentrated Aquatic Animal Production
CAPEX	Capital Expenditure
CCC	California Coastal Commission
CCE	California Current Ecosystem
CCR	California Code of Regulations
CDC	Centers for Disease Control and Prevention
CEQ	Council on Environmental Quality
CFGC	California Fish and Game Commission
CFR	Code of Federal Regulations

chl	chlorophyl
COP	Construction and Operations Plan
CPFV	Commercial Passenger Fishing Vessel
CPS	Coastal Pelagic Species
CUI	Controlled Unclassified Information
CWA	Clean Water Act
CZ	Coastal Zone
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
DFMPA	De Facto Maine Protected Area
DHS	Department of Homeland Security
DOC	Department of Commerce
DOD	Department of Defense
DOT	Department of Transportation
DPH	Department of Public Health
EAA	Ecosystem Approach to Aquaculture
EAFM	Ecosystem Approach to Fisheries Management (pursuant to MSA)
EBFM	Ecosystem Based Fishery Management (pursuant to NOAA Policy Directive 01-120)
EFH	Essential Fish Habitat
e.g.	for example
EIS	Environmental Impact Statement
ENGO	Environmental Non-Government Organization
E.O.	Executive Order
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ETP	Endangered, Threatened, and Protected Species

FAD	Fish aggregating device
FDA	Food and Drug Administration
FEP	Fishery Ecosystem Plan (pursuant to MSA)
FERA	Fate Exposure and Risk Analysis
FGC	Fish and Game Code
FIFO	Fish in Fish out Ratio
FMC	Fishery Management Council
FMP	Fishery Management Plan
ft	feet
FR	Federal Register
GAP	General Activities Plan
GC	General Counsel
GDP	Gross Domestic Product
GRAS	Generally Recognized as Safe
HAB	Harmful Algal Bloom
HACCP	Hazard Analysis Critical Control Point
HAPC	Habitat Areas of Particular Concern
HC	Habitat Committee
HCD	Habitat Conservation Division
HGMP	Hatchery Genetic Monitoring Program
HMS	Highly Migratory Species
HQ	Headquarters
HSP	Habitat Suitability Probability
IMTA	Integrated Multi-Trophic Aquaculture
ISSC	Interstate Shellfish Sanitation Conference
IUUF	Illegal, Unregulated, and Unreported Fishing
LA	Los Angeles

LCP	Local Coastal Program
LEP	Limited English Proficiency
LMR	Living Marine Resources
m	meter
M	million
MESC	Marine Exchange of Southern California
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Area
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSP	Marine Spatial Planning
NAPP	NEPA Advanced Planning Procedure
NCCOS	National Centers for Coastal Ocean Science
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NISC	National Invasive Species Council
NMS	National Marine Sanctuary
NMFS	National Marine Fisheries Service
nd	no date
no.	number
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NOP	National Ocean Policy
NOPP	Department of Energy's National Oceanographic Partnership Program
NOS	National Ocean Service
NPDES	National Pollutant Discharge Elimination System
ns	not specified

NSSP	National Shellfish Safety Program
OAH	Ocean Acidification and Hypoxia
OAQ	Office of Aquaculture
OCM	Office of Coastal Management
OCS	Outer Continental Shelf
OMAO	Office of Marine and Aviation Operations
OMP	Ocean Monitoring Program
OPAREA	[Military] Operating Area
OPEX	Operational expenditure
OSTP	Office of Science and Technology Policy
OSW	Offshore Wind
p	page
pp	pages
PATON	private aids to navigation
PEIS	Programmatic Environmental Impact Statement
PFMC	Pacific Fishery Management Council
POM	particulate (or suspended) organic matter
POTW	Publicly Owned Treatment Works
PPP	Pathogens, Parasites, Pests
PRD	Protected Resources Division
PSMFC	Pacific States Marine Fisheries Commission
RAC	Regional Aquaculture Coordinator
RAS	Recirculating Aquaculture System
RFMO	Regional Fishery Management Organization
RHA	Rivers and Harbors Act
RMIS	Regional Mark Information System
RWQCB	Regional Water Quality Control Board

SA	Scenario Analysis
SAFE	Stock Assessments and Fishery Evaluation
SAP	Site Assessment Plan
SB	State Bill
SCB	Southern California Bight
SCC	Southern California Countercurrent (also known as the Davidson Current)
SERO	Southeast Regional Office
SFD	Sustainable Fisheries Division
SHPO	State Historic Preservation Officer
SLC	State Lands Commission
SSFA	Small-Scale Fisheries and Aquaculture (sector)
SST	Sea surface temperature
SWFSC	Southwest Fisheries Science Center
TAC	Toxic Air Contaminant
TEK	Traditional ecological knowledge
U.S.	United States
U.S.C.	United States Code
USCG	United States Coast Guard
USACE	United States Army Corps of Engineers
VMS	Vessel Monitoring System
WCR	West Coast Region

List of Figures

List of Tables

Executive Summary

A. Introduction

This Draft Programmatic Environmental Impact Statement (DPEIS) analyzes the potential impacts to the human environment that could result from identifying Aquaculture Opportunity Areas, hereafter referred to as AOAs, in federal waters in the Southern California Bight (SCB) and evaluates the impacts of siting aquaculture in those locations. An AOA is a defined geographic area that has been evaluated to determine its potential suitability for commercial aquaculture. The AOA options analyzed in this Draft PEIS are based on information including a marine spatial planning process. They are between 500 and 2,000 acres, which meets the industry and engineering requirements of ranges of depth and distance from shore and may be suitable for all types of aquaculture. This spatial planning process considered administrative boundaries, national security (i.e., military), navigation and transportation, energy and industry infrastructure, commercial and recreational fishing, natural and cultural resources, and oceanography (i.e., non-living resources) to identify areas that have the highest potential to support three to five marine aquaculture operations and the least amount of conflict with other ocean uses (see Morris et al 2021, incorporated by reference). The AOA options were developed using an evaluation of available spatial data within the SCB, feedback received during public scoping, as well as the best available science and literature on aquaculture and the region.

NMFS prepared this PEIS to comply with the National Environmental Policy Act (NEPA) and Executive Order 13921, *Promoting American Seafood Competitiveness and Economic Growth*. This Draft PEIS will not result in the approval of any activities. NMFS is developing this Draft PEIS to identify AOAs and evaluate the impacts of siting aquaculture in those locations. This PEIS considers a long-term planning effort that is not a regulatory or permitting action and does not propose to authorize or permit any specific aquaculture-related activities or individual aquaculture projects. Project-specific NEPA analyses, consultations, and permits may be needed in the future. Future proposed aquaculture projects may tier from the PEIS if the lead agency determines the PEIS is appropriate for its needs.

B. Purpose and Need for the Proposed Action

The Federal action proposed in this DPEIS is to identify one or more AOAs that may be suitable for multiple future offshore aquaculture projects in Federal waters of the SCB (outside of state waters within the U.S. Exclusive Economic Zone), and to evaluate the impacts of siting aquaculture in those locations. AOAs identified through this process could be considered potentially suitable for finfish, shellfish, macroalgae, or multi-species aquaculture. The proposed action is a long-term planning effort. It is not a regulatory or permitting action and does not propose to authorize or permit any specific aquaculture-related activities or individual aquaculture projects. The analysis may be used to inform such processes for individual projects proposed later in time.

The purpose of the proposed action is to apply a science-based approach to identify AOAs in Federal waters. The goal of identifying AOAs is to promote American seafood competitiveness, food security, economic growth, and to support the development of domestic commercial aquaculture, consistent with sustaining and conserving marine resources and applicable laws, regulations and policies. The proposed action is needed to meet the directives of E.O. 13921 to address the increasing demand for seafood, facilitate long-term planning for marine aquaculture development, and address interests and concerns regarding offshore marine aquaculture siting.

C. Public Involvement

Following the publication of E.O. 13921 on May 7, 2020, NMFS began a public outreach effort that included stakeholder engagement, video and print informational products, and soliciting input from stakeholders, including the commercial and recreational fishing communities, academia, non-governmental organizations (NGOs), the general public, and coastal and ocean managers. Part of the initial public outreach effort included publication of a Request for Information (RFI) in the Federal Register (85 FR 67519, Oct. 23, 2020). The RFI solicited public input to help identify data needs, data sources, and project requirements for offshore aquaculture. At the same time, the National Center for Coastal Ocean Science (NCCOS) worked with the NMFS regional offices in Southern California to collect data for a spatial modeling analysis for the region. The work by NCCOS was published as a peer-reviewed technical memorandum entitled, "An Aquaculture Opportunity Area Atlas for the Southern California Bight," hereafter referred to as "the Atlas" (Morris et al. 2021).

Through the end of 2021, and into the spring of 2022, NMFS used the results in the Atlas, along with the public input gathered through the RFI, to develop the Notice of Intent (NOI) for the PEIS.

NMFS published an NOI on May 23, 2022 to initiate the NEPA process. The NOI included prompts to gather input from the public for the PEIS. Public comments for the Southern California AOA PEIS were accepted from May 23, 2022 to July 22, 2022 (60 days). Two webinar-based public listening sessions were held during scoping, in which comments could be submitted orally. Written submissions were accepted during the public comment period via the federal docket with the identification number, NOAA-NMFS-2022-0051. A public scoping report was published to the Southern California AOA website and to the Office of Aquaculture (OAQ) AOA website on March 29, 2023 that summarizes the process, participants, and the themes of scoping comments (NMFS 2023a). From 2021 through 2024, NMFS WCR gathered the information from pre-scoping outreach, the scoping period, best available science, and additional expertise from NOAA offices to write this DPEIS. The publication of the DPEIS in the Federal Register initiates the 60-day public comment period on the draft, after which all the comments received will be assessed and considered by NMFS in preparation of a Final PEIS.

D. Alternatives

NMFS considered a reasonable range of alternatives during the PEIS development process that were identified through coordination with cooperating and participating agencies and through public comments received during the public scoping period for the PEIS. The Draft PEIS evaluates the No Action Alternative and three action alternatives with sub-alternatives. Alternatives considered but dismissed from detailed analysis and the rationale for their dismissal are described in Chapter 2.B. Identification of AOAs and alternatives considered here that analyze potential impacts as a result of specific types of aquaculture would not prohibit any type of aquaculture in an AOA—a future applicant may propose any aquaculture type anywhere.

The alternatives are as follows:

i. Alternative 1: No Action Alternative

In the No Action Alternative, NMFS would not identify any AOA in Federal waters offshore of Southern California, including not identifying any sub-alternatives.

ii. Alternative 2: Santa Barbara Channel

NMFS would identify one or more AOAs within Federal waters offshore of Santa Barbara and Ventura Counties in the Santa Barbara Channel. The eight AOA options are located between 10.02 and 19.72 kilometers (5.41 and 10.65 nautical miles) offshore (Figure 1). Each area ranges from 1,500 to 2,000 acres (607 to 809 ha); the total combined acreage is 15,000 acres (6,070 ha), or 60.7 km^2 (23.4 mi^2).

- Sub-alternative 2a: macroalgae and shellfish aquaculture only
- Sub-alternative 2b: all types of commercial aquaculture

iii. Alternative 3: Santa Monica Channel

NMFS would identify one or more AOAs within Federal waters offshore of Los Angeles County in Santa Monica Bay. The two AOA options are located between 8.06 and 8.82 kilometers (4.35 and 4.76 nautical miles) offshore (Figure 2). The areas are 500 and 1,000 acres (202 and 405 ha); the combined total acreage is 1,500 acres (607 ha), or 6.1 km^2 (2.4 mi^2).

- Sub-alternative 3a: shellfish and macroalgae aquaculture only
- Sub-alternative 3b: all types of commercial aquaculture

iv. Alternative 4: Combination of Geographic Areas

NMFS would identify AOA(s) from within the boundaries of either Alternative area, up to a maximum area to be determined by NMFS with input from the public. The total 10 AOA options are depicted in (Figure 3).

- Sub-alternative 4a: shellfish and macroalgae Aquaculture only
- Sub-alternative 4b: all types of commercial Aquaculture (Preferred Alternative)

E. Environmental Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact. Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here to inform our assessment of the alternatives described above.

Resource areas analyzed include oceanography and climate, marine managed areas and special resource areas, seafloor characteristics, water quality, air quality and aesthetics, acoustic environment, protected species and protected habitat, wild fish stocks, non-listed species and communities, potentially-farmed species, commercial fishing, recreational fishing, markets and regional food systems, ports and working waterfronts, tourism and other recreation, transportation and navigation, offshore energy and public services, public health and safety, environmental justice, tribal resources and cultural practices, non-tribal cultural and traditional practices, and archaeological resources. Table ES-1 provides a comparison of the potential environmental impacts reflected in Alternative 1, Alternative 2 (2a and 2b), Alternative 3 (3a and 3b) and Alternative 4 (4a and 4b) from the identification of AOAs and potential impacts associated with future aquaculture operations that may be sited in an AOA.

Table ES-1: Summary and Comparison of Impacts Among Alternatives

Resource Category	Summary and Comparison of Impacts
Administrative Environment	Alternative 1 If AOAs were not identified there are potential adverse effects to permitting and environmental review processes.
	Alternatives 2-4 Potential beneficial effect to permitting and environmental review processes.
Oceanography and Climate	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential adverse effects by disrupting hydrodynamic processes.
	Alternative 2b Potential adverse effects as discussed in Alternative 2a.
	Alternative 3a Potential adverse effects by disrupting hydrodynamic processes. Impacts to hydrodynamic processes may be lessened compared to Alternative 2 due to the smaller size and deeper depths.
	Alternative 3b Potential adverse effects as discussed in Alternative 3a.
	Alternative 4a Potential adverse effects as discussed in Alternatives 2-3. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified..
	Alternative 4b Potential adverse effects as discussed in Alternative 4a.
Marine Managed Areas and Special Resource Areas	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Possible adverse or beneficial effects on marine resources connectivity due to FAD effects or changes in hydrodynamic processes.

Resource Category	Summary and Comparison of Impacts
	Alternative 2b Possible adverse effects on water quality within marine managed areas. Possible adverse or beneficial effects on marine resources connectivity due to FAD effects or changes in hydrodynamic processes.
	Alternative 3a Possible adverse or beneficial effects on marine resources connectivity due to FAD effects or changes in hydrodynamic processes. Potential for impacts is reduced compared to Alternative 2, due to distance from managed areas.
	Alternative 3b Possible adverse effects on water quality within marine managed areas. Possible adverse or beneficial effects on marine resources connectivity due to FAD effects or changes in hydrodynamic processes. Potential for impacts is reduced compared to Alternative 2, due to distance from managed areas.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternative 4a.
Seafloor Characteristics	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential adverse effects due to physical damage could occur from, anchoring, scouring, fuel or chemical leak or changes in hydrodynamic processes.
	Alternative 2b Potential adverse effects due to physical damage could occur from anchoring, scouring, fuel or chemical leak or changes in hydrodynamic processes. Sediment enrichment could alter benthic communities.
	Alternative 3a Potential adverse effects due to physical damage could occur from anchoring, scouring, fuel or chemical leak or changes in hydrodynamic processes. Mapped hard-bottom is relatively closer to the Alternative 3 area than Alternative 2, which could indicate higher potential for hard bottom to occur within an AOA.

Resource Category	Summary and Comparison of Impacts
	Alternative 3b Potential adverse effects due to physical damage could occur from anchoring, scouring, fuel or chemical leak or changes in hydrodynamic processes. Sediment enrichment could alter benthic communities. Sediment quality in and around Alternative 3 has higher historic impacts relative to Alternative 2. Mapped hard-bottom is relatively closer to the Alternative 3 area than Alternative 2, which could indicate higher potential for hard bottom to occur within an AOA.
	Alternative 4a Potential adverse effects as discussed in Alternatives 2a-3a. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.
	Alternative 4b Potential adverse effects as discussed in Alternatives 4a.
Water Quality	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential adverse effects due to accidental spills or leaching of hazardous materials or generation of marine debris, turbidity, or nutrient deficits if carrying capacity of the area is exceeded. Potential beneficial effects of farmed species taking up nutrients, organic matter and other particulates.
	Alternative 2b Potential adverse effects due to excess organic enrichment, accidental spills or leaching of hazardous materials or generation of marine debris, turbidity.
	Alternative 3a Potential adverse effects due to accidental spills or leaching of hazardous materials or generation of marine debris, turbidity, or nutrient deficits if carrying capacity of the area is exceeded. Potential beneficial effects of farmed species taking up nutrients, organic matter and other particulates; potential improvements in water quality may serve more of an ecosystem service in Alternative 3 compared to Alternative 2, because of the historic and existing water quality concerns in the area.

Resource Category	Summary and Comparison of Impacts
	Alternative 3b Potential adverse effects due to excess organic enrichment, accidental spills or leaching of hazardous materials or generation of marine debris, turbidity. Potential beneficial effects of farmed species taking up nutrients, organic matter and other particulates; potential improvements in water quality may serve more of an ecosystem service in Alternative 3 compared to Alternative 2, because of the historic and existing water quality concerns in the area. A combination of different types of facilities could mitigate some nutrient related impacts, effectively serving as an IMTA type of system.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Theoretically, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified, however, it is unlikely potential adverse water quality impacts would be much different than Alternatives 2 and 3 given the low probability that future aquaculture projects would discharge large quantities and concentrations of water pollutants if they are sited and operated appropriately.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternatives 4a
Air Quality and Aesthetics	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential adverse effects due to operational emissions of air pollutants and night lighting. Potential beneficial effects of carbon sequestration. Alternative 2 is closer than Alternative 3 to existing offshore infrastructure, which may create a cumulative impact for light and glare.
	Alternative 2b Potential adverse effects due to operational emissions of air pollutants and night lighting. Emissions per facility will be higher compared to shellfish and macroalgae operations. Alternative 2 is closer than Alternative 3 to existing offshore infrastructure, which may create a cumulative impact for light and glare.

Resource Category	Summary and Comparison of Impacts
	Alternative 3a Potential adverse effects due to operational emissions or air pollutants and night lighting. Potential beneficial effects of carbon sequestration. Emissions per trip in Alternative 3 may be lower than Alternative 2 given distance to shore, and emissions in total may be lower due to lower number of total facilities with potential to be sited given the smaller acreage.
	Alternative 3b Potential adverse effects due to operational emissions of air pollutants and night lighting. Emissions per facility will be higher compared to shellfish and macroalgae operations. Emissions per trip will be lower than Alternative 2 given distance to shore and emissions in total may be lower due to lower number of total facilities with potential to be sited.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Theoretically, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified, however it unlikely potential air impacts or aesthetics would be much different than Alternatives 2 and 3 given the low probability that future aquaculture projects would emit large quantities and concentrations of pollutants.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternative 4a.
Acoustic Environment	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential adverse effects to baseline soundscape due to generation of in-air and in-water noise. Alternative 2 is closer than Alternative 3 to existing offshore infrastructure, which may create a cumulative impact for noise.
	Alternative 2b Potential adverse effects to baseline soundscape due to generation of in-air and in-water noise. Finfish aquaculture operations require additional vessel trips or vessels for feeding purposes or the addition of automated feeders that could generate more noise compared to shellfish and macroalgae only aquaculture. Alternative 2 is closer than Alternative 3 to existing offshore infrastructure, which may create a cumulative impact for noise.

Resource Category	Summary and Comparison of Impacts
	Alternative 3a Potential adverse effects to baseline soundscape due to generation of in-air and in-water noise. Baseline noise levels are relatively lower and the total number of potential facilities and footprint that may generate noise is lower compared to Alternative 2. Facilities in Alternative 3 may be less impactful on the overall acoustic environment, but may represent a larger proportional change relative to baseline.
	Alternative 3b Potential adverse effects to baseline soundscape due to generation of in-air and in-water noise. Finfish aquaculture operations could require additional vessel trips or vessels for feeding purposes or the addition of automated feeders that could generate more noise compared to shellfish and macroalgae only aquaculture. Baseline noise levels are relatively lower and the total number of potential facilities and footprint that may generate noise is lower compared to Alternative 2. Facilities in Alternative 3 may be less impactful on the overall acoustic environment, but may represent a larger proportional change relative to baseline.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified. Given the baseline condition in Southern CA, it is unlikely that aquaculture development would cause appreciable noise impacts.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternative 4a.
Federally-Protected Species and Habitat	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.

Resource Category	Summary and Comparison of Impacts
	Alternative 2a Potential adverse effects due to entanglement, marine debris, vessel strike/human interaction, and noise/light pollution associated with fixed gear and other equipment placed in the water column, surface or bottom, and increased vessel/human activity. Adverse effects could include death, injury, displacement, and reduction in fitness or behavioral change. FAD effects and changes in habitat characteristics and habitat use may be beneficial and/or adverse, potential beneficial effects include reproductive opportunity and opportunity to feed, shelter, shade. Changes in water quality may increase risk of disease. Longline aquaculture would have less of a FAD effect than finfish aquaculture, but has a greater risk of entanglement. There is high potential aquaculture facilities in Alternative 2 would have geographic overlap with breeding, feeding, migrating areas for listed species, but the total amount of habitat overlap that could occur would be about 1.2% of the total habitat in Federal waters of the SCB, and less than one-tenth of a percent of the total area of the SCB. N1-C and N1-D are the only AOA options without nearby mapped coral and hard bottom.
	Alternative 2b Potential adverse effects due to entanglement, marine debris, vessel strike/human interaction, and noise/light pollution associated with fixed gear and other equipment placed in the water column, surface or bottom, and increased vessel/human activity. Adverse effects could include death, injury, displacement, and reduction in fitness or behavioral change. FAD effects and changes in habitat characteristics and habitat use may be beneficial and/or adverse, potential beneficial effects include reproductive opportunity and opportunity to feed, shelter, shade. FAD effects are more pronounced around finfish facilities than around other types of aquaculture. Changes in water quality may increase risk of disease.
	Alternative 3a Potential adverse effects due to entanglement, marine debris, vessel strike/human interaction, and noise/light pollution associated with fixed gear and other equipment placed in the water column, surface and bottom, and increased vessel/human activity. Adverse effects could include death, injury, displacement, and reduction in fitness or behavioral change. FAD effects and changes in habitat characteristics and habitat use may be beneficial and/or adverse, potential beneficial effects include reproductive opportunity and opportunity to feed, shelter, shade. Changes in water quality may increase risk of disease. There is high potential aquaculture facilities in an AOA within Alternative 3 would have geographic overlap with breeding, feeding, migrating areas for listed species, but the overlap and potential impact would be less than Alternative 2. Both AOA options within Alternative 3 are within close proximity to mapped coral and hard-bottom habitat. Longline aquaculture would have less of a FAD effect than finfish aquaculture, but has a greater risk of entanglement.

Resource Category	Summary and Comparison of Impacts
	Alternative 3b Potential adverse effects due to entanglement, marine debris, vessel strike/human interaction, and noise/light pollution associated with fixed gear and other equipment in the water column, surface and bottom, and increased vessel/human activity. Adverse effects could include death, injury, displacement, and reduction in fitness or behavioral change. FAD effects and changes in habitat characteristics and habitat use may be beneficial and/or adverse, potential beneficial effects include reproductive opportunity and opportunity to feed, shelter, shade. Changes in water quality may increase risk of disease. FAD effects are more pronounced around finfish facilities than around other types of aquaculture.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. Identifying AOAs across a larger geographic area may increase the risk of interactions more because the impacts are dispersed over a higher range of protected species stocks. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternative 4a.
Wild Fish Stocks	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential adverse effects due to marine debris, entanglement, human interaction, and noise/light pollution associated with fixed gear and other equipment in the water column/surface and increased vessel/human activity. Adverse effects could include death, injury, displacement, and reduction in fitness or behavioral change. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse; potential beneficial effects include potential improvements in water quality, increased structural complexity, productivity and connectivity of the pelagic environment, reproductive opportunity and opportunity to feed, shelter, shade, while potential adverse FAD effects include increased risk of entanglement, predation, targeted fishing, and exposure to other risks like disease. Longline aquaculture would have less of a FAD effect than finfish aquaculture.

Resource Category	Summary and Comparison of Impacts
	Alternative 2b Potential adverse effects due to escapes, marine debris, entanglement, disease, human interaction, and noise/light pollution associated with fixed gear and other equipment/target species in the water column/surface and increased vessel/human activity. Adverse effects could include death, injury, displacement, and reduction in fitness or behavioral change. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse; potential beneficial effects include increased structural complexity, productivity and connectivity of the pelagic environment, reproductive opportunity and opportunity to feed, shelter, shade, while potential adverse FAD effects include increased risk of entanglement, predation, targeted fishing, and exposure to other risks like disease. Adverse effects in water quality and FAD effects may be higher in finfish aquaculture compared to shellfish/macroalgae. FAD effects are more pronounced around finfish facilities than around other types of aquaculture.
	Alternative 3a Potential adverse effects due to marine debris, entanglement, human interaction, and noise/light pollution associated with fixed gear and other equipment in the water column/surface and increased vessel/human activity. Adverse effects could include death, injury, displacement, and reduction in fitness or behavioral change. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse; potential beneficial effects include potential improvements in water quality, increased structural complexity, productivity and connectivity of the pelagic environment, reproductive opportunity and opportunity to feed, shelter, shade, while potential adverse FAD effects include increased risk of entanglement, predation, targeted fishing, and exposure to other risks like disease. Longline aquaculture would have less of a FAD effect than finfish aquaculture. Potential improvements in water quality may have more of a beneficial effect on wild fish stocks in Alternative 3 because the existing water quality is worse compared to Alternative 2.

Resource Category	Summary and Comparison of Impacts
	Alternative 3b Potential adverse effects due to escapes, marine debris, entanglement, disease, human interaction, and noise/light pollution associated with fixed gear and other equipment/target species in the water column/surface and increased vessel/human activity. Adverse effects could include death, injury, displacement, and reduction in fitness or behavioral change. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse; potential beneficial effects include increased structural complexity, productivity and connectivity of the pelagic environment, reproductive opportunity and opportunity to feed, shelter, shade, while potential adverse FAD effects include increased risk of entanglement, predation, targeted fishing, and exposure to other risks like disease. Adverse effects in water quality and FAD effects may be higher in finfish aquaculture compared to shellfish/macroalgae, but may be smaller compared to Alternative 2 given smaller number of potential facilities to be sited. FAD effects are more pronounced around finfish facilities than around other types of aquaculture.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternative 4a.
Ecologically-Important Marine Communities	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.

Resource Category	Summary and Comparison of Impacts
	Alternative 2a Potential adverse effects due to escapes, disease, marine debris, entanglement, human interaction, and noise/light pollution associated with fixed gear and other equipment/target species in the water column/surface and increased vessel/human activity. Adverse effects could include death, injury, displacement, and reduction in fitness or behavioral change. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse; potential beneficial effects include potential improvements in water quality, increased structural complexity, productivity and connectivity of the pelagic environment, reproductive opportunity and opportunity to feed, shelter, shade, while potential adverse FAD effects include increased risk of entanglement, predation, targeted fishing, and exposure to other risks like disease. Longline aquaculture would have less of a FAD effect than finfish aquaculture. Macroalgae farming could represent a large percent increase in the amount of comparable habitat in the SCB, enabling adverse impacts to fouling invertebrate and fish communities that will use facilities as habitat.
	Alternative 2b Potential adverse effects due to escapes, disease, marine debris, entanglement, human interaction, and noise/light pollution associated with fixed gear and other equipment/target species in the water column/surface and increased vessel/human activity. Adverse effects could include death, injury, displacement, and reduction in fitness or behavioral change. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse; potential beneficial effects include increased structural complexity, productivity and connectivity of the pelagic environment, reproductive opportunity and opportunity to feed, shelter, shade, while potential adverse FAD effects include increased risk of entanglement, predation, targeted fishing, and exposure to other risks like disease. FAD effects are more pronounced around finfish facilities than around other types of aquaculture.

Resource Category	Summary and Comparison of Impacts
	Alternative 3a Potential adverse effects due to escapes, disease, marine debris, entanglement, human interaction, and noise/light pollution associated with fixed gear and other equipment/target species in the water column/surface and increased vessel/human activity. Adverse effects could include death, injury, displacement, and reduction in fitness or behavioral change. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse; potential beneficial effects include potential improvements in water quality, increased structural complexity, productivity and connectivity of the pelagic environment, reproductive opportunity and opportunity to feed, shelter, shade, while potential adverse FAD effects include increased risk of entanglement, predation, targeted fishing, and exposure to other risks like disease. Longline aquaculture would have less of a FAD effect than finfish aquaculture. Macroalgae farming could represent a large percent increase in the amount of comparable habitat in the SCB, enabling adverse impacts to fouling invertebrate and fish communities that will use facilities as habitat.
	Alternative 3b Potential adverse effects due to escapes, disease, marine debris, entanglement, human interaction, and noise/light pollution associated with fixed gear and other equipment/target species in the water column/surface and increased vessel/human activity. Adverse effects could include death, injury, displacement, and reduction in fitness or behavioral change. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse; potential beneficial effects include increased structural complexity, productivity and connectivity of the pelagic environment, reproductive opportunity and opportunity to feed, shelter, shade, while potential adverse FAD effects include increased risk of entanglement, predation, targeted fishing, and exposure to other risks like disease. FAD effects are more pronounced around finfish facilities than around other types of aquaculture.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified..
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternative 4a.
Potentially-Farmed Species	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.

Resource Category	Summary and Comparison of Impacts
	Alternative 2a Potentially adverse and beneficial effects on potentially farmed species due to the use of native versus naturalized species, the use of genetically-modified stock in cultivated organisms, the use of antibiotics and/or other husbandry materials, the translation and adoption of surveillance and eradication programs, biosecurity guidance, import controls, and emergency response and planning from land-based and coastal systems to the offshore space; and animal welfare in artificial containments.
	Alternative 2b Potentially adverse and beneficial effects on potentially farmed species due to the use of native versus naturalized species, the use of genetically-modified stock in cultivated organisms, the use of antibiotics and/or other husbandry materials, the translation and adoption of surveillance and eradication programs, biosecurity guidance, import controls, and emergency response and planning from land-based and coastal systems to the offshore space; and animal welfare in artificial containments.
	Alternative 3a Potentially adverse and beneficial effects on potentially farmed species due to the use of native versus naturalized species, the use of genetically-modified stock in cultivated organisms, the use of antibiotics and/or other husbandry materials, the translation and adoption of surveillance and eradication programs, biosecurity guidance, import controls, and emergency response and planning from land-based and coastal systems to the offshore space; and animal welfare in artificial containments.
	Alternative 3b Potentially adverse and beneficial effects on potentially farmed species due to the use of native versus naturalized species, the use of genetically-modified stock in cultivated organisms, the use of antibiotics and/or other husbandry materials, the translation and adoption of surveillance and eradication programs, biosecurity guidance, import controls, and emergency response and planning from land-based and coastal systems to the offshore space; and animal welfare in artificial containments.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternative 4a.

Resource Category	Summary and Comparison of Impacts
Commercial Fishing	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential adverse effects due to displacement or disruption of commercial fishing associated with fixed gear and other equipment placement in the water column, surface and bottom, marine debris, increased vessel traffic in and out of coastal areas. Certain vessels could be excluded completely due to new operation costs. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse. Potential benefit to commercial fishery employees participating in offshore aquaculture operations through diversification of labor and revenue, while creating potential for resource competition between the industries.
	Alternative 2b Potential adverse effects due to displacement or disruption of commercial fishing associated with fixed gear and other equipment placement in the water column, surface and bottom, marine debris, increased vessel traffic in and out of coastal areas. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse. FAD effects are more pronounced around finfish facilities than around other types of aquaculture. Potential benefit to commercial fishery employees participating in offshore aquaculture operations through diversification of labor and revenue, while creating potential for resource competition between the industries.
	Alternative 3a Potential adverse effects due to displacement or disruption of commercial fishing associated with fixed gear and other equipment placement in the water column, surface and bottom, marine debris, increased vessel traffic in and out of coastal areas. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse. Potential benefit to commercial fishery employees participating in offshore aquaculture operations through diversification of labor and revenue, while creating potential for resource competition between the industries. Minimal commercial fishing occurs in the Santa Monica Bay, so the impact is lower compared to Alternative 2. Within the bay, the impacts of finfish and non-finish options are similar.

Resource Category	Summary and Comparison of Impacts
	Alternative 3b Potential adverse effects due to displacement or disruption of commercial fishing associated with fixed gear and other equipment placement in the water column, surface and bottom, marine debris, increased vessel traffic in and out of coastal areas. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse. FAD effects are more pronounced around finfish facilities than around other types of aquaculture. Potential benefit to commercial fishery employees participating in offshore aquaculture operations through diversification of labor and revenue, while creating potential for resource competition between the industries. Minimal commercial fishing occurs in the Santa Monica Bay, so the impact is lower compared to Alternative 2. Within the bay, the impacts of finfish and non-finish options are similar.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternative 4a.
Recreational Fishing	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential adverse effects due to displacement or disruption of recreational fishing associated with fixed gear and other equipment placement in the water column, surface and bottom, marine debris, increased vessel traffic in and out of coastal areas. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse; recreational fishing opportunities may increase or improve when aquaculture activities act as FADs.

Resource Category	Summary and Comparison of Impacts
	Alternative 2b Potential adverse effects due to displacement or disruption of recreational fishing associated with fixed gear and other equipment placement in the water column and surface, marine debris, increased vessel traffic in and out of coastal areas. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse; recreational fishing opportunities may increase or improve when aquaculture activities act as FADs. FAD effects are more pronounced around finfish facilities than around other types of aquaculture.
	Alternative 3a Potential adverse effects due to displacement or disruption of recreational fishing associated with fixed gear and other equipment placement in the water column and surface, marine debris, increased vessel traffic in and out of coastal areas. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse; recreational fishing opportunities may increase or improve when aquaculture activities act as FADs. Aquaculture would be more of a disruption in Alternative 3 compared to Alternative 2 because recreational fishers do not have existing competition with commercial fishers, there are less artificial FADs already in the area, and depths may be more attractive to recreational fishers. Beneficial FAD effects would be reduced compared to Alternative 2 due lower number of total facilities with potential to be sited.
	Alternative 3b Potential adverse effects due to displacement or disruption of recreational fishing associated with fixed gear and other equipment placement in the water column and surface, marine debris, increased vessel traffic in and out of coastal areas. Potential FAD effects, changes in habitat characteristics/habitat use, and the potential introduction of nonnative species may be beneficial and/or adverse; recreational fishing opportunities may increase or improve when aquaculture activities act as FADs. FAD effects are more pronounced around finfish facilities than around other types of aquaculture, but beneficial FAD effects would be reduced compared to Alternative 2 due lower number of total facilities with potential to be sited. Aquaculture would be more of a disruption in Alternative 3 compared to Alternative 2 because recreational fishers do not have existing competition with commercial fishers, there are less artificial FADs already in the area, and depths may be more attractive to recreational fishers.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. Siting aquaculture in multiple Alternative areas may mitigate the advantage smaller, recreational vessels may gain over commercial fleets due to navigation safety and gear compatibility. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified**.**

Resource Category	Summary and Comparison of Impacts
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternatives 4a.
Markets and Regional Food Systems	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential beneficial and adverse effects due to introduction of new domestic products, increase in the supply of domestic products, new or increased interactions with wild-caught seafood products, new or increased interactions with existing interstate or international trade markets. The overall growth in a market may be considered an economic benefit, but local or regionally-scaled costs may occur simultaneously. Offshore aquaculture could adversely impact the current aquaculture and fisheries industries, which are made up of a small number of small businesses. High capital investment would likely be required for start-up, which may mean that large, established businesses (domestic or international) could have an advantage over local or regional stakeholders to benefit from the AOA planning process. Santa Barbara channel has existing interest, investment, infrastructure ready for aquaculture activities which may reduce conflicts.
	Alternative 2b Potential beneficial and adverse effects due to introduction of new domestic products, increase in the supply of domestic products, new or increased interactions with wild-caught seafood products, new or increased interactions with existing interstate or international trade markets. The overall growth in a market may be considered an economic benefit, but local or regionally-scaled costs may occur simultaneously. Offshore aquaculture could adversely impact the current aquaculture and fisheries industries, which are made up of a small number of small businesses. High capital investment would likely be required for start-up, which may mean that large, established businesses (domestic or international) could have an advantage over local or regional stakeholders to benefit from the AOA planning process. Santa Barbara channel has existing interest, investment, infrastructure ready for aquaculture activities which may reduce conflicts. Finfish offers more potential for competition at markets.

Resource Category	Summary and Comparison of Impacts
	Alternative 3a Potential beneficial and adverse effects due to introduction of new domestic products, increase in the supply of domestic products, new or increased interactions with wild-caught seafood products, new or increased interactions with existing interstate or international trade markets. The overall growth in a market may be considered an economic benefit, but local or regionally-scaled costs may occur simultaneously. Offshore aquaculture could adversely impact the current aquaculture and fisheries industries, which are made up of a small number of small businesses. High capital investment would likely be required for start-up, which may mean that large, established businesses (domestic or international) could have an advantage over local or regional stakeholders to benefit from the AOA planning process.
	Alternative 3b Potential beneficial and adverse effects due to introduction of new domestic products, increase in the supply of domestic products, new or increased interactions with wild-caught seafood products, new or increased interactions with existing interstate or international trade markets. The overall growth in a market may be considered an economic benefit, but local or regionally-scaled costs may occur simultaneously. Offshore aquaculture could adversely impact the current aquaculture and fisheries industries, which are made up of a small number of small businesses. High capital investment would likely be required for start-up, which may mean that large, established businesses (domestic or international) could have an advantage over local or regional stakeholders to benefit from the AOA planning process. Finfish offers more potential for competition at markets.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOAs in both areas may distribute opportunities to more communities, which could reduce conflicts. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternatives 4a.
Ports and Working Waterfronts	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.

Resource Category	Summary and Comparison of Impacts
	Alternative 2a Potential beneficial and adverse effects due to increased vessel traffic in and out of coastal areas, increased vessel demand in and out of ports, harbors, and storage facilities, harvested product moving through coastal facilities, and the need for shore side industrial-use infrastructure (e.g. processing, storage).
	Alternative 2b Potential beneficial and adverse effects due to increased vessel traffic in and out of coastal areas, increased vessel demand in and out of ports, harbors, and storage facilities, harvested product moving through coastal facilities, and the need for shore side industrial-use infrastructure (e.g. processing, storage).
	Alternative 3a Potential beneficial and adverse effects due to increased vessel traffic in and out of coastal areas, increased vessel demand in and out of ports, harbors, and storage facilities, harvested product moving through coastal facilities, and the need for shore side industrial-use infrastructure (e.g. processing, storage).
	Alternative 3b Potential beneficial and adverse effects due to increased vessel traffic in and out of coastal areas, increased vessel demand in and out of ports, harbors, and storage facilities, harvested product moving through coastal facilities, and the need for shore side industrial-use infrastructure (e.g. processing, storage).
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOAs in both areas may distribute opportunities to more communities, which could reduce conflicts. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternatives 4a.
Tourism and Other Recreation	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.

Resource Category	Summary and Comparison of Impacts
	Alternative 2a Potential adverse effects due to displacement or disruption of the recreational experience associated with fixed gear and other equipment placement in the water column and surface, increased vessel traffic in and out of coastal areas, or changes in ecosystem services that support tourism and other recreational activities. Potential beneficial effect due to new areas where wildlife aggregations may occur.
	Alternative 2b Potential adverse effects due to displacement or disruption of the recreational experience associated with fixed gear and other equipment placement in the water column and surface, increased vessel traffic in and out of coastal areas, or changes in ecosystem services that support tourism and other recreational activities. Potential beneficial effect due to new areas where wildlife aggregations may occur. There may be less seasonality and more frequent vessel operations associated with aquaculture operations targeting finfish that may displace or disrupt tourism and recreation compared to shellfish and macroalgae, but more FAD effects.
	Alternative 3a Potential adverse effects due to displacement or disruption of the recreational experience associated with fixed gear and other equipment placement in the water column and surface, increased vessel traffic in and out of coastal areas, or changes in ecosystem services that support tourism and other recreational activities. Potential beneficial effect due to new areas where wildlife aggregations may occur. Impacts to tourism and recreation may be reduced compared to Alternative 2 due to less existing recreational vessel traffic and lower number and smaller footprint of facilities that may be sited.
	Alternative 3b Potential adverse effects due to displacement or disruption of the recreational experience associated with fixed gear and other equipment placement in the water column and surface, increased vessel traffic in and out of coastal areas, or changes in ecosystem services that support tourism and other recreational activities. Potential beneficial effect due to new areas where wildlife aggregations may occur. There may be less seasonality and more frequent vessel operations associated with aquaculture operations targeting finfish that may displace or disrupt tourism and recreation compared to shellfish and macroalgae, but more FAD effects. Impacts to tourism and recreation may be reduced compared to Alternative 2 due to less existing recreational vessel traffic and lower number and smaller footprint of facilities that may be sited.

Resource Category	Summary and Comparison of Impacts
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOAs in both areas may distribute opportunities to more communities, which could reduce conflicts. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternatives 4a.
Transportation and Navigation	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential adverse effects due to introduction of new structures, obstructions, or hazards to navigation associated with fixed gear and other equipment in the water column/surface and disruption to established navigational patterns of marine vessels and increased vessel traffic volume, both offshore and near ports and harbors.
	Alternative 2b Potential adverse effects due to introduction of new structures, obstructions, or hazards to navigation associated with fixed gear and other equipment in the water column/surface and disruption to established navigational patterns of marine vessels and increased vessel traffic volume, both offshore and near ports and harbors. There may be less seasonality and more frequent vessel operations associated with aquaculture operations targeting finfish compared to shellfish and macroalgae.
	Alternative 3a Potential adverse effects due to introduction of new structures, obstructions, or hazards to navigation associated with fixed gear and other equipment in the water column/surface and disruption to established navigational patterns of marine vessels and increased vessel traffic volume, both offshore and near ports and harbors. Impacts may be reduced compared to Alternative 2 due to less existing vessel traffic, smaller number and size of facilities that could potentially be sited, and closer distance to shore.

Resource Category	Summary and Comparison of Impacts
	Alternative 3b Potential adverse effects due to introduction of new structures, obstructions, or hazards to navigation associated with fixed gear and other equipment in the water column/surface and disruption to established navigational patterns of marine vessels and increased vessel traffic volume, both offshore and near ports and harbors. There may be less seasonality and more frequent vessel operations associated with aquaculture operations targeting finfish compared to shellfish and macroalgae. Impacts may be reduced compared to Alternative 2 due to less existing vessel traffic, smaller number and size of facilities that could potentially be sited, and closer distance to shore.
	Alternative 4a Potential adverse effects as discussed in Alternatives 2-3. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternatives 4a.
Offshore Energy and Public Services	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Oil and gas operations, marine mineral operations, submarine utilities, and direct ocean-outfalls are not anticipated to be impacted by Alternatives 2 given the geographical distance to the structures and standard setbacks, however the growth of offshore aquaculture within an identified AOA could disrupt established navigational patterns of marine vessels and increase vessel traffic volume that may have indirect impacts on operations associated with on-going offshore activites.. Alternative 2 overlaps with active BOEM lease blocks where leases could occur in the future.
	Alternative 2b Oil and gas operations, marine mineral operations, submarine utilities, and direct ocean-outfalls are not anticipated to be impacted by Alternatives 2 given the geographical distance to the structures and standard setbacks, however the growth of offshore aquaculture within an identified AOA could disrupt established navigational patterns of marine vessels and increase vessel traffic volume that may have indirect impacts on operations associated with on-going offshore activites. Alternative 2 overlaps with active BOEM lease blocks where leases could occur in the future.

Resource Category	Summary and Comparison of Impacts
	Alternative 3a Oil and gas operations, marine mineral operations, submarine utilities, and direct ocean-outfalls are not anticipated to be impacted by Alternatives 3 given the geographical distance to the structures and standard setbacks, however the growth of offshore aquaculture within an identified AOA could disrupt established navigational patterns of marine vessels and increase vessel traffic volume that may have indirect impacts on operations associated with on-going offshore activites.
	Alternative 3b Oil and gas operations, marine mineral operations, submarine utilities, and direct ocean-outfalls are not anticipated to be impacted by Alternatives 3 given the geographical distance to the structures and standard setbacks, however the growth of offshore aquaculture within an identified AOA could disrupt established navigational patterns of marine vessels and increase vessel traffic volume that may have indirect impacts on operations associated with on-going offshore activites.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternatives 4a.
Public Health and Safety	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential adverse effects due to fixed gear and other equipment in the water column and surface, more people working overwater in offshore environments, challenges for offshore monitoring and compliance, oversight and enforcement challenges for seafood safety oversight and changes to consumer trends and public health topics related to seafood. In addition to surface buoys or anchored lines that would be present for all types of aquaculture operations, growing vegetation/shellfish on longlines may create more hazards to navigation.

Resource Category	Summary and Comparison of Impacts
	Alternative 2b Potential adverse effects due to fixed gear and other equipment in the water column and surface, more people working overwater in offshore environments, challenges for offshore monitoring and compliance, oversight and enforcement challenges for seafood safety oversight and changes to consumer trends and public health topics related to seafood. In addition to surface buoys or anchored lines that would be present for all types of aquaculture operations, growing vegetation/shellfish on longlines may create more hazards to navigation. Finfish sub-alternatives have a higher FAD effect, which is linked to potential higher risk of human/marine life interactions, concerns for worker safety. Finfish will require more engineering considerations for gear integrity. Finfish raises public concerns about exposure pathways to chemicals of concern (husbandry bioaccumulation, antibiotics/drug resistant bacteria, and vaccines/heavy metals).
	Alternative 3a Potential adverse effects due to fixed gear and other equipment in the water column and surface, more people working overwater in offshore environments, challenges for offshore monitoring and compliance, oversight and enforcement challenges for seafood safety oversight and changes to consumer trends and public health topics related to seafood. In addition to surface buoys or anchored lines that would be present for all types of aquaculture operations, growing vegetation/shellfish on longlines may create more hazards to navigation. In addition to surface buoys or anchored lines that would be present for all types of aquaculture operations, growing vegetation/shellfish on longlines could entangle vessels transiting through the area which could cause vessel damage and safety incidents. Santa Monica Bay often has seafood harvesting advisories in place, related to runoff from the greater LA area.
	Alternative 3b Potential adverse effects due to fixed gear and other equipment in the water column and surface, more people working overwater in offshore environments, challenges for offshore monitoring and compliance, oversight and enforcement challenges for seafood safety oversight and changes to consumer trends and public health topics related to seafood. In addition to surface buoys or anchored lines that would be present for all types of aquaculture operations, growing vegetation/shellfish on longlines may create more hazards to navigation. Finfish sub-alternatives have a higher FAD effect, which is linked to potential higher risk of human/marine life interactions, concerns for worker safety. Finfish will require more engineering considerations for gear integrity. Finfish raises public concerns about exposure pathways to chemicals of concern (husbandry bioaccumulation, antibiotics/drug resistant bacteria, and vaccines/heavy metals).

Resource Category	Summary and Comparison of Impacts
	Alternative 4a Potential adverse effects as discussed in Alternatives 2-3. AOAs in both areas may distribute risks to more communities. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternatives 4a.
Environmental Justice Considerations	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential adverse and beneficial effects due to expanded aquaculture production into new geographies, which may increase risks to human health and community well-being, particularly in low-income regions, considering local history of discrimination and/or racism in economic opportunity, seafood safety and pollutant exposure, principles of food justice. The disproportionate advantage for large-scale businesses due to high start-up costs may perpetuate disparities in business ownership, employment, and income. In contrast, new opportunities in employment and trade may help to alleviate some of the race and gender gaps in socioeconomic participation in ocean-related industries. Alternative 2 has communities that may be limited by resources in various ways and show high vulnerability from existing gentrification pressures; these communities may be less able to adapt to changes brought on by a developing new industry such as offshore aquaculture.
	Alternative 2b Potential adverse and beneficial effects due to expanded aquaculture production into new geographies, which may increase risks to human health and community well-being, particularly in low-income regions, considering local history of discrimination and/or racism in economic opportunity, seafood safety and pollutant exposure, principles of food justice. The disproportionate advantage for large-scale businesses due to high start-up costs may perpetuate disparities in business ownership, employment, and income. In contrast, new opportunities in employment and trade may help to alleviate some of the race and gender gaps in socioeconomic participation in ocean-related industries. Alternative 2 has communities that may be limited by resources in various ways and show high vulnerability from existing gentrification pressure and some communities that show high existing reliability on commercial fishing, which could make them especially-vulnerable to potential impacts from finfish or IMTA aquaculture.

Resource Category	Summary and Comparison of Impacts
	Alternative 3a Potential adverse and beneficial effects due to expanded aquaculture production into new geographies, which may increase risks to human health and community well-being, particularly in low-income regions, considering local history of discrimination and/or racism in economic opportunity, seafood safety and pollutant exposure, principles of food justice. The disproportionate advantage for large-scale businesses due to high start-up costs may perpetuate disparities in business ownership, employment, and income. In contrast, new opportunities in employment and trade may help to alleviate some of the race and gender gaps in socioeconomic participation in ocean-related industries. Alternative 3 has more potential communities at risk than Alternative 2 due to demographic factors that leave communities, which have a high reliance on fishing, vulnerable to change. Alt 3 also has history of public health advisories related to seafood harvesting.
	Alternative 3b Potential adverse and beneficial effects due to expanded aquaculture production into new geographies, which may increase risks to human health and community well-being, particularly in low-income regions, considering local history of discrimination and/or racism in economic opportunity, seafood safety and pollutant exposure, principles of food justice. The disproportionate advantage for large-scale businesses due to high start-up costs may perpetuate disparities in business ownership, employment, and income. In contrast, new opportunities in employment and trade may help to alleviate some of the race and gender gaps in socioeconomic participation in ocean-related industries. Alternative 3 has more potential communities at risk than Santa Barbara due to demographic factors that leave communities, which have a high reliance on fishing, vulnerable to change. Alt 3 also has history of public health advisories related to seafood harvesting.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOAs in both areas may distribute impacts to more communities. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.Any differences or compounding impacts that may affect participation in any existing fisheries, including any artisanal commercial, recreational, ceremonial, or subsistence fisheries in offshore marine waters, should be considered carefully for potential EJ concerns.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternatives 4a.
Tribal Resources and Cultural Practices	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.

Resource Category	Summary and Comparison of Impacts
	Alternative 2a Potential adverse effects due to increased demand on Tribal members for information and coordination, risk of disturbance and/or damage to artifacts, changes in artifact historic and/or cultural value, area disturbance on community practices, wellbeing, and access. Potential beneficial effects if socioeconomic benefits go to Tribes.
	Alternative 2b Potential adverse effects as discussed in Alternative 2a.
	Alternative 3a Potential adverse effects due to increased demand on Tribal members for information and coordination, risk of disturbance and/or damage to artifacts, changes in artifact historic and/or cultural value, area disturbance on community practices, wellbeing, and access. Potential beneficial effects if socioeconomic benefits go to Tribes. Alternative 3 is further away from Chumash lands and the proposed Chumash Heritage National Marine Sanctuary and impacts may be reduced compared to Alternative 2.
	Alternative 3b Potential adverse effects as discussed in Alternative 3a.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOAs in both areas may distribute impacts to more communities. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternatives 4a.
Non-Tribal Cultural and Traditional Practices	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential adverse and beneficial effects due to biological, socioeconomic, and cultural impacts of increased aquaculture operations. More interest, investment, infrastructure may increase baseline social license relative to Alternative 3. Shellfish and macroalgae is consistent with state policy and results in less competition with fisheries, which may further contribute to social license.

Resource Category	Summary and Comparison of Impacts
	Alternative 2b Potential adverse and beneficial effects due to biological, socioeconomic, and cultural impacts of increased aquaculture operations. More interest, investment, infrastructure may increase baseline social license relative to Alternative 3. Finfish is not consistent with current state policy and may have less social license compared to shellfish and macroalgae aquaculture.
	Alternative 3a Potential adverse and beneficial effects due to biological, socioeconomic, and cultural impacts of increased aquaculture operations. Less interest, investment, and infrastructure may decrease baseline social license relative to Alternative 2, and more fishing communities have lower resiliency scores in Alternative 3.
	Alternative 3b Potential adverse and beneficial effects due to biological, socioeconomic, and cultural impacts of increased aquaculture operations. Less interest, investment, and infrastructure may decrease baseline social license relative to Alternative 2, and more fishing communities have lower resiliency scores in Alternative 3. Finfish is not consistent with current state policy and may have less social license compared to shellfish and macroalgae aquaculture.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. AOAs in both areas may distribute impacts to more communities. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternatives 4a.
Archeological Resources	Alternative 1 If AOAs were not identified there would be no impact to the baseline conditions.
	Alternative 2a Potential adverse effects to archeological resources due to seafloor disturbance. Known archaeological resources have been avoided, but anywhere in the SCB continental shelf has potential occurrence of archaeological resources.
	Alternative 2b Potential adverse effects as discussed in Alternative 2a.

Resource Category	Summary and Comparison of Impacts
	Alternative 3a Potential adverse effects to archeological resources due to seafloor disturbance. Known archaeological resources have been avoided, but anywhere in the SCB continental shelf has potential occurrence of archaeological resources. Overall probability of occurrence and overlap may be reduced compared to Alternative 2 due to lower number and smaller footprint of facilities that may be sited.
	Alternative 3b Potential adverse effects as discussed in Alternative 3a.
	Alternative 4a Potential adverse and/or beneficial effects as discussed in Alternatives 2-3. Risk could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.
	Alternative 4b Potential adverse and/or beneficial effects as discussed in Alternatives 4a.

i. Cumulative Impacts

Cumulative impacts were analyzed for each resource addressed in Chapter 3 (Affected Environment and Environmental Consequences) for all Alternatives in combination with past, present, and reasonably foreseeable future actions. For past actions, the cumulative impacts analysis only considers those actions or activities that have had ongoing impacts that may be additive to impacts of the alternatives. Likewise, present and reasonably foreseeable future actions selected for inclusion in the analysis are those that may have effects additive to the effects of the alternatives as experienced by specific environmental receptors. The Action Alternatives would contribute incremental adverse and beneficial effects on the human environment, which is already experiencing and absorbing a multitude of stressors to a variety of receptors, if siting aquaculture in those locations. The potential for cumulative impacts and the increment of impact associated with the past, present, and foreseeable actions described for Alternative 2 are not meaningfully different for Alternative 3. The resolution of data and impact potential is generally not sufficient to identify fine-scale difference in potential for increment of cumulative impact between the two potential AOA alternative areas. Alternative 4 would have similar impacts to Alternatives 2 and 3, with an increased increment of impact on cumulative effects, but the scale of Alternative 4 is not large enough that a substantive increase in increment of effect would be anticipated. At the stage of individual project proposals, finer-scale consideration for local interactions may result in different localized cumulative effects in space or time.

Chapter 1: Introduction and Background

A. Introduction

Aquaculture is an important agricultural sector and one of the fastest-growing forms of food production in the world. Aquaculture is generally defined as the propagation, rearing, and harvesting of aquatic species in controlled or selected environments. It is the cultivation of aquatic organisms for any commercial, recreational or public purpose. This includes production of finfish, shellfish, macroalgae, or multi-species aquaculture. Technological innovations have made it possible to culture marine species offshore in the open ocean. "Offshore" aquaculture here means the propagation, rearing, and harvesting of marine organisms in federal waters (3 to 200 nautical miles (nm) from shore), in locations characterized by exposure to open ocean conditions with potential wave energy and strong currents, differing from coastal, nearshore waters (Moore and Wieting 1999, Rubino (ed.) 2008, Froehlich et al. 2017a, CEA 2018, CRS 2019, CDFW 2019, Fujita et al 2023, and Bath et al. 2023).

The National Oceanic and Atmospheric Administration (NOAA) has directives to facilitate domestic aquaculture and to preserve ocean sustainability in the United States (U.S.), consistent with the National Aquaculture Act of 1980 (16 U.S.C. 2801 et seq.) These directives have established promoting domestic aquaculture as a national policy priority for the U.S. on the basis of the growing demand for aquaculture products, along with an interest in providing domestic food security and jobs. The United Nations Food and Agriculture Organization (FAO) estimates that the U.S. is the world's largest importer of aquaculture products, but ranks 18th in aquaculture production globally (FAO 2022).

Seafood is becoming more integrated into global food systems, with growth and diversity in consumption, production, and competitive product pricing. Aquaculture has been the main source of fish consumed globally since 2016; and the proportion of overall seafood consumed that is from aquaculture is growing annually (CEA 2018, Clavelle et al. 2019, FAO 2020a, and FAO 2022). Aquacultured seafood products grown in the U.S. have historically supplied very little of the domestic demand (Rubino (ed.) 2008). Data for 2020 estimates that 70% to 85% of the seafood consumed in the U.S. is imported, and about half of it is produced by aquaculture from other countries (NMFS 2022a). Domestic aquaculture supplies about 7% of the U.S. seafood supply by volume, contributing to an estimated $17.0 billion seafood trade deficit (NMFS 2022a). These key statistics imply that the economic potential of the commercial aquaculture industry in the U.S. is under-realized.

On May 7, 2020, the White House issued an Executive Order on Promoting American Seafood Competitiveness and Economic Growth (E.O. 13921) (85 FR 28471). E.O. 13921 requires the Secretary of Commerce to identify geographic areas in the U.S. Exclusive Economic Zone (EEZ) suitable for commercial aquaculture, and complete a National Environmental Policy Act (NEPA) Programmatic Environmental Impact Statement (PEIS) for each area identified as a result of the E.O. to assess the impact of siting aquaculture facilities there. These geographic areas would be referred to as Aquaculture Opportunity Areas (AOAs) once a final PEIS is completed, and a Record of Decision (ROD) is issued. An AOA is a defined geographic area that has been evaluated to determine its potential suitability for commercial aquaculture. Identifying AOAs may help support the development of domestic commercial aquaculture, consistent with sustaining and conserving marine resources and applicable laws, regulations and policies.

NOAA's National Marine Fisheries Service (NMFS) selected federal waters in the Southern California Bight (SCB) as one of the first two geographic regions in which to identify AOAs. The SCB is considered as the marine space within the U.S. EEZ associated with the coastline between Point Conception and the U.S./Mexico border, and encompassing the Channel Islands. The geographic area is characterized by a biodiverse ecosystem and a temperate ocean climate that has relatively calm seas and consistent ocean temperatures. In addition, California is one of the most populated coastal states in the U.S. and tops the state rankings with 26.8 million people living in coastal counties (U.S. Census Bureau 2022). The dense human population, along with the climate and ocean conditions, may create promising conditions for offshore aquaculture development in the SCB region. There are also complex existing ocean uses including high shipping traffic, commercial and recreational fishing, other recreational industries, sensitive habitat, protected species, and strategic national security assets that would require any aquaculture project to navigate the existing ocean user-space carefully.

The intent of this draft PEIS (DPEIS) is to support long-term planning for offshore aquaculture. The DPEIS identifies potential locations for one or more offshore AOAs in the SCB and analyzes the types of potential impacts that may be associated with potential aquaculture projects in those locations, if aquaculture projects were sited there in the future. It evaluates the beneficial and adverse impacts associated with offshore aquaculture that could occur through future proposals and project level review, and compares the suitability of different geographic areas. This DPEIS applies CEQ's Phase I NEPA regulations because review of this proposed action began on May 23, 2022 which preceded the effective date of CEQ's Phase 2 NEPA regulations (July 1, 2024).

i. Proposed Action

The Federal action proposed in this DPEIS is to identify one or more geographic locations (referred to as AOAs) that may be suitable for multiple future offshore aquaculture projects in Federal waters of the SCB (outside of state waters, within the U.S. EEZ), and to evaluate the impacts of siting aquaculture in those locations. AOAs identified through this process could be considered potentially suitable for finfish, shellfish, macroalgae, or multi-species aquaculture. The proposed action is a long-term planning effort. It is not a regulatory or permitting action and does not propose to authorize or permit any specific aquaculture-related activities or individual aquaculture projects. The analysis may be used to inform such processes for individual projects proposed later in time.

ii. Purpose and Need

The purpose of the proposed action is to apply a science-based approach to identify AOAs in Federal waters. The goal of identifying AOAs is to promote American seafood competitiveness, food security, economic growth, and to support the development of domestic commercial aquaculture, consistent with sustaining and conserving marine resources and applicable laws, regulations and policies. The proposed action is needed to meet the directives of E.O. 13921 to address the increasing demand for seafood, facilitate long-term planning for marine aquaculture development, and address interests and concerns regarding offshore marine aquaculture siting.

B. Offshore Marine Aquaculture in the United States

The marine economy, also known as the Blue Economy, is defined in the Department of Commerce (DOC) 2022-2026 Strategic Plan as economic activities related to the U.S. oceans, seaports, and Great Lakes. It is estimated that this sector is growing at nearly twice the rate of the overall U.S. economy, including higher growth in employment (DOC 2022). Foods associated with marine systems are an important, sustainable way to meet rising population and income-driven demand for seafood and healthy protein (Naylor et al. 2021, Gephart et al. 2021, and Froehlich et al. 2020). Due to the rising need for seafood, global aquaculture is one of the fastest-growing protein-based food sectors, producing 122.6 million tons in 2020 (FAO 2022). The most recent aquaculture census from the U.S. Department of Agriculture (USDA) estimated 1,047 saltwater aquaculture farms were in operation as of 2018, which accounts for both ocean-based and land-based farms that use saltwater (USDA 2019). The NOAA 2020 Fisheries of the United States report estimated that in 2019 the total U.S. marine aquaculture production was 41,002 metric tons (mt), comprising approximately 13.7% of U.S. annual aquaculture production by weight (NMFS 2022a). The most recent summarized data for national totals of marine aquaculture production by species group, product weight, and U.S. dollars is summarized on page (p.) 17 of the NOAA Fisheries 2020 Fisheries of the United States report (NMFS 2022a).

The EEZ is an offshore area where the aquaculture industry could find opportunity to grow. It is estimated that less than 500 square kilometers (km^2) (193 square miles [mi^2]), which is less than 0.01% of the U.S. EEZ, may be enough to produce up to 600,000 mt or more of farmed seafood per year (Nash 2004). Improved technology to farm aquaculture species in open ocean sites provides the opportunity for marine aquaculture to expand offshore, where there are less user-conflict and environmental constraints (Kapetsky et al. 2013, Kite-Powell et al. 2013, Rust et al. 2014, Costello et al. 2016, Holm et al. 2017, CEA 2018, Lester et al. 2018a, Lester et al. 2018b, and FAO 2020a). In offshore Federal waters, there are currently no commercial projects in operation, although there are some projects that may pursue permits in the foreseeable future. There are a very limited number of small-scale commercial aquaculture projects in State waters. There is high regional variation in the number of aquaculture farms and the value of farmed aquatic products throughout the nation.

i. United States Aquaculture Policy

This DPEIS includes information on U.S. aquaculture policy. Federal governance of ocean uses within the U.S. EEZ can vary greatly based on geographic boundaries, specific activities, protection or conservation of living marine resources, and a federal agency's statutory responsibilities.

The National Aquaculture Act of 1980

In 1980, Congress enacted the National Aquaculture Act (16 U.S.C. § 2801 et seq.) to establish a national aquaculture policy, recognizing the need to reduce the U.S. fisheries product trade deficit, augment existing commercial and recreational fisheries, produce renewable resources, and therefore meet future domestic food needs and contribute to the global seafood supply. Under this law, the Secretary of Agriculture was designated to lead the coordinating committee, established by Executive Order in 1978 (E.O. 12039) as the Joint Subcommittee on Aquaculture within the Office of Science Technology Policy, and charged with creating an Aquaculture Development Plan.

U.S. Department of Commerce and NOAA Aquaculture Policies

After the National Aquaculture Act was authorized, several government initiatives and high-level reports promoted offshore aquaculture and coordinated marine spatial planning in U.S. waters; however, offshore aquaculture development in the U.S. was inhibited by scientific, economic, legal, and production factors (Cicin-Sain et al. 2004; Rubino 2008; and Lester et al. 2018a). To expedite aquaculture development, two corresponding federal policies were enacted. Consistent with the National Aquaculture Act, the U.S. Department of Commerce (DOC) developed an Aquaculture Policy (2011) to specify the goals, objectives, and priorities for all DOC Bureaus, including NOAA, in the context of the Department's overarching emphasis on jobs, the economy, innovation, and international competitiveness. Working in partnership with the U.S. Department of Agriculture, Food and Drug Administration, Department of the Interior, and the Joint Subcommittee on Aquaculture, the policy intent was "to make the U.S. a world leader in developing, demonstrating, and employing innovative and sustainable aquaculture technologies and in encouraging worldwide adoption of sustainable aquaculture practices and systems." Expanding upon the DOC Aquaculture Policy, NOAA's Marine Aquaculture Policy (2011) reaffirmed aquaculture as an important component of NOAA's marine stewardship mission and strategic goals for healthy oceans and resilient coastal communities and economies. By statutory authority, NOAA's National Marine Fisheries Service (NMFS) is also responsible for protecting habitat, vulnerable species, and sustainable fisheries, and thus has responsibility for considering, preventing, and mitigating potential adverse environmental impacts of proposed and existing marine aquaculture development and operational plans.

Executive Order 13921

Executive Order 13921 called for the expansion of sustainable seafood production in the U.S. to ensure food security; provide environmentally safe and sustainable seafood; support American workers; ensure coordinated, predictable, and transparent federal actions; and remove unnecessary regulatory burdens. Importantly, specific action items with defined deliverables are required for the purpose of increasing transparency and coordination among government agencies, reducing regulatory barriers, and facilitating environmentally responsible U.S. offshore aquaculture development. Section 7 of the E.O. directs the Secretary of Commerce to identify Aquaculture Opportunity Areas (AOAs) in consultation with the Secretary of Defense, the Secretary of the Interior, the Secretary of Agriculture, the Secretary of Homeland Security, the Administrator of the Environmental Protection Agency, other appropriate federal officials, appropriate Regional Fishery Management Councils, and in coordination with appropriate state and tribal governments.

Additional information about aquaculture management is provided in Chapter 3. The laws, policies, and regulations that may apply to offshore aquaculture projects are compiled in Chapter 5 (Compliance with other Laws, Policies, and Regulations).

ii. Status of Marine Aquaculture in the Southern California Bight Ecosystem

California supports a robust ocean-based economy, as well as a growing aquaculture industry. USDA aquaculture census data for 2018 ranks California fifth in the nation for total aquaculture sales (from operations in State waters), worth $106 million in sales within the state, and $1.5 billion in distribution sales to the rest of the U.S. (USDA 2013, 2019). An additional overview of marine aquaculture's contribution to the California economy is provided on p. 1-8 of CDFW (2019). The overall economic impact of aquaculture in the state (sales, employment, etc.) is estimated to be about $200 million (CDFW 2022). Saltwater species that are grown in the state for food include oysters, abalone, mussels, clams, seaweed, channel catfish, tilapia, sturgeon, striped bass, and rainbow trout (Sea Grant 2024a). These existing operations occur on land in various types of aquarium systems, or very close to shore. As of the most recent CDFW status report in 2020, a total of 5,740 acres (ac) (2,323 hectares [ha]) of nearshore public tidelands are leased for marine aquaculture, with an estimated 9% of the total acreage in active operation (CDFW 2020a). Additional aquaculture programs exist for certain species of macroalgae, invertebrates, and finfish for the purpose of research and wild population restoration.

C. AOA Planning Process

i. Overview of the PEIS

A programmatic approach to NEPA may be used when an agency plans new policies or programs that may include actions occurring in the same region; common subject matter and methods of implementation; or if a plan encompasses potential future NEPA assessments that may all have similar impacts but with a narrower scope, such as a project-specific, or site-specific, assessment. The programmatic analysis may be used to inform NEPA processes for individual projects proposed later in time. A PEIS may also help eliminate repetitive discussions of the same issues. Just as an EIS, a PEIS considers a range of alternatives for the proposed action, including a No Action alternative. It undergoes the same public review process, and is shaped by public and stakeholder input. A PEIS is a broad, or high level, NEPA document that assesses the impacts of a proposed action.

This DPEIS provides a programmatic-level NEPA assessment of the potential impacts on the human environment, should aquaculture facilities be sited, associated with proposed identification of an AOA or AOAs to be located in Federal waters off the coast of Southern California. The programmatic approach is intended to provide NEPA compliance for planning actions and decision-making, and takes a broad look at issues and geographic alternatives for offshore aquaculture in the SCB. The PEIS may be tiered from for future proposed aquaculture projects if the lead agency determines the PEIS is appropriate for its needs. The lead agency for any site-specific NEPA analysis for potential projects sited in an AOA may depend on the project design, cultivated species, and associated permits, among other considerations. This DPEIS considers a long-term planning effort that is not a regulatory or permitting action and does not propose to authorize or permit any specific aquaculture-related activities or individual aquaculture projects. It is a planning initiative only. Project specific NEPA analysis, consultations, and permits may be needed in the future.

ii. Public Involvement

Following the publication of E.O. 13921 on May 7, 2020, NMFS began a public outreach effort that included stakeholder engagement, video and print informational products, and soliciting input from stakeholders, including the commercial and recreational fishing communities, academia, non-governmental organizations (NGOs), the general public, and coastal and ocean managers. Part of the initial public outreach effort included publication of a Request for Information (RFI) in the Federal Register (85 FR 67519, Oct. 23, 2020). The RFI solicited public input to help identify data needs, data sources, and project requirements for offshore aquaculture in the first two geographic regions in which NMFS has chosen to identify AOAs (Southern California and Gulf of Mexico), as well as on a national level. At the same time, the National Center for Coastal Ocean Science (NCCOS) worked with the NMFS regional offices in Southern California to collect data for a spatial modeling analysis for the region. The work by NCCOS was published as a peer-reviewed technical memorandum entitled "An Aquaculture Opportunity Area Atlas for the Southern California Bight," referred to herein as "the Atlas" (Morris et al. 2021).

Through the end of 2021, and into the spring of 2022, NMFS used the results in the Atlas, along with the public input gathered through the RFI, to develop the Notice of Intent (NOI) for the DPEIS.

NMFS published an NOI on May 23, 2022, to initiate the NEPA process. The NOI included prompts to gather input from the public for the DPEIS (87 FR 31210). Public comments for the Southern California AOA DPEIS were accepted from May 23, 2022 to July 22, 2022 (60 days). Two webinar-based public listening sessions were held during scoping, in which comments could be submitted orally. Written submissions were accepted during the public comment period via the federal docket with the identification number NOAA-NMFS-2022-0051. A public scoping report was published to the Southern California AOA website and to the Office of Aquaculture (OAQ) AOA website on March 29, 2023, that summarizes the process, participants, and the themes of scoping comments (NMFS 2023a). NOAA Fisheries announced public scoping through a variety of internet media, and also through direct outreach to members of the interested public. NOAA Fisheries reached out to tribal governments in the Southern California region to inform them about the AOA PEIS process and invited them to participate in the AOA planning process. From 2021 through 2024, NMFS WCR gathered the information from pre-scoping outreach, the scoping period, best available science, and additional expertise from NOAA offices to write this DPEIS. The publication of the DPEIS in the Federal Register initiates the 60-day public comment period on the draft.

iii. Submitted Alternatives, Information, and Analyses

This section summarizes the alternatives, information, and analyses submitted by tribal, federal, state, and local governments and other public commenters during the scoping process for consideration by the NMFS in developing this DPEIS.

Locations other than the proposed preliminary alternatives were suggested in public comments. There were suggestions for NMFS to consider other areas to identify AOAs, including the Port of Los Angeles, Long Beach, Ventura Harbor, and Huntington Beach. Areas that were suggested to potentially mitigate adverse impacts with other ocean users included using existing oil platforms instead of open ocean, or using areas closed to wild-capture fisheries. Public comments also suggested changing the distance to shore, with commenters suggesting that closer to shore may be more economically viable for small business owners to take part; or, further from shore may avoid more water quality and other environmental safety concerns. Commenters recommended to include alternatives that only included native species, or only shellfish and macroalgae, with the rationale to better-align the AOA identification process with existing CA state policies and ongoing CA aquaculture planning efforts.

Chapter 2: Proposed Alternatives

A. Proposed Alternatives

The spatial modeling approach used in the Atlas was specific to the planning goal of identifying areas that have the highest potential to support three to five marine aquaculture operations and the least amount of conflict with other ocean uses. The AOA options identified in the Atlas were one source of information used by NMFS to inform the development of the DPEIS. The parameters that were selected to conduct spatial modeling for AOAs (e.g. depth, distance to shore, and federal waters) were high level and meant to encompass all types of aquaculture, and have low levels of conflict with other ocean users while meeting basic industry requirements for generalized aquaculture operations. Additional spatial analyses that are specific to types of aquaculture and/or cultivation approaches (e.g. mussel longline aquaculture) could identify different discrete areas that are more suitable than those resulting from the analysis in the Atlas. The larger area of interest considered in the Atlas represents areas that met the industry and engineering requirements for depth and distance from shore; criteria were 3-25 nm offshore and depth ranging from 10-150 m (33-492 ft). Aquaculture planning and siting for marine aquaculture operations requires thorough synthesis and spatial analyses of critical environmental data and ocean space use conflicts (Kapetsky et al. 2013). Marine spatial planning (MSP) incorporates and thereby mitigates many potential deleterious ecosystem-level impacts of aquaculture. The application of MSP is central to an ecosystem approach to aquaculture (EAA) to ensure accountability and equitable shared use of resources (Stelzenmüller et al. 2017; Gimpel et al. 2018). EAA is a strategy for integration of aquaculture activities within the wider ecosystem that promotes sustainable development, equity, and resilience of interlinked social-ecological systems (Brugere et al. 2010).

Spatial data for critical or potential environmental and ocean space use conflicts that could constrain the siting of aquaculture in federal waters were used to identify areas with the highest suitability for aquaculture development. Documented areas of offshore infrastructure, protected species habitat, historic and cultural resources, military, and other ocean uses in the SCB that may not be compatible with aquaculture operations were considered in the site suitability analysis. The modeling results identified eight AOA options in the Santa Barbara Channel, and two AOA options in Santa Monica Bay. The AOA NEPA alternatives are based on the spatial analysis in the Atlas, the evaluation of available spatial data within the SCB, feedback received during scoping, as well as the best available science and literature on aquaculture and the region. The use of AOAs to create a predictable area for aquaculture development may have a beneficial impact on communities in creating predictability and focusing aquaculture in an area that has been evaluated and assessed to be the most suitable in Southern California (Morris et al. 2021), and may be evaluated in the context of minimizing specific impacts (e.g., minimizing use conflict and impacts to wildlife and habitats that are culturally important to tribal and non-tribal communities).

NMFS WCR is proceeding with the four preliminary alternatives described in the NOI (87 FR 31210). In addition, the three action alternatives include two sub-alternatives (a) and (b) that were created as a direct response to public scoping comments and stakeholder requests, while still satisfying the directives of E.O. 13921. The sub-alternatives are based on the types of aquaculture for which an AOA may be identified, however offshore aquaculture development of any kind could still occur outside of or within the AOA options in federal waters.

i. Alternative 1: No Action

In Alternative 1, the no action alternative, NMFS would not identify any AOA in Federal waters offshore of Southern California, including not identifying any sub-alternatives.

ii. Alternative 2: Santa Barbara Channel

In Alternative 2, NMFS would identify at least one and up to eight AOAs from within Federal waters offshore of Santa Barbara and Ventura Counties in the Santa Barbara Channel. The Alternative 2 AOA options are located between 10.02 and 19.72 km (5.41 and 10.65 nm) offshore (Figure 1).

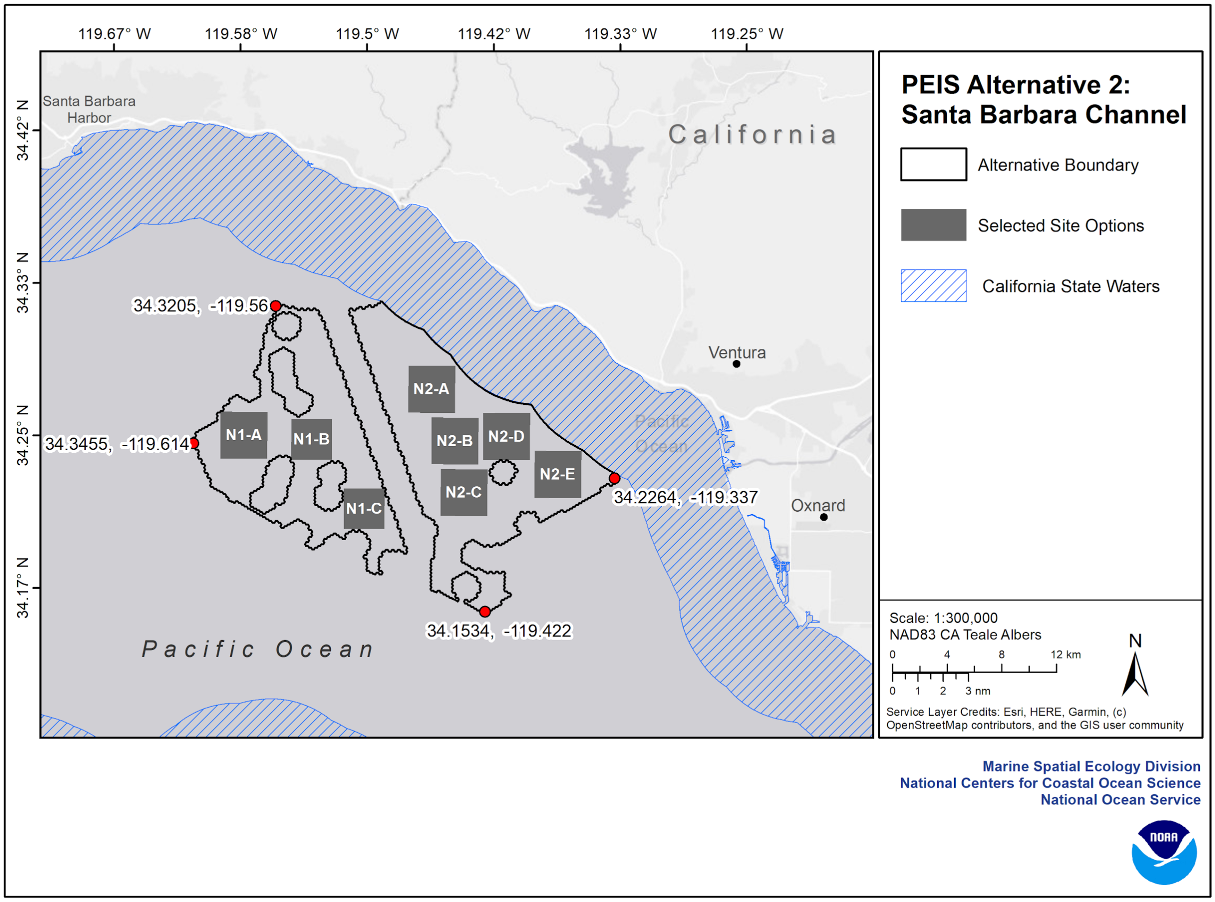


Figure 1: Map of Alternative 2: Santa Barbara Channel

The Santa Barbara Channel is considered to be the submerged portion of the Santa Barbara-Ventura Basin, a marine area of 5,179 km^2 (2,000 mi^2) and approximately 97 km (52 nm) in length, extending north from Point Conception south to Port Hueneme (NCCOS 2005, Heintz et al. 2008). Each AOA option within Alternative 2 ranges from 1,500 to 2,000 acres (607 to 809 ha). The total combined acreage in Alternative 2 is 15,000 acres (6070 ha), or 60.7 km^2 (23.4 mi^2).

The coordinates in Figure 1 represent the most north, east, south, and west points of the alternative boundary. More information about each AOA option within Alternative 2 is provided in Table 3.7 on p. 112 and in Table 3.11 on p. 138 of the Results section of Morris et al. (2021).

a) <u>Shellfish and Macroalgae Aquaculture</u>

In Sub-alternative (2a), NMFS would identify one or more AOAs in the Santa Barbara Channel in which macroalgae and shellfish aquaculture could be sited. Offshore shellfish and seaweed cultivation systems have many similarities (CDFW 2019). Figures and text describing the two cultivation methods, along with comparisons between the two, are provided in pp. 2-15 and 2-16 of the California Department of

Fish and Wildlife (CDFW) Draft Programmatic Environmental Impact Report (PEIR) for a Coastal Marine Aquaculture Program (CDFW 2019).

Seaweed

Seaweed farming, also referred to as kelp or macroalgae cultivation, is a fast growing aquaculture sector. Seaweed refers to a number of green, red, and brown macroalgae species. Seaweeds are different from vascular plants like mangroves and seagrasses as they are photosynthetic algal organisms, are non-flowering, and lack vascular stems, roots, and leaves. Seaweeds derive water, minerals, and nutrients from the water surrounding them. The potential macroalgae species that are thought likely to be pursued in the SCB for commercial production are described in Chapter 3, Section C.iv. (Potentially-Farmed Species).

The following resources that provide background information and an overview of macroalgae aquaculture (e.g. typical cultivation methods, gear materials and set-up, species that may be pursued for commercial purposes):

- an overview of seaweed production globally is provided in Section 1 on pp. 1 through 6 of FAO (2018);
- a literature review of seaweed farming globally is provided in Section 3 on p. 3 of Sultana et al. (2023);
- an overview of macroalgae farming in the U.S. is provided in a webinar by Sea Grant (2022), available online at https://www.youtube.com/watch?v=k9oP-K50KK8;
- seaweed cultivation in California state waters is described on pp. 1-7 and 1-8 in Section 1.1.2 of CDFW (2019);
- optimal culture conditions throughout a lifecycle of cultured seaweed are provided in Table 3.1 on p. 29 of Redmond et al. (2014);
- typical design and operating concepts for a seaweed farm are shown in Figure 1 on p. 437 and Figure 2 on p. 438 of Kite-Powell et al. (2022);
- two examples of macroalgae farm designs, raft and long-line, are presented in Figure 4 on p. 6 of DOE (2021);
- maps and design plans for a longline kelp aquaculture farm in the SCB are provided in Appendix A, starting on p. 50 of U.S. Army Corps of Engineers (USACE (2021); and
- a literature review on the physical properties of long-line kelp aquaculture systems is provided in the introduction of Fredriksson et al. (2023).

Shellfish

Molluscan shellfish (oysters, clams, mussels) is the leading type of aquaculture production in the U.S. (Nelson et al. 2019). And molluscan species are the only type of shellfish cultivated currently in California state waters or on land (mussels, oysters, scallops, clams, abalone) (CDFW 2020a). Shellfish in this DPEIS refers to molluscan species only. The potential molluscan species that are thought likely to be pursued in the SCB for commercial production are described in Chapter 3, Section C.iv. (Potentially-Farmed Species).

Farmed mussel culture operations employ different technologies depending on depth) (Bath et al. 2023). The primary methods of oyster culture used by California growers are longline culture, rack-and-bag, and bottom containers (CDFW 2020a). Abalone operations in California state waters use floating rafts and suspended cages (CDFW 2010, CDFW 2020a). In deep, offshore waters, the most likely types of shellfish culture may include submerged longline systems (Theuerkauf et al. 2019, CDFW 2020a, and Bath et al. 2023). Submerged systems are similar to surface systems, but are submerged 5 - 15 m (16 - 49 ft) below the surface to mitigate against ocean surface conditions such as wind and waves (Young 2015, USACE 2021). Additional resources that provide an overview of shellfish aquaculture (e.g. typical gear materials and set-up, species that may be pursued for commercial purposes):

- shellfish cultivation of abalone, clams, mussels, and oysters in California state waters is described in Sections 18 through 21 in CDFW (2010);
- an overview of the shellfish economy in California is provided on pp. 6 and 7 of Wright (2020);
- four common types of shellfish gear and growing techniques are explained in Section 1.1.1 on pp. 8 through 14 of Mori and Riley (2021);
- three cultivation methods considered for impacts in a potential shellfish program in California state waters are described in Section 2.5 on pp. 9 and 10 of longline methods are described on pp. 20 – 22 of the Humboldt Bay Harbor, Recreation and Conservation District's Draft EIR for the Humboldt Bay Mariculture Intertidal Pre-Permitting Project (Humboldt Bay District 2022);
- longline mussel gear is also reviewed in Section 2.1 on pp. 2 and 3 of Bath et al. (2023);
- Section 2.1 on pp. 2 and 3 of Sunny et al. (2023 draft) provides an overview of a typical mussel farm design; and geometric and mechanical properties of mussel farm components are summarized in Table 1 on p. 4 of the paper; and
- design plans and configurations for a proposed 2,000 acre (809 ha) shellfish operation in the SCB are provided in Figures 19 and 20, on pp. 35 and 36 respectively, as well as in Appendix 1 and Appendix 3 on pp. 37 and 39 respectively, in Theuerkauf et al. (2019).

b) <u>All Types of Commercial Aquaculture</u>

In Sub-alternative (2b), NMFS would identify one or more AOAs in the Santa Barbara Channel in which finfish or Integrated Multi-Trophic Aquaculture (IMTA) facilities in addition to macroalgae and shellfish aquaculture could be sited. IMTA aquaculture grows more than one organism in a facility (e.g. shellfish with finfish). Under Sub-alternative (b), different types of aquaculture may be pursued at different facilities within one AOA; or, different types of aquaculture may be pursued at one facility in an IMTA system. The potential finfish species that are thought likely to be pursued in the SCB for commercial production are described in Chapter 3, Section C.iv. (Potentially-Farmed Species). Any system, species, or combination of systems and species could be possible to site in an AOA.

Common techniques to cultivate finfish are offshore ranching and net pen rearing. Submerged net-pens may be the method most likely utilized in an AOA. Net pens are cage-like structures enclosed by mesh screens and supported by floatation devices and rigid mooring devices and anchoring systems (Mori and Riley 2021). Typically, ocean-based finfish aquaculture requires feed and other husbandry materials as inputs to the system. Cultivated finfish are typically fed dry feed as early as possible; the feed type, characterized by the protein and fat content, may also be adjusted to reduce costs and improve fillet quality (CDFW 2010). Fish feed in aquaculture is a topic that is being researched and improved as the industry develops (Rust et al. 2014). Feed manufacturing undergoes its own regulatory review; therefore, feed sourcing is considered beyond the scope of this DPEIS. Net pen facilities may use young fish produced in hatcheries, which are then placed into pens where they are fed until grown to market size (CDFW 2010). Hatcheries undergo their own regulatory review and permitting process; and it is assumed that any operation sited in an AOA would work with an approved source in compliance with all U.S. regulations. Therefore, hatcheries and broodstock sourcing are considered out of scope for this DPEIS.

Current finfish aquaculture operations in California are public hatcheries or temporary research projects that operate in California state waters as part of native finfish stock enhancement programs to support commercial and recreational fisheries (California Fish and Game Code (CFGC) §6590 et seq.; CDFG 2010). The artificial propagation, rearing or stocking of finfish in state waters is limited to the purpose of recovery, restoration, or enhancement of native fish stocks, and is carried out under either a scientific collecting permit, research permit, or other enhancement programs established under State legislature (CFGC § 15400(b)(10) and (c), CDFG 2010, CDFW 2019, and CDFW 2020a). These types of activities are addressed through a regulatory program separate from commercial aquaculture (CDFW 2020a). The State-run Ocean Resources Enhancement and Hatchery Program (OREHP) in the SCB uses nearshore cages up to 790,000 gallons (gal) (3000 kiloliters [kl]) (CDFW 2010). The RWQCB, responsible for NPDES permits for the State's OREHP, considers a small versus large facility as less than versus greater than 45 mt fish per year, respectively (CDFG 2010). Examples from other countries show that salmon farms commonly produce 1,000 mt of fish per production cycle (Fujita et al. 2023).

The following resources that provide background information and an overview of finfish aquaculture (e.g. typical cultivation methods, gear materials and set-up, species that may be pursued for commercial purposes):

- Sections 2.1 and 2.2 on pp. 2 and 3 of Fujita et al. (2023) provides a literature review of finfish offshore production infrastructure, globally;
- traditional cage technologies used for finfish are described in Section 2.2 on pp. 3 and 4 of Bath et al. (2023);
- limiting variables and processes that may be considered in modeling a finfish farm operation are visualized in Figure 2 on p. 2131, and in Table 4 on p. 2133 of Chary et al. (2022);
- structural components and materials commonly used in net pen designs are reviewed in detail in Section 6 on pp. 13 through 19 of Fredriksson and Beck-Stimpert (2019);
- figures and text describing typical net pen designs and configurations for a theoretical example of 200 acres (81 ha) of finfish operations are provided on pp. 2-8 through 2-14 of CDFW (2019);
- material and structural components of net pens and submerged raceways that are used in the OREHP are described in section 6.1.1 and 6.1.2, respectively, of the white seabass enhancement program (CDFG 2010); and
- Section 3.3 on pp. 43 through 49 of the CDFG OREHP CEQ Declaration also describes net pen designs, conditions, and management systems typically used in the State's program in the SCB (CDFG 2010).

For all types of aquaculture, life history patterns are often used to help guide culture methods, and may be especially important to consider in the offshore environment where operations may be exposed to natural oceanic conditions. Emerging technologies in aquaculture, including IMTA, is reviewed in Section 1.1.1.5 on pp. 16 through 18 of Mori and Riley (2021) which is incorporated by reference. A literature review on the history and global examples of ocean-based IMTA experiments is provided on pp. 2 through 4 of Buck et al. (2018). IMTA may be used for co-use of existing offshore infrastructure, such as wind turbines or oil and gas platforms. The spatial analysis in the AOA planning process excluded existing offshore infrastructure; therefore, IMTA co-use is out of scope for this DPEIS. In other commercial operations, IMTA may be pursued for additional positive economic returns, such as in offshore ranching, as a mitigation technique for supplementing costs from inputs or outputs of a system, or to utilize otherwise waste products. Examples include:

- filter feeders (shellfish or certain species of finfish) may be used to utilize uneaten feed or waste, or stabilize water quality in net pen systems (Alexander et al. 2016, FAO 2022);
- ammonia excreted by fish has been shown to accelerate seaweed growth (Troell et al. 1997);
- profitability of finfish farms may be increased by seaweed production or other types of nutrient biofilters (Chopin et al. 2011);
- cultured algae can be used to supplement naturally occurring food in the water (CDFW 2010);
- instead of spending labor to remove certain biofouling organisms from systems, they may develop practices to harvest both (Peabody and Toft 2021);
- abalone can be housed in offshore grow-out structures such as cages, barrels, tubes, and baskets, which are either kept on long-lines or suspended systems near or within macroalgal lines or fish cages (Purcell et al 2023 (draft)); and
- a multi-species commercial sea-ranching approach used in the Yellow Sea includes scallops, sea urchins, abalone, and sea cucumbers (Buck et al. 2018).

IMTA systems are variable due to the detailed, integrated economic frameworks, hydrodynamic conditions, pelagic primary productivity, water concentrations, waste characteristics, and other environmental externalities or farm system components that may optimize multiple species to grow together. Due to the great variability, IMTA may not be accurately generalized in a programmatic approach. Therefore, the consideration of IMTA in this DPEIS is limited, but included in certain sections, as information was available.

iii. Alternative 3: Santa Monica Bay

In Alternative 3, NMFS would identify at least one and up to two AOAs from within Federal waters offshore of Los Angeles County in Santa Monica Bay. The Alternative 3 AOA options are located between 8.06 and 8.82 km (4.35 and 4.76 nm) offshore (Figure 2).

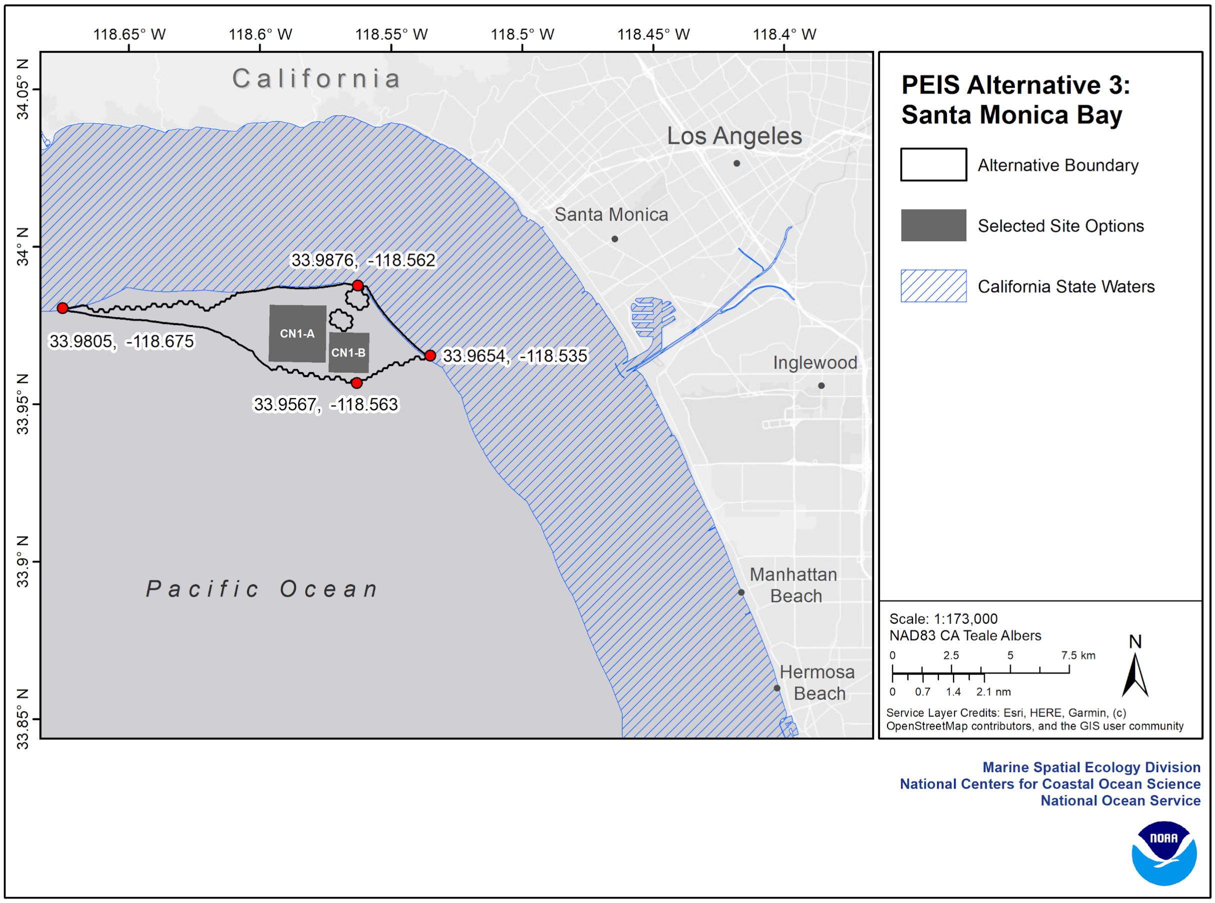


Figure 2: Map of Alternative 3: Santa Monica Bay

Santa Monica Bay is within the Santa Monica-San Pedro Basin, considered to be submerged lands trending northwest-southeast extending northwest from the Los Angeles/Ventura County line south to Point Fermin on the Palos Verdes Peninsula to the southeast (NCCOS 2005, Heintz et al. 2008, LARWQCB 2011). The two AOA options within Alternative 3 are 500 and 1,000 acres (202 and 405 ha), for a combined total of 1,500 acres (607 ha), or 6.1 km^2 (2.4 mi^2).

The coordinates in Figure 2 represent the most north, east, south, and west points of the alternative boundary. More information about each Alternative 3 AOA option is provided in Table 3.17 on p. 170 of the Results section of Morris et al. (2021).

a) <u>Shellfish and Macroalgae Aquaculture</u>

In Sub-alternative (3a), NMFS would identify at least one and up to two AOAs in the Santa Monica Bay in which macroalgae and shellfish aquaculture facilities could be sited. Information about the aquaculture type for the shellfish and macroalgae aquaculture sub-alternative within Alternative 3 is the same as described in Alternative 2.

b) <u>All Types of Commercial Aquaculture</u>

In Sub-alternative (3b), NMFS would identify at least one and up to two AOAs in the Santa Monica Bay in which finfish or Integrated Multi-Trophic Aquaculture (IMTA) facilities in addition to macroalgae and shellfish aquaculture could be sited. Information about the aquaculture type for the all types of commercial aquaculture sub-alternative within Alternative 3 is the same as described in Alternative 2.

iv. Alternative 4: Combination of Geographic Areas

In Alternative 4, NMFS would identify the up to 10 AOA(s) from within the boundaries of either Alternative area, up to a maximum area to be determined by NMFS with input from the public. The total 10 AOA options are shown in Figure 3.

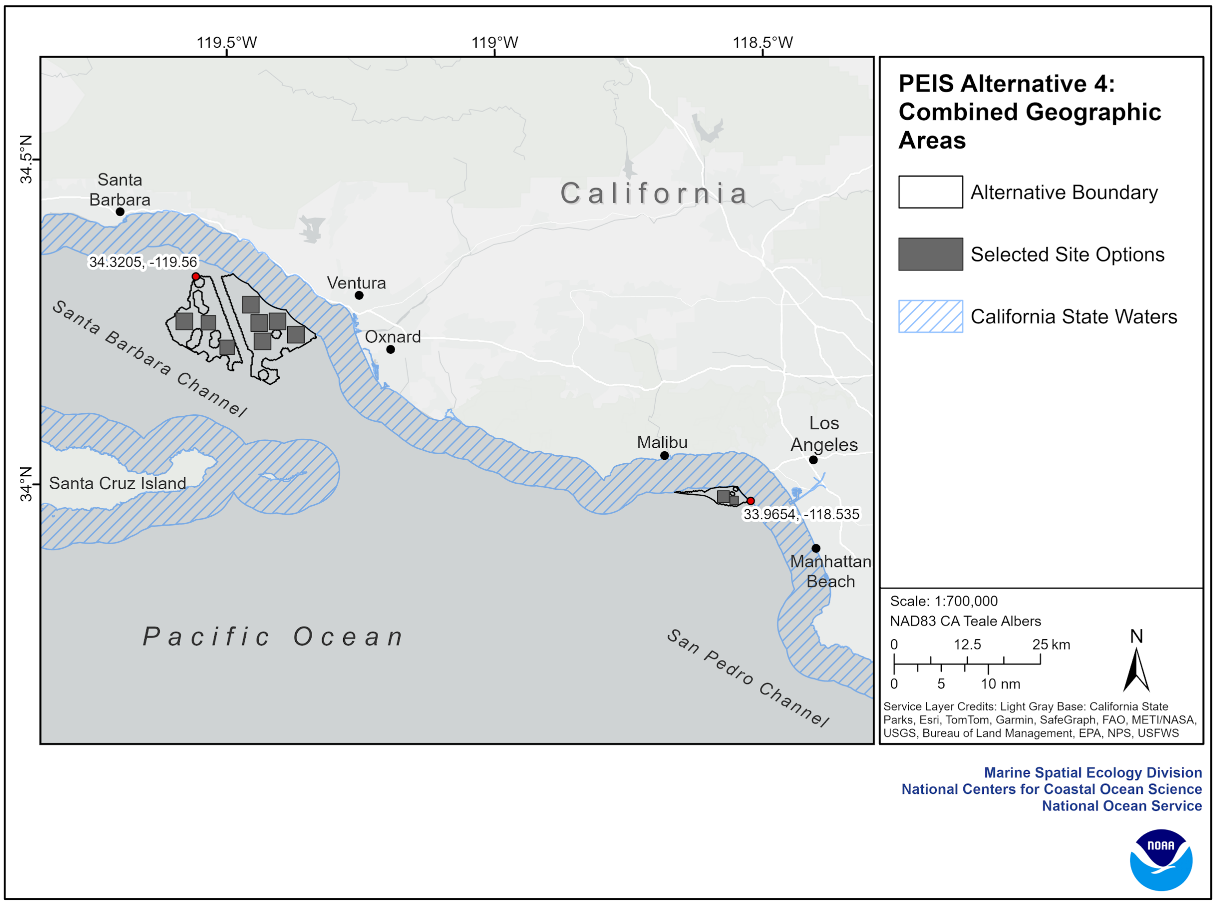


Figure 3: Map of Alternative 4: Combined Geographic Areas

The solid line boundary surrounding all AOA options is the total boundary of analysis for Alternative 4. The north-most coordinate of the Alternative in Santa Barbara Channel is about 100 km (54 nm) from the south-most coordinate of the Alternative in Santa Monica Bay. The nearest distance of marine space between the two areas is about 70 km (38 nm). The total marine space in Federal waters that was analyzed for the combined geographic spaces in Alternative 4 is the sum of Alternative 2 and Alternative 3, about 873 km² (337 mi²).

a) Shellfish and Macroalgae Aquaculture

In Sub-alternative (4a), NMFS would identify one or more AOAs in the Santa Barbara Channel and the Santa Monica Bay in which macroalgae and shellfish aquaculture facilities could be sited. Information about the aquaculture type for the shellfish and macroalgae aquaculture sub-alternative within Alternative 4 is the same as described in Alternative 2.

b) All Types of Commercial Aquaculture (Preferred Alternative)

In Sub-alternative (4b), NMFS would identify one or more AOAs in the Santa Barbara Channel and the Santa Monica Bay in which finfish or Integrated Multi-Trophic Aquaculture (IMTA) facilities in addition to macroalgae and shellfish aquaculture facilities could be sited. Information about the all types of commercial aquaculture sub-alternative within Alternative 4 is the same as described in Alternative 2. This alternative is identified as the preferred alternative. This alternative best meets thedirectives of E.O. 13921 and the Purpose and Need of this Draft PEIS.

B. Alternatives Considered but Not Further Analyzed

Federal waters of the SCB region were considered in the pre-scoping outreach by NCCOS and NMFS, in the NMFS Request for Information (85 FR 67519), and in the spatial analysis of the Atlas (Morris et al. 2021). Spatial modeling parameters are summarized in Table 2.1 of the Atlas (Morris et al. 2021); any areas outside those parameters in the SCB were not considered further. The Atlas analysis included four distinct areas: North, Central North, South, and Central South (see Figure 2.3 of Morris et al. 2021). The South and Central South areas were not further analyzed in the NEPA process because it was determined that there were numerous logistical and environmental constraints that may not make those areas suitable for aquaculture, or, may not be suitable to include in a programmatic NEPA approach (e.g. military activity, offshore marine shipping contingency anchorages).

There is also currently considerable interest in the possibility of using microalgae for producing sustainable biofuel and other industrial uses, and for carbon sequestration potential. Microalgae cultivation primarily occurs on land in contained vessels, tanks, or ponds (CDFW 2020a). Hughes et al. (2014) describes a microalgae research project that occurred in the marine environment in central California; but it occurred in nearshore waters, associated with coastal facilities by design. Because typical cultivation methods and locations are typically land-based or nearshore, microalgae aquaculture is not considered within the scope of this DPEIS.

NMFS considered work with the permitting, cooperating agencies (e.g. USACE and EPA) to develop programmatic permits or programmatic consultations.

Additional aquaculture-related topics that were determined out of scope for this DPEIS include:

- natural disasters and other “force majeure” events;
- broodstock sourcing;
- fish-feed sourcing, except considerations of pressure on forage fish;
- aquaculture that includes the co-use of existing offshore infrastructure;
- land-based transport of harvests;
- environmental planning for coastal auxiliary facilities and coastal development; and
- potential impacts to terrestrial resources and habitat as a result of any coastal development.

Chapter 3: Affected Environment and Environmental Consequences

Each section in this chapter first describes the sensitive resources, cultural resources, and trends in human activities for the SCB region. The distance between the north-most coordinates of Alternative 2 in the Santa Barbara Channel, and the south-most coordinates of Alternative 3 in Santa Monica Bay are only approximately eight nm apart. There is extensive connectivity between these areas for natural resources, cultural connections, and socioeconomic systems that create the baseline conditions for the analysis. As information was found available, the most specific context and geographic scope has been provided around or within each alternative area. Subsequently, each section in this chapter describes the relationship of resources and trends to the potential impacts that may occur as a result of aquaculture activities ranging from one to multiple facilities (e.g., a range of acreage with aquaculture facilities sited within the AOAs). Impacts are described in the alternative areas (Figures 1-3) and in the context of the two sub-alternatives that describe types of aquaculture (see Chapter 2, Section A). For the purposes of this DPEIS, "impacts" is synonymous with "effects." Possible mitigation that may be considered for project-specific NEPA analyses is included in Appendix 1.

This DPEIS will analyze potential impacts to the human environment that may occur from the identification of AOAs and potential impacts associated with future aquaculture operations should aquaculture projects be sited in one or more AOAs, if identified, in order to assist the long-term planning effort. The analysis may be used to inform processes for individual projects proposed later in time. Potential stressors associated with pre-construction, construction, operations and maintenance, and decommissioning of aquaculture activities are included. Impacts reflected in the alternatives include potential modifications to the baseline conditions and trends that exist today, including unavoidable adverse effects as well as benefits.

A. Administrative Environment

i. Federal and State Regulatory Frameworks

Jurisdictional Waters

The Submerged Lands Act (SLA) (43 U.S.C. §§ 1301) grants coastal states title to natural resources located within their coastal submerged lands and navigable waters out to 3 nm from their coastlines. Federal waters extend from the seaward boundary of state waters (3 nm from shore) to the seaward boundary of the U.S. EEZ (200 nm from shore), as well as including the extended continental shelf (continental shelf beyond 200 nm). The U.S. EEZ was established by Presidential Proclamation No. 5030 (March 10, 1983).

Aquaculture Permits in Federal Waters

There are certain primary Federal permits required for aquaculture operations. The USACE has permit authority under Section 10 of the Rivers and Harbors Act (33 U.S.C. § 403) for structures affecting navigable waters. All structures located in, on, or over waters of the U.S. require a permit issued by the USACE under the authority of Section 10, which prohibits creation of structures that obstruct navigable waters of the U.S. without authorization. The permitting process (33 C.F.R. 322 and 325) is designed to assess the environmental effects of a structure and operations associated with the structure, including effects on navigable waters of the United States. NMFS may provide comments to USACE regarding impacts to marine resources of proposed activities and can recommend methods for avoiding such impacts.

Under the authority of the Clean Water Act (CWA), EPA may issue permits for aquaculture-associated activities that may create discharges into the surrounding waters. The EPA is authorized to permit the discharge of specific pollutants associated with an approved aquaculture project pursuant to Section 318 and Sections 402 and 403 of the CWA (33 U.S.C. §§ 1328, 1342, and 1343). The USACE's CWA section 404 authority does not extend into federal waters. The EPA also has NEPA review authority under Section 309 of the Clean Air Act (CAA) (42 U.S.C. 7609) with regards to air emissions. NMFS and USFWS have review and commenting responsibilities under the Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA) (described in Chapter 3, Section C.i.). The ESA requires consultations on federal actions that may affect listed species and critical habitat and the MMPA requires authorizations when actions are expected to result in the take of marine mammals (16 U.S.C. § 1531 et seq. and 16 U.S.C. § 1361 et seq.) If aquaculture activities adversely affect fish resources and Essential Fish Habitat (EFH) under MSA, NMFS and PFMCs have review authority and may provide conservation recommendations (described in Chapter 3, Section C.ii.). The USCG has authority over the marking and lighting of any structures for navigational safety, (described in Chapter 3, Section D.vi.). USCG has statutory responsibility in Federal waters under the Ports and Waterways Safety Act (PWSA) (33 USC § 1221) and aid to navigation (ATON) regulations (33 C.F.R. § 66; 14 U.S.C. § 542, 543, 544 and 43 U.S.C § 1333).

Chapter 5 further describes Compliance with other Laws, Policies, and Regulations. The federal Guide to Permitting Marine Aquaculture (NMFS 2022b) includes lists of federal permits (Table 1 in the guide), federal authorizations (Table 2A in the guide), and federal consultations (Table 3 in the guide) that apply to aquaculture operations.

State Involvement under Federal Statutes

The permitting and authorization requirements for aquaculture development within AOAs are the same as other projects in federal waters. The federal government and coastal states each have roles in the permitting process.

The Coastal Zone Management Act (CZMA) was enacted to preserve, protect, develop, and where possible, to restore or enhance, the resources of the U.S. coastal zone for present and succeeding generations 16 U.S.C. § 1452. Section 307 of the CZMA requires Federal actions which affect any land or water use or natural resource of the coastal zone to be conducted in a manner consistent to the maximum extent practicable with the enforceable policies of a state's approved coastal zone management program (CZMP) (16 U.S.C. § 1456, 15 CFR § 930). The review identifies activities with reasonably foreseeable direct and indirect effects on coastal use or resources.

NOAA's Office of Coastal Resource Management (OCM) administers compliance components of the CZMA, and manages the partnership between Federal and coastal state governments. NMFS WCR conferred with NOAA OCM on the AOA planning process for the purposes of this DPEIS. Because the AOA DPEIS is not an exercise of statutory responsibilities but instead a planning document that does not result in permitting or funding of any activities; and because the impact analysis in this DPEIS is at a programmatic, planning level, a Federal consistency review is not considered. Specific aquaculture projects sited in an AOA may be subject to a CZMA Federal consistency review during the permitting process, with specific project designs and goals to analyze.

The California Coastal Commission (CCC) is the designated coastal management agency responsible for reviewing actions that have potential to impact land, water, and resources in the coastal zone and implementing enforceable policies in the CZMP. The California Ocean Protection Act (COPA) encourages cooperative management with federal agencies, to protect and conserve representative coastal and ocean habitats and the ecological processes that support those habitats (26.5 California P.R.C. §35515). The California Department of Fish and Wildlife (CDFW), operating under the authority of the California Fish and Game Code (FGC), is the principal state management agency responsible for the protection and conservation of the state's fish and wildlife resources, including oversight of certain aspects of commercial aquaculture within State waters (CDFW 2020a). CDFW also provides biological data and expert consultation on fisheries to PFMC for sustainability determinations (PFMC 2013).

Permission and approvals to land, process, or store aquaculture products on shore and in working waterfronts may involve State agencies, described above in this DPEIS, and in Section 3.1 through 3.3 of the Draft EIR for a Coastal Marine Aquaculture Program (CDFW 2019). The information required for coordination may vary based on the location, vessels, and product. In addition, the National Shellfish Sanitation Program (NSSP) is a cooperative program between the Federal and state governments, where a state is the primary authority (pers. comm. FDA and NOAA 2021). Through the NSSP, the FDA evaluates state plans, and NOAA provides oversight on FDA evaluations (pers. comm. FDA and NOAA 2021).

The U.S. Coast Guard conducts and coordinates port, waterways, and coastal security operations in the maritime realm. The Los Angeles/Long Beach Harbor Safety Committee is responsible for planning and providing for the safe navigation and operation of all vessels operating within San Pedro Bay, Santa Monica Bay, the Los Angeles/Long Beach port complex (and the approaches thereto). The Committee also works to address potential pollution of harbors, channels and coastal waters. The Harbor Safety Plan (MESC 2023) provides best practices and implementation measures under local, State, or Federal laws within regulated navigation areas that include State and Federal waters (e.g. 25 nm are for vessel traffic; 40 nm for air quality compliance) (MESC 2023). When Federal authority or action is required to implement the Harbor Safety Plan, or the recommendations therein, the appropriate agency is petitioned as necessary (MESC 2023).

Section 402 National Pollutant Discharge Elimination System (NPDES) regulatory program, water quality standards are incorporated into permits issued to individual projects. In Federal waters, the EPA issues NPDES permits. The Clean Air Act requires EPA to establish requirements to control air pollution from outer continental shelf sources in order to attain and maintain Federal and State ambient air quality standards, for the sources located within 25 miles of the seaward boundary, the requirements are the same as applicable if the source were located in the corresponding onshore area. The authority to implement and enforce these requirements has been delegated to the State. 42 U.S.C. § 7627; 40 C.F.R. 55.

Section 106 of the National Historic Preservation Act (NHPA) requires review of any project funded, licensed, permitted, or assisted by the federal government for impact on historic properties. Federal agencies must allow the State Historic Preservation Officer (SHPO) to comment on a project along with other consulting parties including but not limited to Tribal Historic Preservation Officer (THPO), certified local governments, and members of the general public with an economic, social or cultural interest in the project (GSA 2023). Site-specific aquaculture projects may be required to initiate SHPO/THPO consultation.

ii. Aquaculture Management Guidance

Any offshore aquaculture operation is required to obtain necessary permits, and to fulfill additional consultation and review requirements from appropriate authorities. An aquaculture facility sited in an AOA would be required to do the same. The Federal permitting framework for aquaculture is complex, and efforts to develop a more comprehensive system through legislation is ongoing. The recent Federal publications listed below were developed as references for stakeholders to improve the efficiency, predictability, and timeliness, and reduce the costs of reviewing, approving, monitoring, and enforcing permits and other regulatory requirements for marine commercial aquaculture ventures. These documents describe regulatory, science and technology needs for aquaculture management, and provide information to assist individuals navigate the federal permitting process for marine aquaculture (applicable to finfish, shellfish, invertebrates, seaweed):

- FAO Fisheries National Aquaculture Legislation Overview (web page, available at www.fao.org/fishery/nalo/search/en);

- FAO's Aquaculture Planning: Policy formulation and implementation for sustainable development (Brugere et al. 2010);
- NOAA Fisheries Office of Aquaculture (OAQ) Permitting Guide (NMFS 2022b);
- National Centers for Coastal Ocean Science (NCCOS) Coastal Aquaculture Planning Portal (website, available at https://coastalscience.noaa.gov/science-areas/aquaculture/coastal-aquaculture-planning-portal-capp);
- NOAA Fisheries Aquaculture Strategic Plan 2023 – 2028 (NMFS 2022c);
- A National Strategic Plan for Federal Aquaculture Research (NSTC 2022a);
- A Strategic Plan to Enhance Regulatory Efficiency (NSTC 2022b); and
- Code of conduct for responsible aquaculture development in the U.S. exclusive economic zone (NMFS 2002).

In addition to Federal resources, state-level insight, regional expertise, and services are valuable to support the potential development and sustainability of U.S. marine aquaculture. California has existing experience with marine aquaculture in State waters, and may have important lessons learned that could assist in Federal waters. Beyond the AOA NEPA process, NMFS WCR is working currently in looking to align Federal aquaculture objectives with the developing State's Aquaculture Action Plan, and associated OPC aquaculture principles (see below). Much of the research and funding for State coordination is handled through NOAA's Sea Grant program, and with public-private-academic partnerships (CDFW 2022). This reciprocal science and services to support the expansion of aquaculture into Federal waters could help support sustainable goals for growth of the industry. Documents and web-based resources including data, educational materials, legal and policy discussions, news and other information for stakeholder awareness for the development of aquaculture management include:

- California Ocean Protection Council (OPC) Aquaculture Principles (OPC 2021);
- Permit Guide to Aquaculture in California (website, available at https://permits.aquaculturematters.ca.gov/Permit-Guide);
- Aquaculture Permit Counter – Improving Permitting Efficiency (website, available at https://permits.aquaculturematters.ca.gov/);
- Draft California State Aquaculture Action Plan (anticipated as Objective 4.2 of California Ocean Protection Council's (Cal-OPC) 2020 - 2025 Strategic Plan to Protect California's Coast and Ocean) (OPC 2020); and
- Draft Program EIR for Coastal Marine Aquaculture Program (CDFW 2019).

The License and Revenue Branch within CDFW issues licenses and permits for recreational and commercial fishing activities, aquaculture, and scientific collection in support of educational and research projects (CDFW 2024) in State waters (up to 3 nm from shore). All forms of aquatic plants, fish, and shellfish are subject to approval by CDFW and the Fish and Game Commission (CFGC) working together within California's Natural Resources Agency (PFMC 2013, CDFW 2024). FGC Sections 15000 through 15703 provide the regulatory framework for aquaculture operations in State waters. Additional efforts in California state legislature to plan for ocean-based aquaculture is summarized on p. 7 of the Introduction in the Atlas); on p. 14 of the workshop summary Offshore Aquaculture in the SCB (Aquarium of the Pacific 2015); and in Section 6.4 on pp. 128 through 130 of the NOAA Water Quality Characterization of the Channel Island National Marine Sanctuary and Surrounding Waters (CINMS 2010).

iii. Potential Impacts

<u>Alternative 1: No Action</u>

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions. There is a potential adverse impact due to potential inefficiencies in the permitting and environmental review processes for any future aquaculture activities. Adverse effects to permitting and environmental review processes for future aquaculture operations could occur through ad hoc siting analyses conducted by aquaculture operation proponents. While resources such as the Southern california Aquaculture Opportunity Atlas could be used to assist project proponents in siting decisions, with ad-hoc siting, there is potential for inconsistent site suitability analysis processes and lack of data access.

Alternatives 2 (Santa Barbara Channel), 3 (Santa Monica Bay), and 4 (Combination of Geographic Areas)

The effort to identify AOAs in federal waters of the SCB is an administrative planning effort intended to identify potentially suitable locations for offshore aquaculture development and assess the potential impacts associated with siting aquaculture in those areas. This work supports the long-term planning for marine aquaculture development in U.S. federal waters. It provides information to help inform the aquaculture industry when considering locations to site future operations, and assists regulatory authorities by providing information to support the permitting and environmental review processes for operations located within those locations. While the identification of AOAs does not change existing regulatory authorities or processes related to permitting offshore aquaculture, there may be a potential beneficial impact reflecting efficiencies in permitting and environmental review processes for future aquaculture through the information developed in this DPEIS.

The impacts to the administrative environment reflected in the Action Alternatives would be consistent across Alternatives 2 through 4, as offshore aquaculture operations would fall under the same (or very similar) permitting or environmental review processes across the federal waters off of Southern California. With all potential AOA Alternatives analyzed in this DPEIS, a similar level of information to support the permitting and environmental review processes would exist, except in instances where there are data and information gaps. Any additional considerations that could result in additional permits, authorizations or consultations are discussed in this DPEIS to the extent these considerations are known.

B. Physical Environment and Potential Impacts

i. Oceanography and Climate

Affected Environment

The SCB is within the southern portion of the California Coastal Ecosystem (CCE) (Schiff et al. 2000, NCCOS 2005, Huff et al. 2013, and Kramer et al. 2015). The SCB has relatively calm seas, low storm frequency, and a temperate climate (Morris et al. 2021). As the coastline cuts southeast in the SCB, it changes how upwelling and ocean currents influence the area in contrast to the rest of the CCE. The Davidson Current, also known as the Southern California Countercurrent (SCC), flows north into the SCB carrying warmer, less productive waters (Kramer et al. 2015) and creating an exchange of nearshore and offshore waters (Schiff et al. 2000, NCCOS 2005, and CDFW 2022). A more detailed description of ocean currents and upwelling in the SCB is provided on pp. 19 through 21 of the NCCOS Biogeographical Assessment of the Channel Islands National Marine Sanctuary (NCCOS 2005). Nishimoto et al. (2019) further provides details about current and eddy systems in the SCB. Figure 4 shows all of the major ocean currents that influence the SCB and the west coast EEZ.

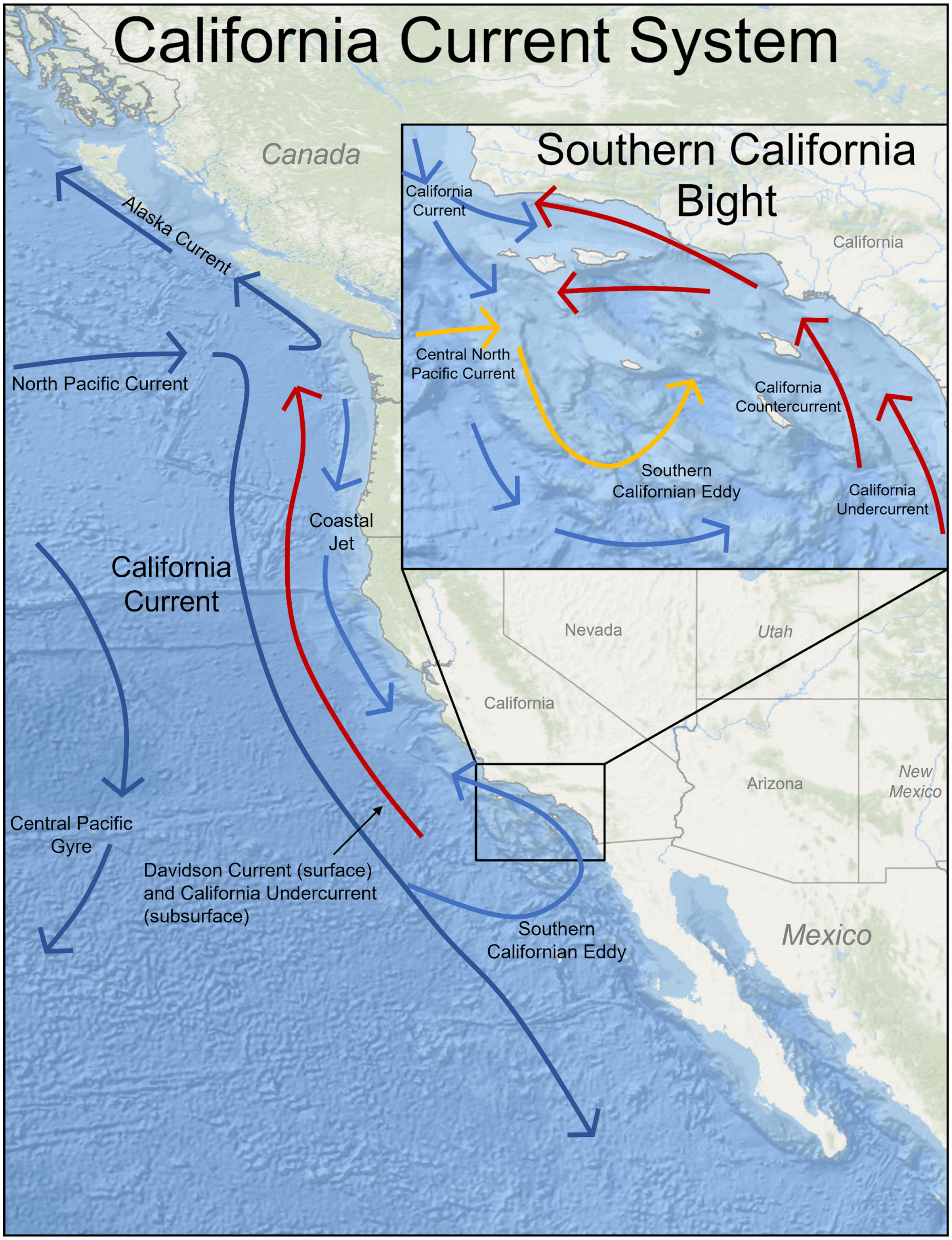


Figure 4: The California Current System and the Southern California Bight

The waters of the SCB are generally warmer and less nutrient-rich compared to other portions of the CCE influenced by deep ocean water (CDFG 2001a, CDFW 2022). Ocean surface temperatures range from 11 to 23°C (51.8 to 73.9°F) (Schiff et al. 2000, CDFW 2010, and Morris et al. 2021). In general, temperatures in Alternative 2 are slightly lower than Alternative 3. Alternative 3 is further south than Alternative 2, and more influenced by subtropical waters (Morris et al. 2021).

Bathymetric and depth features of the SCB can be found in Morris et al. 2021. The SCB has complex bathymetry that includes 11 deep-water basins, three major banks and seamounts, and 13 major submarine canyons (see Chapter 3, Section B.iii. Seafloor Characteristics), including the Santa Barbara Basin and Santa Barbara Channel (Alternative 2) and Santa Monica-San Pedro Basin (Alternative 3). Waters 0 to 50 m (164 ft) are considered surface waters; waters greater than 50m (164ft) deep are considered subsurface (Harvey et al. 2023).

All areas of analysis in the DPEIS are less than 150 m (492 ft) deep by design (Morris et al. 2021). Alternative 2 includes both surface and subsurface waters except in AOA options N2-D and N2-E, on the easternmost side of Alternative 2, where measured depths are all less than 50 m (Morris et al. 2021). The measured depths in Alternative 3 are all greater than 50m (164 ft) (Morris et al. 2021). Surface salinity in all areas analyzed is consistent throughout the year at an average of 33.6 psu (Morris et al. 2021).

Low oxygen, or hypoxic, conditions may occur over the continental shelf following spring upwelling, and continue into the summer and early fall months (Harvey et al. 2023, Chan et al. 2008). Data from 1993 through 2023 show lower spring and summertime dissolved oxygen in surface waters, close to a hypoxic threshold, while subsurface waters 50 to 150 m (164 to 492 ft) usually stay at least two times higher than the hypoxic threshold except for in localized areas (Harvey et al. 2023).

Surface waters of the SCB form a counterclockwise eddy due to surface winds and the mixing of warm surface waters from the Southern California Countercurrent with colder waters of the California Current (Schiff et al. 2000, NCCOS 2005, and Whitmire and Clarke 2007). Localized currents form smaller eddies and island wakes (Mitarai et al. 2009, Morris et al. 2021, and CDFW 2022). Ocean currents affect invertebrate density, larval distribution mechanisms, organic matter and other nutrient and sediment flows (Schiff et al. 2000, Huff et al. 2013). Surface flows are complex and produced by forces acting over broad time and spatial scales and shifting seasonally.

Winds in the SCB are generally weaker compared to the rest of the California coast. During fall and winter months, the Santa Ana winds blow northeasterly from inland desert basins and out to sea with unusually high speeds and gusts that can exceed 96 km/h (26 m/s) (NCCOS 2005). Data analyzed from 2016-2020 show the prevailing wind direction in Alternative 2 is from the west, with slightly stronger winds on the western side of Alternative 2 (in the N-1 AOA options) than on the eastern side of Alternative 2 (in the N-2 AOA options)). In Alternative 3, the prevailing wind direction is from the west-southwest, with lower velocities compared to Alternative 2 (Morris et al. (2021)).

Fine-scale mixing and circulation patterns in the Santa Barbara Basin have been studied extensively, showing a persistent counterclockwise gyre (Vetter et al. 2003). Winds in the Santa Barbara Channel (Alternative 2) are predominantly from the northwest, and the predominant currents are southbound, which influences the movement of debris in a south or southeast direction (Spykra 2017, Morris et al. 2021, Steele and Miller 2022). The Santa Barbara Channel is a transition zone where cold waters north of Point Conception mix with the warmer waters of southern California, creating a biodiverse mixture of northern and southern marine life (CDFW 2016a). In addition, upwellings frequently occur off Point Conception, typically from March through September. These upwellings provide nutrient-rich waters that extend eastward through the channel. Gyre circulation patterns exist year-round with seasonal variations in intensity – strongest in summer, weakest in winter (Hendershott and Winant 1996, Lagerloef and Bernstein 1988). These processes may be observed in the variations in surface currents within the alternative areas, as modeled in Morris et al. (2021). On the western side of Alternative 2 (in the N-1 AOA options), the prevailing surface currents flow west-northwest, while on the eastern side of Alternative 2 (in the N-2 AOA options), the prevailing surface currents flow southeast. Mean current velocities are estimated to be generally the same throughout Alternative 2, but the maximum current velocities are slightly greater on the eastern side, closer to shore. Current magnitude and direction at varying depths in Alternative 2 are shown in Figures 3.50, 3.51, 3.52, on pp. 118 through 120 and in Figures 3.68, 3.69, 3.70 on pp. 145 through 147 of the Results section of of the Atlas (Morris et al. 2021).

In contrast to waters further north, Alternative 3 is in closer proximity to subtropical waters, which adds to its biodiversity and productivity. Given the coastal geography and wind patterns, upwelling is more limited in the region; however, several submarine canyons provide nutrient-rich waters enhancing local production (CDFW 2016a). The surface currents in Alternative 3 flow generally southeast, with lower mean and maximum velocities compared to Alternative 2 (Morris et al. 2021). Current magnitude and direction at varying depths in Alternative 3 are shown in Figures 3.88, 3.89, 3.90 on pp. 177 through 179 of the Results section of the Atlas (Morris et al. 2021).

Wave heights are affected by complex processes within the SCB (Guza and O'Reilly 2001, NCCOS 2005). The curve in the coastline shelters the SCB from prevailing swell, resulting in lower wave heights and energy compared to the rest of the west coast (Dailey et al. 1993, Hickey and Banas 2003, and CDFW 2022). The prevailing swell direction in both Alternatives is from the west or southwest. As water moves from west to east and closer to shore, the modeled mean significant height decreases, while period increases. There is a difference again between the western and eastern sides of Alternative 2, and the trend continues comparing Alternative 3 to Alternative 2. In general, wave heights vary from 0.6 to 1m (2.0 to 3.3ft) within Alternative 2, and from 0.5 to 0.68 m (1.6 to 2.2 ft) within Alternative 3. Seasonal trends in wave height and swell period in Alternative 2 are shown in Figure 3.54 on p. 122 and Figure 3.72 on p. 149 of the Results section of Morris et al. (2021). Seasonal trends in wave height and swell period in Alternative 3 are shown in Figure 3.92 on p. 181 of the Results section of Morris et al. (2021).

Stressors

Potential impacts of climate change on overall oceanography and climate of the SCB are discussed in Chapter 4, Section A.i. The naturally-occurring variability of the SCB ecosystem is an existing stressor to baseline conditions on annual and decadal scales and on marine life, discussed in Chapter 3, Section C (Biological Resources). Variation in climate and oceanographic conditions across the SCB act as a stressor on financial costs, structural requirements, and the viability of cultured species and should be considered at the project level, particularly with respect to engineering evaluations and operations plans. Variation in climate and oceanographic conditions further influences potential impacts to water quality, sediments, disease potential and biosecurity (Rhodes et al. 2023a).

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- changes in hydrodynamic processes.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Marine aquaculture facilities, like any fixed structure in the water column, can disrupt localized hydrology, potentially impacting circulation patterns, flow, current speeds, upwelling, eddy effects, and sedimentation and/or erosion rate. Research is ongoing to understand how offshore wind structures affect hydrodynamic processes and cascading biological impacts (Chen et al. 2016, Johnston et al. 2022; and van Berkel et al. 2020), particularly with respect to larval transport of commercially important species. Oil and gas platforms can affect hydrodynamic processes and larval connectivity, with some positive effects noted (McLean et al. 2022). It is noted that the literature may not be directly transferable to the impacts of offshore aquaculture given that aquaculture facilities differ in both above and below surface structures.

We consider the general impacts of aquaculture gear to hydrological conditions. Project level NEPA would need to consider site location relative to other aquaculture facilities and offshore infrastructure to further assess potential impacts to hydrodynamic processes.

Local changes to current velocities were observed around mussel facilities between 3 and 10 km (1.6 and 5.4 nm) offshore in depths between 20 and 30 m (66 and 98 ft) (Mascorda-Cabre et al. 2024). Mascorda Cabre et al. (2021) provides an overview of potential impacts of offshore mussel aquaculture on water flow, wake formation, wave attenuation, and water column processes (e.g., vertical mixing), which can ultimately impact the carrying capacity in and around aquaculture facility sites. Frieder et al. (2022) developed the Macroalgal Cultivation Modeling System (MACMODS) to explore within-facility modifications to light, seawater flow, and nutrients, finding that regional ocean conditions influence overall yield, longlines affect flow, circulation and turbulence, and effects extend beyond the aquaculture facility. MACMODS could be used in facility design and project level analysis.

Individual aquaculture facility characteristics as well as local conditions need to be considered to assess impacts. Hulolt et al. (2020) suggests that effects vary with structure type and water permeability as well as spatial organization. Impacts to carrying capacity are influenced by facility dimensions, extent, and shape and layout, including orientation to prevailing currents and waves and culture density. Bathymetry and structural features of the facility (e.g., density of lines and canopy, proportion of water depth occupied, proximity to other aquaculture facilities or structure) can interact with and influence potential impacts (Mascorda Cabre et al. 2021). Small facilities in high energy offshore environments are likely to have a smaller impact compared to natural variability and overall system dynamics. Larger developments may have more of an impact on flow and energy dissipation and local hydrodynamics. Larger structures can act as physical obstacles to water flow, affecting current velocities and the velocity profile of the water column, which could result in an increase in seabed scour and biodeposit resuspension, drag and formation of a wake, or water column stratification and nutrient and carrying capacity impacts. Mascorda-Cabre et al. (2024) suggests that aquaculture siting and positioning should consider current direction to minimize drag effect.

Siting aquaculture in the offshore environment at a relatively low density can lessen impacts to hydrodynamic processes as compared to siting aquaculture in nearshore coastal environments. Offshore environments can have relatively few fixed structures and larger oceanographic processes on temporal and spatial scales are unlikely to be impacted by fixed structures.

Siting aquaculture in AOA options could limit impacts to oceanographic conditions because the areas have relatively few fixed structures, by design. With site-specific planning, monitoring and gradual expansion, it is expected that siting aquaculture facilities in AOAs may not impact larger oceanographic processes. Modeling approaches used for other industries (e.g., wind) could be incorporated into analyses of individual projects and include forecasting impacts on other stressors such as hypoxia, ocean acidification, marine heat wave events, and ocean warming. Potential impacts may be examined for individual aquaculture facilities as well as those sited within close proximity within the specific environmental context.

Siting aquaculture in higher energy offshore environments could result in higher rates of infrastructure loss or damage (Fujita et al. 2023). Aquaculture facilities may need to be engineered to withstand the associated operating environments. Engineering design standards take into account typical as well as extreme conditions (Stevens et al. 2008; Fredriksson et al. 2020). See also Chapter 3, Section D.vii. (Public Health and Safety). Practices need to be compatible with changing ocean conditions, with species selected for culture resilient to storms and environmental shifts accompanying El Niño and La Niña conditions (e.g., Buck et al. 2018 for IMTA) or aquaculture practices including gear removal at certain times. Operational windows may be needed to accommodate weather conditions. New, innovative designs that are currently being tested could allow systems to adjust to changes in circulation and nutrient flows.

Alternative 1: No Action

Under the no action alternative, no AOAs would be identified, and there may be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The mean depth for all eight AOA options in Alternative 2 range from 25 to 95 m (82 to 312 ft) deep. The shallowest depths in Alternative 2 are in the N2 cluster, AOA option N2-E (25.4 m [83.3 ft]), N2-D (31.5 m [103.3 ft]), and N2-C (48.1 m [157.8 ft]). Predominant currents are from the east-southeast with mean velocities ranging from 0.3 m/sec to upwards of 1.3 m/sec. The area consists of a mild wave climate with wave heights averaging 0.6 to 1 m [2.0 to 3.3 ft] with 7 to 10 second wave periods predominantly from the west or west-southwest (Morris et al. 2021).

The Alternative 2 area has a higher concentration of fixed structures already present in the region compared to Alternative 3, (Kramer et al. 2015, Nishimoto et al. 2019, USACE 2021, and Morris et al. 2021), which contribute to baseline hydrodynamic conditions. This includes offshore oil platforms and associated platforms and the Santa Barbara mariculture facility. Sites N2-A, N2-B and N2-D are farthest from oil and gas platforms. A number of boreholes can be found near all of the sites in this alternative. These factors influence the baseline hydrodynamics of the area. Alternative 2 includes more AOA options than Alternative 3 and may have relatively more impacts if all 8 AOA options have aquaculture facilities developed in them.

a) Shellfish and Macroalgae

Macroalgae cultivation can reduce current speeds, deflect wave energy and alter sedimentation patterns (USACE 2021). MACMODS (Frieder et al. 2022) was developed to model kelp aquaculture within the Santa Barbara Channel and could be used to model specific impacts. Shellfish aquaculture can also impact flow.

b) All Types of Commercial Aquaculture

Without specific information about the individual aquaculture facility, it is not possible to conclude the relative impact reflected in this alternative on hydrodynamic processes. Impacts are likely to be similar to those summarized above under potential impacts. Finfish aquaculture has been shown to create a drag effect (Jiang et al. 2022). Hydrodynamic impacts for siting all types of commercial impacts are expected to be more than those for macroalgae and shellfish as finfish aquaculture has been shown to create drag effect.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The mean depth for the AOA options in Alternative 3 range from 66.6 m (218.5 ft) to 98.9 m (324.5 ft) deep. The shallowest depths in Alternative 3 are in 55.4m (181.8 ft). Current speed and direction vary by month and depth with a southeasterly direction on the surface. Average current velocity at the surface was 0.11 m/s, with a minimum of 0 m/s and maximum of 0.48 m/s, respectively. Current speed decreased with depth, with average current speeds of 0.07 m/s at 10 m depth and 0.05 m/s at 40 m (131 ft) depth. The current speed did not exceed 1 m/s over the 5-year period. Wind velocity at the site averaged 4.5 m/s, with a minimum of 0 m/s and a maximum of 16.8 m/s, predominantly from the west-southwest (see Figure 3.91 of the Atlas (Morris et al. 2021)). The average significant wave height from 1979 to 2010 was 0.91 m (3.0 ft) with a period of 13.8 seconds, with waves predominantly from the west (Morris et al. 2021).

Overall, AOA options reflected in Alternative 3 have deeper maximum depths and fewer fixed structures nearby potentially affecting the baseline condition as compared to Alternative 2. The two AOA options are two of the smaller options, with the largest being 1,000 acres (405 ha). Impacts to hydrodynamic processes may be lessened due to the smaller size and deeper depths depending upon specific aquaculture facility characteristics (e.g., depth of facility in relation to the water column). Current speeds are also slower, so any impacts from the facilities could be more pronounced.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from shellfish and macroalgae reflected under Alternative 2a is the same as reflected under Alternative 3a. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

b) All Types of Commercial Aquaculture

The impacts under Alternative 3 may be the same as Alternative 2b, except they would take place in the Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3b. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

Alternative 4: Combination of Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Impacts to hydrodynamic processes may depend upon aquaculture facility scale and proximity to other facilities and fixed structures. Several facilities spread across a large area could result in less impact than concentrated aquaculture in a localized area. Siting aquaculture in more shallow areas could result in more of an impact compared to deeper depths, but this is highly dependent upon the number and density of other structures in the area. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

ii. Marine Managed Areas and Special Resource Areas

Affected Environment

Managed Marine areas and Special Resource Areas, for the purposes of this DPEIS, are considered to include areas identified within those boundaries of a National Marine Sanctuary (NMS) defined under the National Marine Sanctuaries Act (NMSA) (1972), Marine National Monument under the Antiquities Act, National Estuarine Research Reserve under the Coastal Zone Management Act or Coastal and Estuarine Land Conservation Program (CELCP), NMFS gear restricted areas, National Parks and National Wildlife Refuge under the Administration Act and National Wildlife Refuge System Improvement Act, as well as state or local level protected areas. Some of these areas can be considered Marine Protected Areas (MPAs). A de facto MPA is a broad term for a park or other protected area that includes marine areas where access or activities for reasons other than conservation or natural resource management are restricted (National Marine Protected Areas Center 2008). They do not include areas managed for sustainable production. E.O.13158 (2000) called for the US to develop and support a national system of MPAs. Each type of protected area has a unique regulatory structure that may prohibit activities associated with aquaculture or regulate for the potential impacts. Cetacean Biologically Important Areas, which are not regulatory, are discussed in Chapter 3, Section C.i (Federally-Protected Species and Habitat).

Natural and cultural resources considerations were included in the relative suitability analysis for the atlas (Morris et al.2021). NMS and MPAs relative to the Alternative areas are shown in Figure 3.3 on p. 57 of the Results Section of Morris et al. (2021). Tables 3.7 (p. 112), Table 3.11 (p. 158), and Table 3.17 (p. 170) provide information about protected areas within 5km (2.7 nm) of each AOA option (Morris et al. 2021). Some Alternative 1 AOA options overlap with Important Bird Areas (N1 and N2) and with Critical Habitat for Humpback Whales (N2). Figure 5 provides an additional map that illustrates the alternative areas with respect to managed marine and special resource areas occurring within each basin.

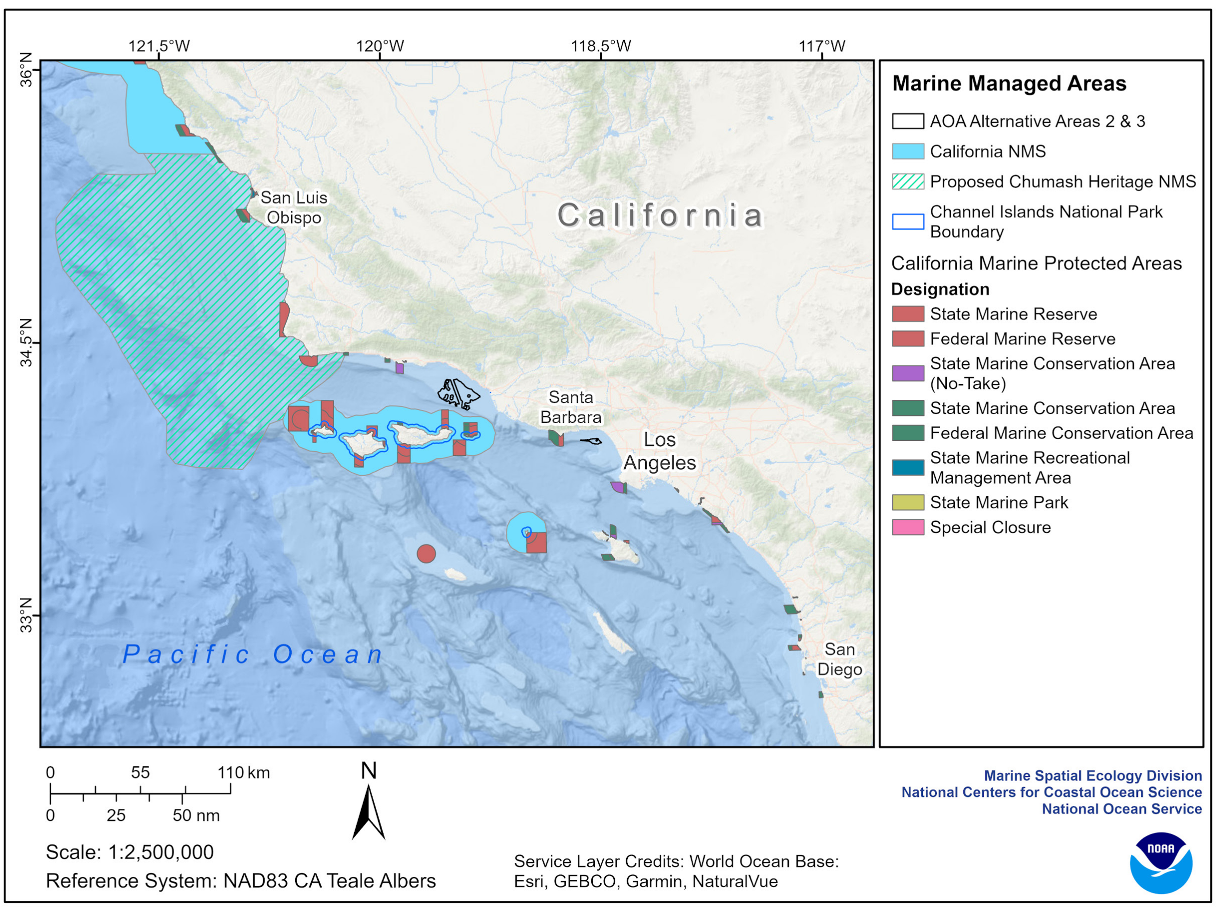


Figure 5: Marine Managed Areas in Proximity to Alternative Areas

While our action of identifying AOAs may not impact these areas, areas outside the boundaries of the AOAs considered here could be impacted if an aquaculture facility is sited within an AOA in the future. Proximity, currents, facility type, and boat traffic patterns need to be considered. None of the areas listed below overlap with any AOA options, but may still be impacted indirectly by an aquaculture facility, if one is sited within an AOA.

- The California Coastal National Monument is located along the entire coastline of California and ensures the protection of all islets, reefs and rock outcroppings along the coast of California within 22 km (12 nm) of shore.
- The 2001 Cowcod Conservation Areas (CCAs) have been repealed in federal regulations as of January 1, 2024.
- The Channel Islands NMS protects 1,470 mi^2 of ocean waters around the Northern Channel Islands: Anacapa, Santa Cruz, Santa Rosa, San Miguel, and Santa Barbara Islands (https://channelislands.noaa.gov/). This NMS provides protection for endangered species, sensitive habitat, historic shipwrecks, and cultural resources. This Sanctuary is closest to Alternative 2. The submerged lands and waters within 1 nm of each island are also part of the designated Channel Islands National Park.
- The proposed Chumash Heritage National Marine Sanctuary (CHNMS) sanctuary area comprises the coastline and waters offshore San Luis Obispo and northern Santa Barbara counties and includes the Santa Lucia Bank, its escarpment, Rodriguez Seamount, Arguello Canyon, and other offshore features and resources to approximately 78 miles offshore (NOAA ONMS 2023). The area is north of Alternative 2.
- California MPAs, designated under the California Marine Life Protection Act (CMLPA), as amended, (Fish and Game Code Sections 2850-2863) (incorporate by reference from online resources) and Marine Life Management Act (MLMA), make a network of protection along the entire California coast in state waters (CDFW 2022). Several State Marine Conservation Areas (SMCA) and State Marine Reserves (SMR) (no-take) occur near both Alternatives (https://wildlife.ca.gov/Conservation/Marine/MPAs/Network). Alternate 2 locations have no-take SMCA to northwest and both SMCA and SMR to southwest on the Channel Islands that protect rocky shorelines, eelgrass beds, and kelp forests. Alternative 3 locations have coastal SMCA and SMR to northwest and SMCA's to the southeast. A SMR offshore from Alternative 3 supports the resources noted above plus garibaldi, rockfish, spiny lobster, and other species.
- The Santa Barbara Channel Ecological Preserve and buffer is reserved for scientific, recreational, and other similar uses pursuant to Public Land Order 4587 (34 FR 5655). The area is exempt from exploratory drilling and operations for oil, gas, and minerals (BOEM 1971). Commercial and recreational fishing and other related activities are allowed (34 FR 5655). The preserve occurs near Alternative 2 between three to five miles from shore (BLM 1979). The preserve was incorporated into the Atlas as part of the site characterization for natural and cultural resources, but was not considered incompatible with aquaculture (Morris et al. 2021).
- The nearshore area between Ventura County line and Latigo Point is an Area of Special Biological Significance (ASBS), designated by the State Water Resources Control Board (SWRCB), and known as a State Water Quality Protection Area (SWQPA) (LARWQCB 2011). The same area and the nearshore area between Palos Verdes Point and Flat Rock Point is also designated a significant ecological area by the County of Los Angeles. This area is closest to Alternative 3.

See Chapter 3, Section B.iv. for Water Quality discussions and modeling. See Chapter 3, Sections C.i. and C.ii. for Critical Habitat, Essential Fish Habitat (EFH), and USFWS Wildlife Refuges discussions. See Chapter 3, Sections Sections E.i. and E.iii. for Tribal and Archeological discussions.

Stressors

None of the areas within Alternative 2 or 3 are within a marine managed area. Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- changes in water quality;
- changes in hydrodynamic processes; and
- increased vessel traffic in and out of coastal areas.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact. Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. Water quality impacts could occur within marine managed areas due to siting and operation of aquaculture within an AOA. Increases in turbidity from placement and decommissioning may depend on prevailing currents and winds. Water quality impacts are considered in Chapter 3, Section B.iv. (Water Quality). Given baseline conditions of considerable vessel activity in the region and vessel traffic patterns, no meaningful change from baseline conditions is expected with respect to vessel traffic in or within close proximity to marine managed areas due to placement, operation, or decommissioning (see Chapter 3, Section D.vi. (Transportation and Navigation)). For impacts to biological resources that are supported by marine managed areas (e.g., as population sources or refugia) see Chapter 3, Section C.

Impacts to marine resources connectivity are considered below. As indicated above, marine managed areas around Alternative 2 and 3 have been identified for mobile resources. The CA MPA Network was designed to ecologically connect populations and habitats and promote ecosystem integrity and resilience to environmental change. The network can also provide for transport of non-living material among locations and seascape connectivity linking habitats of differing types, useful for species that use diverse habitats across their life history. Many marine managed areas act as sinks or sources for marine processes. Work is ongoing to model levels and patterns of connectivity across the CA MPA network using Regional Ocean Models (ROMs) (CDFW 2022). Such models could consider impacts on connectivity from the placement and operation of aquaculture structures

Active (migratory) connectivity is the purposeful, self-directed movement of organisms from place to place. Installation and operation of offshore aquaculture facilities could result in placement of structures and vessel traffic within important migratory corridors or in the vicinity of nursery sites, which could disrupt normal movement, breeding, and foraging behavior of marine organisms. Impacts to actively migrating animals are considered in Chapter 3, Section C. Passive (oceanographic) connectivity is the movement of organisms, nutrients, and materials through physical processes like currents, sinking, or upwelling, such as the transport of larvae via ocean currents and is considered below.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there may be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

If aquaculture sited in Alternative 2 disrupts hydrodynamic processes, passive connectivity between and among marine managed areas could be impacted. Facilities could have benefits if they provide habitat by acting as a larval source Alternative 2 includes more AOA options than Alternative 3 and may have relatively more impacts if all 8 AOA options have aquaculture facilities sited in them.

a) Shellfish and Macroalgae

If sited, shellfish and macroalgae facilities could change marine connectivity among marine managed areas if they impact hydrodynamic processes. The areas could alter patterns of connectivity while also serving as sinks for passively dispersing resources, effectively blocking flow of resources, or acting as sources if the facility serves a habitat function. There would be no impacts in identifying AOAs.

b) All Types of Commercial Aquaculture

Effects could be similar to those above with the added potential effect of effluent discharge into marine managed areas. The geographic extent of water quality impacts from operation of a finfish facility, and the potential to impact marine managed areas would be quantified through water quality and depositional modeling. There would be no impacts in identifying AOAs.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Siting aquaculture in Alternative 3 could have relatively similar impacts to Alternative 2, although this area is farther from marine managed areas and could therefore have fewer impacts depending upon prevailing currents and winds.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from shellfish and macroalgae reflected under Alternative 2a is the same as reflected under Alternative 3a. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3b. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

Alternative 4: Combination of Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified. If multiple AOAs were identified, then more aquaculture may develop in the identified areas. There is a greater potential for impacts with more facilities sited but modeling is needed to understand the impacts.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as those described under Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4b.

iii. Seafloor Characteristics

Affected Environment

The USACE, under section 10 of the Rivers and Harbors Act of 1899 [RHA (33 U.S.C. §403)], including the extension of the RHA to the limits of the outer continental shelf by the Outer Continental Shelf Lands Act {OCSLA [43 U.S.C. §1333(a)(1)]} [1] is responsible for regulating structures affecting navigable waters. Section 10 authority prohibits the unauthorized obstruction or alteration of any navigable water of the U.S. The construction of any structure in or over any navigable water of the U.S., excavating from or depositing of material in such waters, or the accomplishment of any other work affecting the course, location, condition, or capacity of such waters is unlawful unless the work has been authorized by USACE through a permit (33 CFR 320.2(b)).

The California coast represents a tectonically active area with a continental shelf that is only a few miles wide and coast that drops quickly into deep water. The SCB as a geologic region is called the Continental Borderland, which is characterized by the large-scale interactions of the North American Plate and the Pacific Plate within the San Andreas Fault System (Dailey et al. 1993, NCCOS 2005). Bathymetric features of southern California include the continental shelf, steep and eroded continental slope, continental rise, and deep-sea floor (Whitmire and Clarke 2007, Heintz et al. 2008, Kramer et al. 2015, Morris et al. 2021). High ridges between the basins can influence circulation and upwelling patterns (Hickey 2000, NCCOS 2005).

Geological activity in the SCB, particularly in the Santa Barbara Channel, has influenced the design and construction of oil and gas facilities as well as wind in other areas of CA (Tajalli Bakhsh et al. 2023). Offshore oil wells have been damaged by subsurface faulting during earthquakes. Natural oil seeps in the Santa Barbara Channel are estimated to discharge approximately 150-170 barrels (6,300-7,140 gallons) of oil per day.

The Santa Barbara Basin is bounded by the California coast, Channel Islands, and narrow sills to the west. A detailed map of the Basin can be found in Eichhubl et al. (2002). The maximum depth is 550m (1,804 ft) (Bograd et al. 2002). The Santa Monica Basin is open to the San Diego Trough to the southeast, the Santa Barbara Channel to the northwest, and the Santa Cruz basin to the west. It is bounded by the Palos Verdes Peninsula to the South, and Point Dume to the North. Tabau et al. (2015) detail the bathymetry of the region from shallow nearshore to depths of 1,000 m (3,281 ft) in the basin. Seafloor characteristics include submarine canyons such as Dume, Santa Monica and Redondo canyons (Tabau et al. 2015, Morris et. al 2021). Submarine canyons impact local and regional circulation (CDFW 2016a, CDFW 2022).

Seafloor substrates are important when siting aquaculture and modeling potential water quality and depositional impacts. Morris et al. (2021) included data layers for known deep sea corals, hard bottom and rocky reefs to constrain the model with respect to these resources. The Atlas considers setbacks from certain habitats or management areas (rocky reef EFH HAPCs with a 152 m (500 ft) setback, deep sea coral and sponge observations with a 500 m (1,640 ft) setback, hard bottom habitat with a 152 m setback, (Morris et al. 2021). A more detailed and site-specific Baseline Environmental Survey (BES) may be needed for siting and permitting individual projects, providing archaeological, hydrographic, and geophysical descriptions and high-resolution maps of the seafloor, cultural resources, and surrounding

[1] The Outer Continental Shelf Lands Act (OCSLA) established Federal jurisdiction over submerged lands on the OCS seaward and outside of those under State jurisdiction pursuant to the SLA (described in Section A.ii. (Federal and State Regulatory Frameworks) (43 U.S.C. § 1331(a) and (e)).

sensitive habitats for consideration in NEPA and project-specific planning. The BES informs environmental models, siting, and project design (e.g., anchoring and mooring systems).

Sediments of the SCB consist of sand and mud (McDermott et al. 1974, Dailey et al. 1993, and Schiff et al. 2000). Sediments with high percentages of sand generally dominate the shelf, whereas sediments with high percentages of silt generally dominate the slope and basins. Rocky bottom is more common along the shelf of the onshore islands and banks where the supply of sand and silt is minimal. The Santa Monica Bay bottom habitat includes sandy soft sediments inshore and silts along slopes and canyons. Sediment resuspension can be caused by natural and anthropogenic forces.

See Chapter 3, Section C.ii. (Wild Fish Stocks) for more information on EFH, and Chapter 3, Section C.iii. (Ecologically-Important Marine Communities) for more information on benthic communities.

Stressors

Existing stressors include baseline seismic activity, anoxic sediments (Hickey 2000, Yousavich et al. 2024), sediment contamination with PCBs, DDT and PAHs, copper, zinc, and chlordane (Mearns et al. 1991, Fairey et al. 1998, Schiff et al. 2000, and Morris et al. 2021), oil and gas infrastructure and activity, shipping and port activity, and coastal population pressures. Sediment toxicity across the SCB is low, with 98% considered unimpacted, and chemical exposure categories generally greater in embayments than offshore (SCB 2018 Regional Monitoring Program Sediment Quality Assessment Planning Committee 2022, Du et al. 2020).

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- benthic impacts due to anchors, deposition, site surveys, and monitoring; and
- changes in hydrodynamic processes that could result in changes in erosion or siltation.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact. Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. Impacts to seafloor characteristics may be influenced by factors including type of aquaculture, mooring system, and sediment type. The seafloor footprint of a facility may be larger than the surface area covered by cages or longlines.

Setbacks from sensitive seafloor habitats are used in siting aquaculture projects and were used during the Atlas spatial modeling process (Morris et al. 2021). These setbacks allow distance between the aquaculture operation and the habitat, minimizing potential impacts from anchoring, sediment deposition, or water quality changes. Analyses in the Atlas used a 10 acre grid size, however direct seafloor impacts from anchoring to sensitive habitats are not expected to occur because more detailed site surveys could be conducted before siting projects and placing anchors. Modeling may be conducted to examine depositional impacts beyond the facility site footprint.

Seafloor damage (i.e., breaking, scraping or crushing) associated with installation of anchors or permanent moorings, or the swing of a mooring line during operations could occur. The extent of the impact may depend on the number of moorings and the specific type of substrate. For instance, a single-point mooring swings in a radius around an anchor, which could potentially scour the seafloor within the mooring's footprint. This activity could flatten an area that previously contained elevated, breakable habitat (e.g., relic reef, rock pinnacles). Multiple-point moorings sway back and forth and have much less slack that could make contact with the seafloor, thus reducing the potential impacts to elevated benthic structures. There may be little to no effect from these types of impacts on soft sediment or sandy substrate (Helsley 2000, as cited in NMFS 2021a).

Deposition from all types of facilities can result in changes to seafloor sediments (e.g., Sun et al. 2023). Particulate and dissolved organic matter depositing on the seafloor could provide substrate for fouling organisms, impact sedimentation rates and sediment sulfide or organic enrichment levels, modifying the benthic environment (LaCoste et al. 2018, Tan et al. 2024). Depositional models can be used to understand the potential impacts for specific projects (e.g., Cromey et al. 2002; Weise et al. 2009; and Cromey et al. 2012).

Numerous studies have shown that organic enrichment of the seabed is the most widely encountered environmental effect of culturing fish (Karakassis et al. 2000, Karakassis et al. 2002, and Price and Morris 2013). Deposition of feces and uneaten food from finfish facilities can increase organic matter within sediments, particularly in nearshore, shallow systems, and impact physio-chemical processes, oxygen availability, and benthic communities (Brooks et al. 2003, Price and Morris 2013, Legrand et al. 2024, and Ocean Era 2021). Indicators of potential environmental impacts include total organic carbon, redox potential, free sulfides, abundance and diversity of marine organisms (Porrello et al. 2005, Price and Morris 2013, and Rust et al. 2014). The U.S. EPA 2020 evaluation of the Ocean Era Final Ocean Discharge Criteria Evaluation provides an extensive review of potential impacts (EPA 2020).

Sediment quality around finfish aquaculture operations may be determined, in part, by the composition and size (i.e. pelleted feed) of the feed used on-site. Feed settling rates vary by feed type, with slower sinking feeds resulting in greater dispersion. Feed quality and feed management are important considerations with respect to the potential environmental effects of finfish net pen aquaculture. Inappropriate feeding practices can result in overfeeding, increased feed wastage, excess nutrients released from the facility, and increased risk for environmental impacts (Hasan and New 2013).

The spatial patterns of organic enrichment from fish aquaculture varies with physical conditions at the sites and facility specifics (Mangion et al. 2014). An environmental monitoring study of offshore finfish culture of mutton snapper (*Lutjanus analis*) and cobia (*Rachycentron canadum*) in waters of Puerto Rico reported no evidence of anaerobic sediments beneath the fish cages, and inorganic nitrogen levels near the cages similar to background levels (Alston et al. 2005). Alston et al. (2005) noted that effects to sediments were observed directly beneath the cages, just prior to harvest (a period when feeding rates are at their highest). A benthic monitoring study near a Pacific threadfin (*Polydactylis sexfilis*) aquaculture operation in the waters of Hawaii reported the impacts of a gradual buildup of organic material beneath the fish cages and shift toward anaerobic conditions at sites near the fish culture cages (Lee et al. 2006). A 2006 report by New Hampshire Sea Grant indicated no measurable environmental impacts associated with its offshore aquaculture demonstration project (Barnaby 2006). Benthic impacts can occur when the decomposition rate is insufficient to keep up with the supply of uneaten fish feed and fish waste, resulting in an accumulation of solids and nutrient enrichment to sediments. The settlement rate of particulate waste is a function of current speed, with lower-velocity currents resulting in greater localized waste accumulation and high-velocity currents resulting in a greater spatial distribution of material. Depositional sites tend to accumulate organic matter, while particulate accumulation is unlikely to occur on erosional seafloors due to greater material dispersion and subsequent decomposition and assimilation by benthic organisms (Rust et al. 2014).

Siting in deep, well-flushed areas over erosional seafloor limits effects seen in nearshore environments (Hartstein and Stevens 2005, Price and Morris 2013, and Rust et al. 2014). Net movement of organic matter away from the site disperses nutrients over a broader area for decomposition and assimilation. Depositional modeling as well as monitoring can predict and track the extent of impact. Accumulation of some organic matter below facilities may occur toward the end of a grow-out period when aquacultured biomass is at its peak. Fujita et al. (2023) note that while metabolic waste products have on occasion resulted in eutrophication and low oxygen conditions at some nearshore aquaculture facilities, similar impacts are not expected to occur at offshore facilities given the assumption that increased flushing rates may aid dispersion. However, Fujita et al. (2023) caution that such impacts are still possible, especially when considering cumulative impacts, given the dynamic nature of nutrient fate and transport in the ocean environment. Fallowing may be needed to mitigate impacts and allow for sedimentary chemical recovery

(Brooks et al. 2003, Rust et al. 2014, Keeley et al. 2019, and Sim et al. 2024). Site specific characteristics may interact to determine the need for fallowing and length of time.

IMTA may increase on-site retention of aquaculture waste products. IMTA can reduce accumulation of bivalve biological deposits and total organic carbon in sediments (Ning et al. 2016; Tan et al. 2024). Estimated bioremediation efficiencies of 40-50% could be realistic for open aquaculture systems (Nederlof et al. 2022).

Materials used in offshore aquaculture can include plastics, steel, and copper alloy mesh or copper treated nets (Fujita et al. 2023). Some of these materials could degrade over time and settle to the seafloor. Aquaculture operations can be a source of plastic pollution (Skirtun et al. 2022, Lin et al. 2022). Copper and zinc are also sometimes used in fish feed and could deposit on the seafloor (Brooks and Mahnken 2003, Brooks and Drawbridge 2005). Kalantzi et al. (2016) found no copper in sediments after one year of use of copper alloy mesh and net with copper antifouling paint. Brooks et al. (2003) and Fujita et al. (2023) recommended BMPs that include washing copper-treated nets or using net cleaning robots and copper alloy nets that do not require these treatments. Other reports indicate zinc returns to baseline over time (Brooks et al. 2003; CDFG 2010). Published sediment benchmarks for zinc and copper are summarized in CDFG (2010). Changes in free sediment sulfide concentrations, copper, and zinc are sometimes used as benchmarks for when fallowing is needed (Brooks and Mahnken 2003, Brooks and Drawbridge 2005, and CDFG 2010).

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Substrate types are provided per AOA option for Alternative 2 in the Atlas on pp. 127, 130, 133, 154, 156, 159, 162 and 166 of the Results section of Morris et al. (2021). The bottom sediment is mostly mud-like, with the exception of N2-E, which contains nearly equal parts mud-like and sand sediment. Morris et al. (2021) noted that deep sea coral observations in this area warrant comprehensive site review and survey to characterize benthic habitat. Sites N1-A, N1-B, and N1-C are within 5 km (2.7 nm) of deep sea coral, but not within 5 km of hard bottom or rocky reef habitat (Table 3.7 p. 112 in Morris et al. 2021). None of the N2 sites are within 5 km of deep sea coral or rocky reefs. Sites N2-A, N2-B, and N2-E are within 5 km of hard bottom (Table 23.11 pag 178 in Morris et al. 2021). Overall, N2-C and N2-D are farthest from seafloor characteristics of concern and siting aquaculture in these areas could have relatively less adverse impacts. Sediment quality across the Santa Barbara Channel is reported as unimpacted (SCB 2018 Regional Monitoring Program Sediment Quality Assessment Planning Committee 2022). Sites differ in depths and currents which could be taken into account when modeling for potential depositional impacts. Impacts from anchoring may be localized, and sensitive habitats could be avoided with proper siting considerations. Depositional impacts are less likely given the offshore environment. Additional modeling could be needed to predict impacts to nearby seafloor characteristics of concern.

a) Shellfish and Macroalgae

As described above, shellfish and macroalgae aquaculture can impact seafloor characteristics through deposition of solids. Potential impacts to hard bottom or deep sea coral are unlikely given limited extensive depositional impacts from these types of aquaculture. MACMODS (Frieder et al. 2022) was developed to model kelp aquaculture within the Santa Barbara Channel and may be useful in examining depositional impacts. As compared to activities reflected in Alternative 2b, activities reflected in this alternative may have relatively less impact on seafloor characteristics.

b) All Types of Commercial Aquaculture

Seafloor impacts are more likely with finfish aquaculture due to deposition of feces and uneaten feed and potential deposition of elements within feed. Depositional modeling may be needed to understand potential impacts to hard bottom or deep sea coral in the area. As compared to activities reflected in Alternative 2a, activities reflected in this alternative may have relatively more impact on seafloor characteristics.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Substrate types are provided per AOA option for Alternative 3 in the Atlas on pp. 186 and 188 of the Results section, and indicate nearly equal parts mud-like and sand sediment in the two AOA options (Morris et al. 2021). Morris et al. (2021) noted that further consideration of this may be needed in the permitting stage. The two AOA options are within 5 km (2.7 nm) of hard bottom substrate, deep sea corals, and rocky reefs as noted in Table 3.17 and Figure 3.86 of the Atlas (Morris et al. 2021). Sites are in general closer to these types of habitats compared to Alternative 2. One site within the vicinity of these areas was found to have "possibly impacted" sediment quality while other sites were considered unimpacted according to the Southern California Bight 2018 Regional Monitoring Program Sediment Quality Assessment Planning Committee (2022). The impacts of baseline conditions of sedimentation and sediment contaminants on wildlife and the marine habitat is described on pp. 24 and 25 of the Los Angeles Region Regional Water Quality Control Board (LARWQCB) State of the Watershed Report (LARWQCB 2011).

a) Shellfish and Macroalgae

The best available information to describe potential impacts from shellfish and macroalgae reflected under Alternative 2a is the same as reflected under Alternative 3a. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

As described above, shellfish and macroalgae aquaculture can impact seafloor characteristics through deposition of solids. Potential impacts to hard bottom or deep sea coral are unlikely given limited widespread depositional impacts from these types of aquaculture, however sites in Alternative 3 are in closer proximity to these habitats as compared to Alternative 2.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from shellfish and macroalgae reflected under Alternative 2b is the same as reflected under Alternative 3b. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

Seafloor impacts are more likely with finfish aquaculture due to deposition of feces and uneaten feed and potential deposition of elements within feed. Depositional modeling may be needed to understand potential impacts to sensitive habitats in the area. As compared to activities reflected in Alternative 2a, 2b, and 3a, activities reflected in this alternative may have relatively more impact on seafloor characteristics.

Alternative 4: Combination of Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified. Sites that would be within Alternative 2 are generally farther away from sensitive seafloor characteristics compared to sites that would be within Alternative 3, particularly N2-C and N2-D. Impacts to the seafloor resulting from siting selection of multiple areas could result in a greater area impacted by anchoring. Depositional impacts may be greater with more area selected for all types of aquaculture; however dispersed spaces could result in less concentrated depositional impact.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

iv. Water Quality

Affected Environment

Water quality is determined by complex interactions among physical, chemical, and biological processes. Physical processes include region-wide currents and tidal flows, seasonal weather patterns and temperature, sediment characteristics, and unique local conditions, such as the volume of fresh water delivered by large rivers. Chemical processes involve salinity, pH, dissolved minerals and gasses, particulates, nutrients, and pollutants. Biological processes involve the influence of living things on the physical and chemical environment. The Clean Water Act (CWA) addresses the chemical, physical, and biological integrity of U.S. waters (33 U.S.C. § 1251(a)). The EPA administers the CWA in federal waters and may delegate the responsibility to a state government for implementation in state waters. Discharges from aquaculture operations are primarily governed by the implementing regulations of CWA Sections 402 and 403. The CWA Section 402 authorizes the EPA to issue National Pollutant Discharge Elimination System (NPDES) permits for the discharge of pollutants from point sources in compliance with CWA Section 403, and ocean discharges may not result in "unreasonable degradation of the marine environment." Potential pollutant discharges from aquaculture operations include solids, nutrients, ammonia, fish waste, feed waste, pharmaceuticals, and chemicals. Shellfish and macroalgae operations that do not discharge at any time during operations may not need NPDES permits; most finfish operations require a NPDES permit. The Oil Pollution Act of 1990 (OPA) replaced many CWA legal provisions, but Section 311 continues to provide the framework for civil and criminal enforcement for oil spills and for notification to EPA or the USCG when a spill of oil or a hazardous substance occurs (33 U.S.C. §§ 2701, 42 U.S.C. §§ 9601-9675).

Other statutes have water quality elements. Standards set under the Act to Prevent Pollution from Ships (APPS) are the responsibility of EPA and USCG, and enforced by the USCG (33 U.S.C. § 1905-1915). Title I of the Marine Protection, Research, and Sanctuaries Act, known as the Ocean Dumping Act (ODA), regulates ocean disposal of wastes by persons or vessels within the U.S. EEZ (33 U.S.C. §§ 1401). The USACE, EPA, USCG, and NOAA all have responsibilities under the ODA permitting program. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. §9601 et seq. (1980)) authorizes the President to respond to releases or threatened releases of hazardous substances into the environment. Executive Order No. 12580 (1987) delegates response authorities to EPA and USCG. The Resource Conservation and Recovery Act (RCRA) (42 U.S.C. §6901 et seq. (1976)) gives EPA the authority to control hazardous waste from cradle to grave.

The Food and Drug Administration's (FDA) Center for Veterinary Medicine (CVM) regulates the manufacture and distribution of food additives and drugs that may be given to aquatic animals. In the U.S., the use of antibiotics in aquaculture production is highly regulated and there are currently no antibiotics approved for use in the open ocean environment for warm water marine species. All FDA approved antibiotics for use in animals require a veterinary feed directive (VFD) if administered in feed or a veterinary prescription if administered by other routes (e.g., immersion or injection). Additional information about the regulatory environment for drug use and approval can be found in the Rhodes et al. (2023a) and NMFS (2022b). The National Shellfish Sanitation Program (NSSP) is the federal/state cooperative program for the sanitary control of shellfish produced and sold for human consumption. NSSP promotes and improves the sanitation of shellfish moving in interstate commerce through federal/state cooperation and uniformity of State shellfish programs. The Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA 1998; embedded in Public Law 105-383), Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2004 (HABHRCA 2004, Public Law 108–456), and 2014 (HABHRCA 2014, Public Law 113–124) mandate that NOAA advance the scientific understanding of and detect, monitor, assess, and predict HAB and hypoxia events. Congress reauthorized HABHRCA through the National Integrated Drought Information System (HABHRCA 2017, Public Law 115-423). EPA has regulatory responsibilities for marine waters affected by HABs under the CWA.

Persistent organic pollutants (POPs) of concern in the Pacific Ocean include pesticides, dioxins, polychlorinated biphenyls (PCBs), DDT, and poly-aromatic hydrocarbons (PAHs). Heavy metals of concern include mercury, lead, arsenic, cadmium, chromium, copper, trace selenium, and other trace metals (USFWS 2005). Mercury and total PCBs have exceeded thresholds in fish tissue in the SCB, but have generally decreased over time (McLaughlin et al. 2020).

Marine debris is a problem in the SCB (McLaughlin et al. 2023). The prevalence of marine debris is affected by natural forces (e.g. currents) and anthropogenic drivers (e.g. coastal development, vessel traffic). Projected increases in vessel traffic, increased commercial and recreational fisheries effort, population growth and associated development, are expected to continue to increase pressures from marine debris (Miller et al. 2018, ONMS 2019, and Steele and Miller 2022). Plastic makes up most marine debris globally and marine debris is composed of multiple chemical compounds, some classified as POPs (Barnes et al. 2009). Compounds from marine debris can leach into ocean waters and organismal tissues (Talsness et al. 2009; Barnes et al. 2009; and Spykra 2017).

Another factor that can influence and degrade water quality are large concentrations of algae. Harmful algae are unicellular phytoplankton, or microalgae, that produce biotoxins, which often cause adverse effects on animals and humans when populations expand (Rhodes et al. 2023a,b). Populations can expand to large numbers in a short-period, creating a harmful algal bloom (HAB) event, which can impact local marine life. *Alexandrium* spp., a dinoflagellate, can cause paralytic shellfish poisoning, and *Pseudo-nitzschia* spp., a diatom, can cause amnesic shellfish poisoning (ASP); *Dinophysis* spp., a dinoflagellate, can cause diarrhetic shellfish poisoning (DSP). HABs can cause sub-lethal and lethal impacts to marine organisms, which usually leads to shellfish harvest closures. HABs occur periodically in the SCB (Lewitus et al. 2012,), and toxic algal blooms have become more common in nearshore waters off California in recent years (USFWS 2005, CDFW 2010). Some recent HABs have caused fisheries and shellfish harvest closures and marine mammal and seabird mass mortality events (Lewitus et al. 2012; Smith et al. 2018). Researchers have reported elevated domoic acid along the West Coast is related to the warm phases of the PDO and the Oceanic Niño Index, and HABs may increase over time given the increasing frequency of anomalously warm ocean conditions (Krause et al. 2013, Cavole et al. 2016, and McKibben et al. 2017). Warming waters could enhance *Pseudo-nitzschia* blooms and climate change and acidification could affect HAB dynamics (Tirado et al. 2010; Bialonski et al. 2016; and Jardine et al. 2020).

The Atlas considered baseline water quality conditions (chlorophyll-a, water clarity, mean nutrient concentration for nitrate, phosphate, and dissolved oxygen at depth) as described on p. 29 of Morris et al. (2021). Concentrations at depth for nitrates, phosphates, and dissolved oxygen (DO) in Alternative 2 are shown in Figure 3.55, in Figure 3.73, and summarized on pp. 111 and 137 of Morris et al. (2021). Concentrations at depth for nitrates, phosphates, and DO in Alternative 3 are shown in Figure 3.93 on p. 182, and summarized on p. 169 of the Atlas (Morris et al. 2021). Concentrations were generally similar across the Alternative areas of analysis; data sources can be found in Appendix A of the Atlas. Surface salinity in all areas analyzed is consistent throughout the year and among sites at an average of 33.6 psu (Morris et al. 2021). Current speed and direction vary by month and depth, and water temperatures fluctuate seasonally with episodic storm events and shifting current patterns. Chlorophyll-a concentration, which is an indicator of phytoplankton abundance, also fluctuates seasonally).

Stressors

A variety of ongoing stressors impact water quality in the SCB, such as wastewater discharge, nonpoint source contaminants, HABs, airborne pollutants, harbor discharge, marine transportation discharge, marine debris, natural oil seeps, and contaminated groundwater (Schiff et al. 2000; Kessouri et al. 2021). Sea surface temperature and episodic warm water anomalies, periodic decreased DO, and ocean acidification have also been noted (ONMS 2009, CINMS 2010). Proximity to existing water quality stressors are noted in the Atlas.

The Santa Barbara Channel AOA options are within 5 km (2.7 nm) of inactive and active oil platforms and oil wells, and Santa Monica AOA options are within 5 km of inactive oil platforms, and a wastewater outfall. Twenty-four major watersheds drain into the SCB (McGinnis 2006). Currents can transport water from heavily urbanized and industrialized waters of Los Angeles and Orange Counties into the Alternative areas and eddy systems can entrain and trap waters carrying contaminants. Sewage treatment plant effluent has declined over time, but surface water runoff is still a primary source of pollution impacting water quality. In the past, oil, sewage, chemical spills, and dumping of DDT occurred in the SCB, which is still impacting some sections of the region (Morris et al. 2021; Rhodes et al. 2023b), but it is primarily off Los Angeles away from the proposed AOAs; chemical substances were dumped in the ocean near Catalina Island, including DDT after it was banned in the 1970s. Other stressors impacting water quality include natural oil seeps and coastal runoff; natural seeps are the primary source of oil pollutants. Figure 6 shows the proximity of coastal river outlets to the Alternative areas. Kessouri et al. (2021) indicated nitrogen from anthropogenic activities was modifying the coastal oxygen and acidification levels in the SCB. Transient deoxygenation from natural processes is also affecting water quality in the SCB (Yousavich et al. 2024).

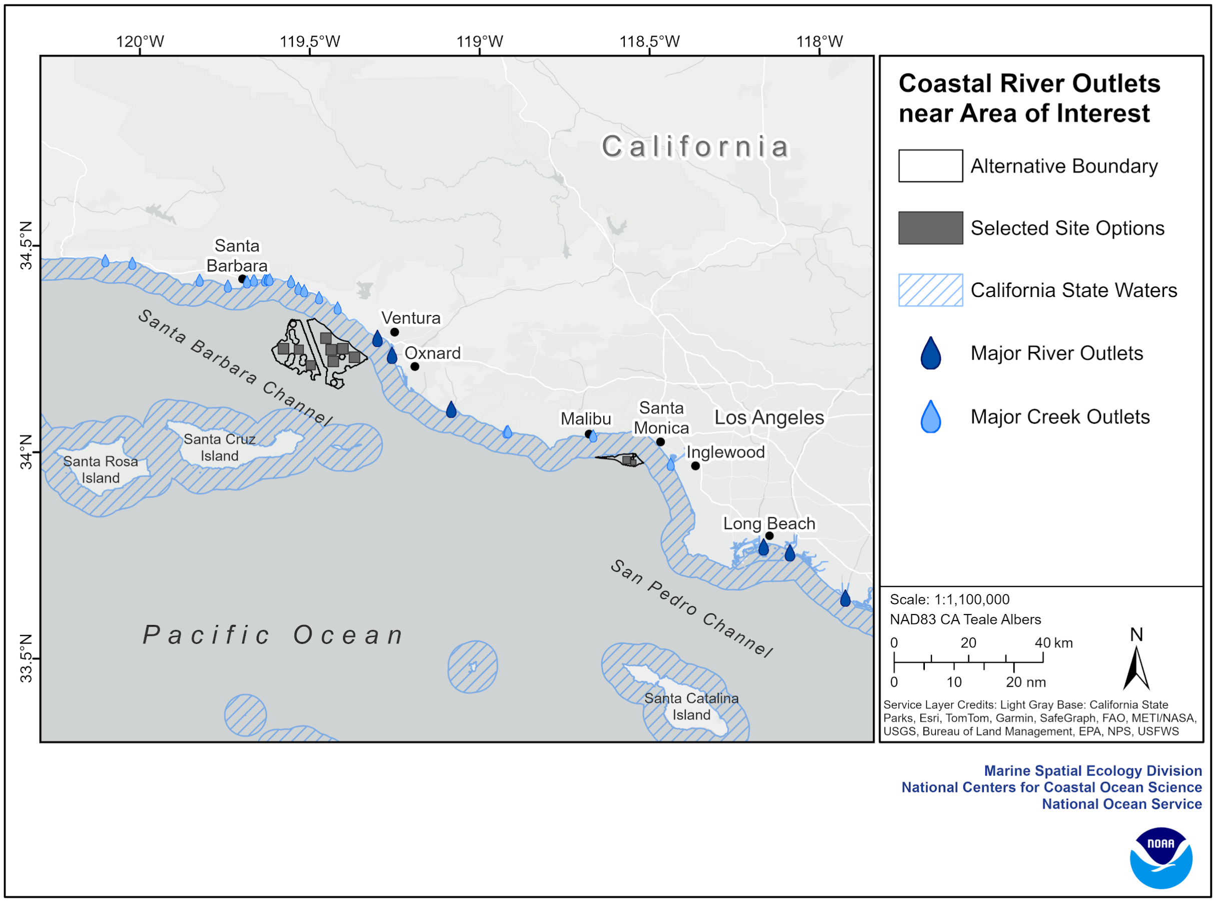


Figure 6: Coastal River Outlets in Proximity to Alternatives

Climate change can affect overall water quality and cause changes in marine ecosystems. Ocean temperatures have increased over the last two decades (UNESCO 2024) and episodic warm water anomalies have been documented in California, which is altering and stressing the local marine community. Decreased DO and ocean acidification have also been documented, which is adding to stress (CINMS 2010). Water quality can potentially interact with pathogens and disease, which could be a concern for future aquaculture operations (Rhodes et al. 2023a). Aquaculture could result in stressors to existing NPDES discharge monitoring programs by potentially affecting the baseline condition.

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- excess feed, metabolic waste, other particulates or suspended organic matter;
- nutrient enrichment;
- nutrient deficits;
- HAB interactions;
- vessel fuel emissions into water, fuel and chemical spills, other pollutants from mechanical operations;
- changes in turbidity;
- sediment disturbance due to vessels and equipment placement
- risk of marine debris; and
- chemical leaching.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact. Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. Potential impacts to water quality could vary in severity and magnitude depending on various factors, such as the average current speed and direction and project design if aquaculture facilities are sited in these areas. Physical changes to water quality are considered in this section, while water quality nexus issues are discussed in various other sections, including animal health and wild populations (Chapter 3, Section C); and human health aspects of seafood safety and quality (Chapter 3, Section D.viii.).

Aquaculture operations could impact water quality through effluent discharge (e.g., ammonium, nitrate, phosphate, and organic carbon compounds). This is primarily a concern for finfish operations. Feed accounts for most of the environmental impact from fed aquaculture (Naylor et al. 2021) and feed quality is an important factor with respect to potential water quality impacts (Kong et al. 2020). Nutrients, feed and feces are soluble (Fernandes et al. 2007). Waste can change the DO and other water quality parameters or have compounding effects with existing threats, such as acidification and HABs (Price and Morris 2013, Kessouri et al. 2021). Impacts can extend beyond the aquaculture operation's footprint. Research indicates that siting facilities in well-flushed water, like offshore, can usually mitigate many of the potential adverse water quality impacts associated with finfish cage culture operations and enrichment to the water column is generally not detectable (Benetti and Meltzoff 2005; Price et al. 2015, Tlusty et al. 2005, and Welch et al. 2019). Price et al. (2015) reported no significant differences in dissolved nitrogen concentrations between the aquacultured and control sites in many offshore cage culture operations; concentrations of phosphorus, DO, turbidity, and lipids were sometimes elevated at or near the offshore cages, but declined with distance. Primary production (chlorophyll a) can be elevated distance (e.g., 1,000 m [3,280 ft]) from operations (Price et al. 2015). The impacts of particulate discharges relative to marine finfish aquaculture are reviewed on pp. 23 through 25 of Rhodes et al. (2023a). The open ocean environment, in addition to depths and circulation patterns across all AOA options should minimize adverse impacts. IMTA can also mitigate adverse water quality impacts. In oligotrophic environments, any added nutrients from finfish operations could prove beneficial, but more research is needed (Ticina et al. 2020).

Overall, potential water quality impacts associated with marine fish cage culture may be avoided or minimized through proper site selection and management. Documented water quality impacts vary among sites and between species, but advances in feed formulation and marine cage management operation has reduced water quality-related impacts associated with offshore aquaculture operations (Price et al. 2015). Research has shown that siting offshore cage operations in deep areas with strong currents at a depth twice the height of the cage are thought to dilute excess nutrients within 100 m (328 ft) (Belle and Nash 2008) and sometimes around 30 m (98 ft) (Rust et al. 2014). The ocean circulation within and adjacent to the AOA options is dynamic because it is influenced and controlled by numerous elements, such as wind, water temperature, bottom topography, the California Current, eddy formation, upwelling, and downwelling. As such, currents may disperse effluent waste.

Despite the concerns associated with aquaculture effluent and primary production, there is currently no link between aquaculture discharge and HABs; nutrient input is a key factor, but the formation of HABs is associated with different elements (Price et al. 2015). In general, eutrophication (nutrient pollution) or hypoxia (low oxygen concentration) are expected to be less of a concern offshore compared to the nearshore environment given the dynamic oceanographic conditions (Fujita et al. 2023).

Adverse water quality impacts through nutrient enrichment are not expected from bivalve or macroalgae aquaculture operations because they use no feed. However, adverse water quality impacts can occur with shellfish aquaculture if carrying capacity of the area is exceeded and changes in water chemistry and primary production results (Liang et al. 2019). Shellfish aquaculture can alter nutrient cycling and result in changes in primary production and possible alteration of planktonic communities (Hulolt et al. 2020; CDFW 2019).

Beneficial impacts to water quality from shellfish and seaweed have also been widely noted (CDFW 2019; Gentry et al. 2020; Theuerkauf et al. 2021; and Barrett et al. 2022). Shellfish aquaculture provides positive benefit through assimilation of nutrients like nitrogen and phosphorus and can improve water quality (Naylor et al. 2021; Garlock et al. 2024). Seaweed aquaculture can enhance water quality by reducing nitrogen and can help control phytoplankton blooms and toxic algal bloom (Naylor et al. 2021). Both shellfish and algae take up nutrients (e.g., nitrogen, phosphate, carbon), remove organic matter and other particulates, thereby reducing excess anthropogenic nutrients and combating eutrophication (Alleway et al. 2019). Cultivation of algae and bivalves may be important in carbon sequestration and storage and protection from ocean acidification, although more research is needed (Alleway et al. 2019). Algae cultivation can also be useful for toxic metal pollution remediation (Bigelow Laboratory for Ocean Sciences 2024)

Other potential water quality impacts associated with offshore aquaculture operations are vessel fuel, fuel, chemicals, and other pollutants from mechanical operations that can accidentally spill into the water. This is a concern across all phases of a project and with different types of aquaculture. Another factor that could adversely influence water quality is the installation of the anchor system. Installation and general daily use has the potential to disturb seafloor sediment and cause localized turbidity. Aquaculture operations can further impact water quality through marine debris. Materials used in offshore aquaculture can include plastics, steel, and copper alloy mesh or copper treated nets (Fujita et al. 2023). Some of these materials could degrade over time and be a source of pollution (Skirtun et al. 2022, Lin et al. 2022). Copper from fish feed or nets could leach (Brooks et al. 2003, Kalantzi et al. 2016).

Projects sited in an AOA would likely have BMPs or other permitting requirements that would be designed to manage water quality stressors; prevent spills, fires, or other sources of hazardous materials; conduct monitoring; and identify procedures to manage and clean up and report incidents. Likely all water quality impacts will be mediated and monitored through BMPs in permits, in accordance with the rules and regulation described in the beginning of this section.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Alternative 2 straddles RWCB areas 4 (Los Angeles) and 3 (Central Coast). In general, less literature about water quality is available compared to Alternative 3. Overall, the EPA classifies water quality in the Santa Barbara Channel between fair and good (ONMS 2019). Eight watersheds drain into the Santa Barbara Channel, and marine debris and pollutants are attributed mostly to land-based sources, especially from the Ventura and Santa Clara Rivers (Spykra 2017, ONMS 2019). Based on surveys of northern Channel Islands beaches, there is a seasonal increase in trash during fall and winter months (Steele and Miller 2022). Channel Islands beaches also seem to accumulate heavier debris than mainland beaches, mostly fisheries gear (Miller et al. 2018, Steele and Miller 2022). Winds in the Santa Barbara Channel are predominantly from the northwest, and the predominant currents are southbound, which influences the movement of debris and effluents in a south or southeast direction (Spykra 2017, Morris et al. 2021, Steele and Miller 2022). Thus, future aquaculture projects would need to consider site location relative to other aquaculture facilities and offshore infrastructure to minimize risk of marine debris and effluent from other ocean-based sources; this is discussed more in Chapter 4, Section A.ii. (Other Ocean Uses) and Section B (Cumulative Impacts). Aquaculture operations would not likely meaningfully contribute to the marine debris problem in the area, but accidental loss could occur.

Discharge facilities and marine-based NPDES monitoring stations are shown in Figure 7. Besides input from rivers, water quality is impacted by the shipping industry, oil infrastructure, and past oil spills (Morris et al. 2021). Fine-scale mixing and eddy circulation in the Santa Barbara Basin has shown oil slicks from spills in the Santa Barbara Channel generally follow surface currents and counterclockwise gyres in the Channel; but wind conditions dominate movement and persistence (Pacific Northwest Laboratories 1969). Oil plumes can move up to 4.6 km (2.5 nm) per day (Pacific Northwest Laboratories 1969). The Alternative 2 AOA options are located downstream of natural hydrocarbon seeps along the coast. It is unlikely these seeps would impact offshore aquaculture. At least 38 oil seeps are located in the Santa Barbara Channel (ONMS 2019). Research showed there was no significant population change in kelp, mussel beds, abalone, urchins, and kelp bed fishes from exposure to natural petroleum seeps in the area (Straughan et al. 1982). There were some ecological differences in the intertidal areas near the seeps, but those differences decreased with distance and depth along the shelf (Straughan et al. 1982). The area may act as a sink for fixed nitrogen and a net source of N2O to the water column (Peng et al. 2024).

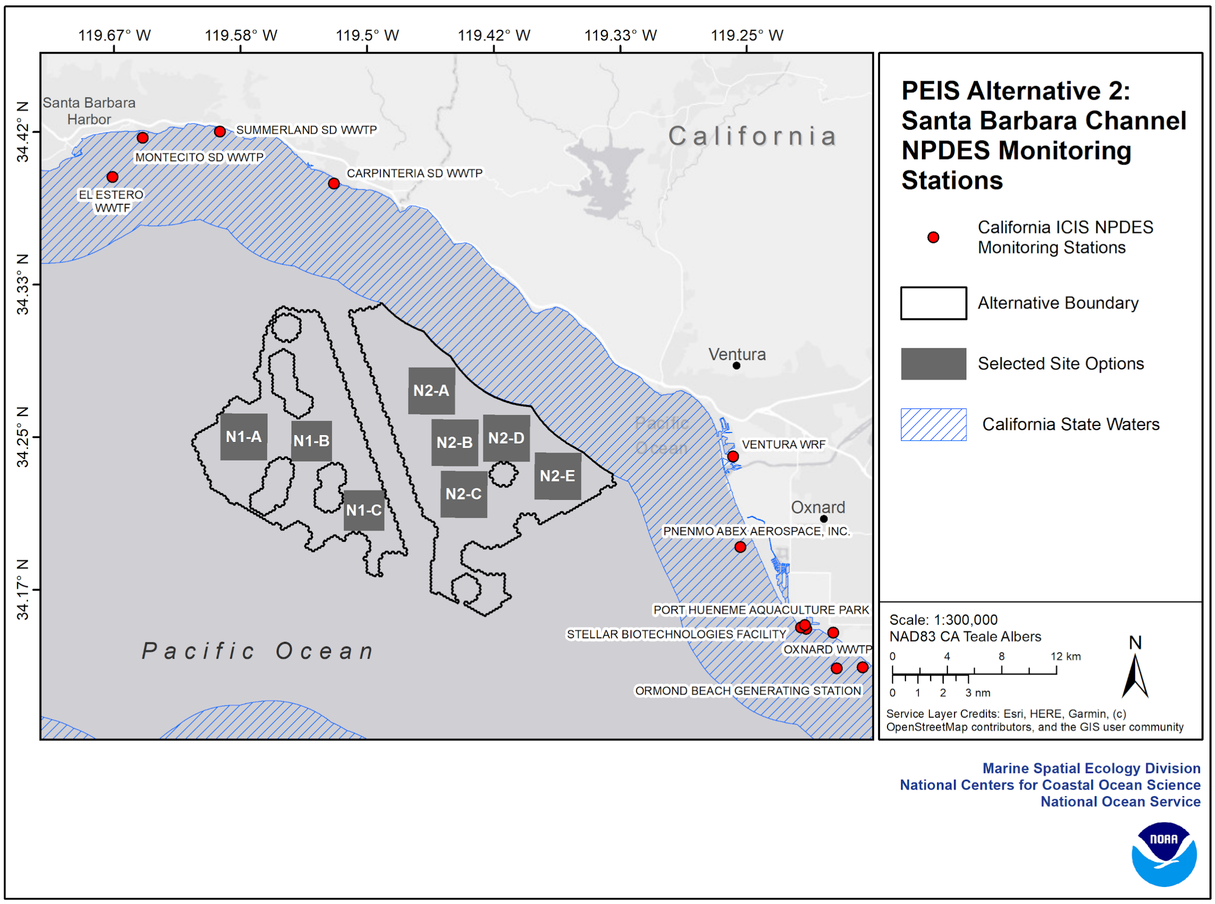


Figure 7: NPDES Monitoring Stations in Proximity to Alternative 2

The Santa Barbara Channel has been a hotspot for seasonal *Pseudonitzschia* blooms and other HAB activity in the Southern California Bight over the past 24 years; HABs have increased in frequency, spatial distribution, and toxicity (Anderson et al. 2009, Anderson et al. 2011, and Sekula-Wood et al. 2011). Population blooms usually occur in spring and fall during the upwelling (cold water, high nutrients) periods.

Baseline water quality conditions (chlorophyll-a, water clarity, mean nutrient concentration for nitrate, phosphate, and dissolved oxygen at depth) in the Santa Barbara Channel were examined by Morris et al. (2021). Findings showed nitrate, phosphate, and DO concentrations varied slightly by depth. In the N1 cluster, chlorophyll-a concentration (mg/m^3) was highest in April (2.70 mg/m^3) and lowest in October (0.96 mg/m^3). Surface salinity was consistent throughout the year with an average of 33.6 psu (Morris et al. 2021). The surface water temperature varied between 11°C and 22.9°C, and the average was 16.4°C (see Figure 3.49 in Morris et al. (2021)). Current speed and direction vary by month and depth with a west-northwest direction at the surface. The annual average current velocity was 0.14 m/s. The current speed was 0.12 m/s at 10 m depth and slightly slower at 75 m (0.09 m/s). The water temperature decreased to 15.8°C at 10 m depth and was the lowest at 75 m depth (11.2°C). Percent light transmissivity was lowest in May at 74.8% and highest in October at 87.8% (see Figure 3.58 in Morris et al. (2021)). In the N2 cluster, the water temperature and other key parameters were similar in the N1 cluster.

a) Shellfish and Macroalgae

There would be no impacts in identifying AOAs, however if shellfish and macroalgae operations are sited in an AOA they could beneficially impact and even improve water quality because they may filter out pollutants. Additional benefits could be seen with respect to carbon sequestration and ocean acidification protection. Adverse impacts could be avoided with proper siting and aquaculture density management that recognizes carrying capacity of the system.

b) All Types of Commercial Aquaculture

There would be no impacts in identifying AOAs, however, if finfish operations are sited in an AOA they have the potential to impact water quality through discharge of effluent and associated waste products and result in nutrient enrichment. As discussed above, the risk can be minimized by properly siting the operations and using best management practices. It could be important for cage systems to be secured at a depth with adequate current flow. An increased number of finfish operations could increase demands on EPA resources in terms of permitting and could also impact baseline water quality monitoring in the region associated with existing water quality permit requirements. While potential impacts to EPA permitting and/or monitoring resources are not physical changes to the environment, they would occur incidentally and directly related to the water quality stressors and impacts that would occur under sub-alternative b. Therefore, they point out an important contrast between sub-alternative a and sub-alternative b as part of the impacts analysis related to physical impacts. Water quality impacts may increase due to the concentration of finfish facilities, related to the production size of each facility and the distance between facilities. Permitting and site-specific analyses could restrict water quality impacts. IMTA can be used to decrease potential adverse effects to water quality.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Water quality in the Santa Monica Bay is classified by the EPA as poor and is worse than in the Santa Barbara Channel. It is designated as an impaired water body under CWA section 303(d) based on the concentrations of arsenic, mercury, and trash (SWRCB 2024). Besides the waters in Santa Monica Bay, impaired waters have been documented in San Pedro Bay because of pesticides, industrial chemicals, heavy metals, and toxicity, which could also have implications for Santa Monica Bay (OEHHA 2019). The 2010 list of impaired waters indicates there are 30 mi^2 (out of 226 mi^2 total) of impairments in the Santa Monica Bay nearshore and offshore waters, which is impacting aquatic life, fish consumption, and shellfish harvesting (LARWQCB 2011). Previous oil spills have also impacted water quality in Santa Monica Bay (Morris et al. 2021). Water quality is influenced mostly by the runoff from Malibu Creek and Ballona Creek; Ballona Creek is runoff from the greater Los Angeles area (USGS 2003). Ballona Creek is recognized as a water quality Critical Coastal Area by the CCC. In addition, the Hyperion Treatment Plant Outfall could affect the water quality in Santa Monica Bay. Beside Malibu and Ballona creeks, Big Sycamore Canyon, Garapito Canyon, Dominguez Channel, and San Pedro Bay can influence the local water quality conditions in the Santa Monica Bay watershed. The Santa Monica watershed has over 180

NPDES discharges, including two direct ocean discharges (LARWQCB 2011). Discharge facilities and marine-based NPDES monitoring stations are shown in Figure 8. Specific information on each of the NPDES discharges can be found in the LARWQCB State of the Watershed Report (2011). The release of untreated wastewater is also a problem that occurs occasionally in the area. In July 2021, 17 million gallons of untreated wastewater was released into Santa Monica Bay through the 1 mile outfall and discharge pipe (EPA 2024a). Smaller releases have occurred because of maintenance, overflow, blockages, or human error. According to the 2021 Water Quality Report Card, trash conditions are improving in Santa Monica Bay. Alternative 2 may have more baseline trash compared to Alternative 3 (McLaughlin et al. 2023).

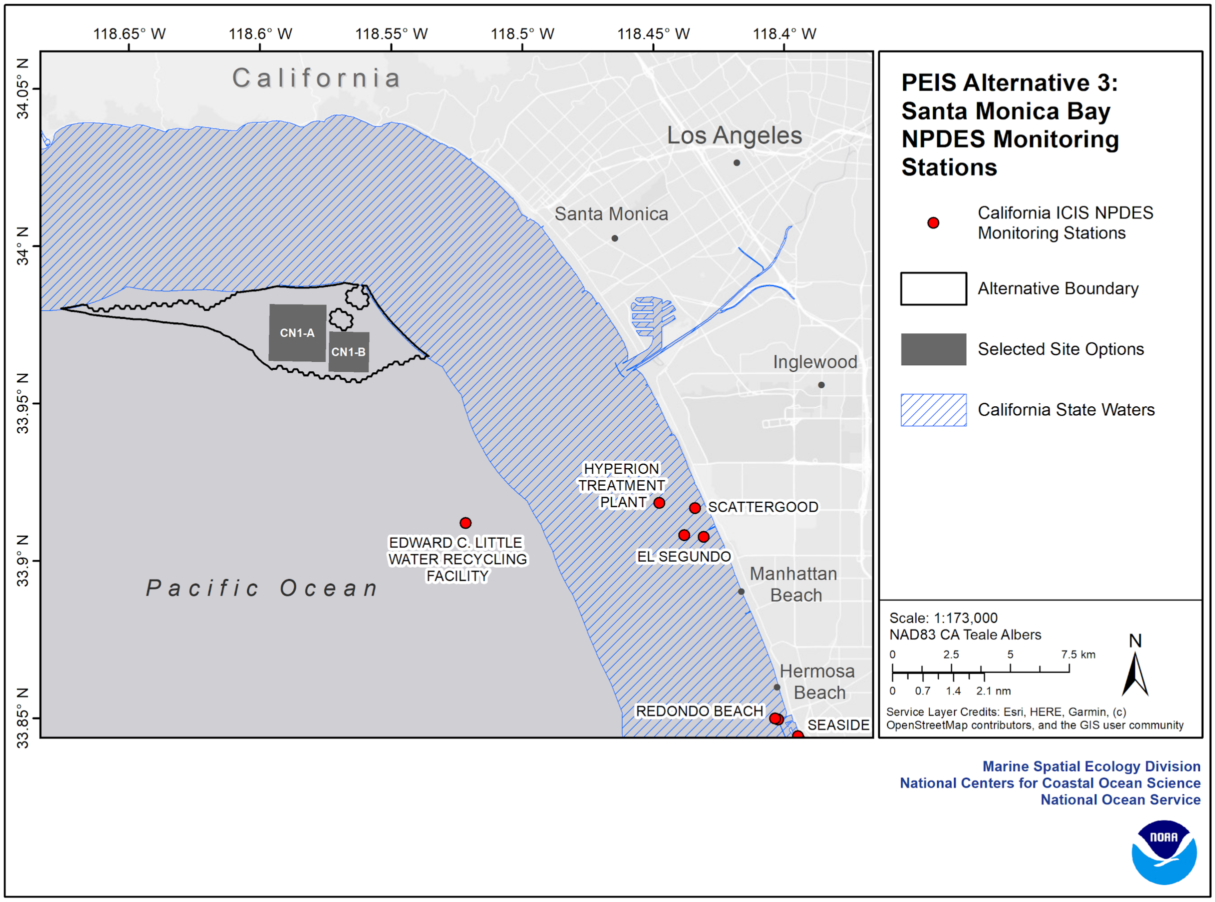


Figure 8: NPDES Monitoring Stations in Proximity to Alternative 3

Ongoing stressors are more severe in Santa Monica Bay than the Santa Barbara Channel, but the conditions at the AOA options within Santa Monica are relatively similar based on a recent assessment (Morris et al. 2021). The average key water quality parameters were similar to the Santa Barbara Channel AOA options. In cluster CN1, the surface water temperature varied between 11.9°C and 23.3°C, and the average was 17.2°C (see Figure 3.87 in Morris et al. (2021)). The water temperature decreased to 16.4°C at 10 m depth and was the lowest at 40 m depth (13.1°C). The current speed and direction vary by month and depth with a southeasterly direction on the surface. The annual average current velocity was 0.11 m/s. The current speed was 0.07 m/s at 10 m depth and slower at 40 m (0.05 m/s). Percent light transmissivity was lowest in April at 79.5% and highest in November at 88.1% (see Figure 3.96 in Morris et al. (2021)).

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same for Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternative 2b is the same for Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

Alternative 4: Combination of Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified. In theory, potential water quality impacts could be more considerable, positive or negative, compared to impacts reflected in Alternatives 2 and 3. It is unlikely potential adverse water quality impacts would be much different than Alternatives 2 and 3 given the low probability that future aquaculture projects would discharge large quantities and concentrations of water pollutants if they are sited and operated appropriately. Anticipated impacts on water quality from waste would be localized and small in magnitude, assuming projects are sited at an appropriate depth with current flow. A combination of different types of aquaculture facilities could mitigate some nutrient related impacts, effectively serving as an IMTA type of system. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2a and 3a is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4b. Overall depositional impacts could be greater with more area identified; however dispersed spaces could result in less concentrated water quality impacts.

v. Air Quality and Aesthetics

Affected Environment

This section provides an overview and discussion of the general impacts on air quality and aesthetics. As a form of air pollution, potential greenhouse gas emissions/reductions are presented here, for additional discussion of those emissions/reductions in the context of climate change see Chapter 4, Section i. Presently, the air quality analysis does not consider potential air quality impacts associated with any onshore facility areas or port(s); potential impacts would be evaluated during the individual permit and consultation processes for specific aquaculture projects. Air quality analyses are subject to EPA review as part of permitting under the Clean Air Act (CAA).

Air Quality

The CAA of 1963, revised in 1970 and 1990, forms the basis for controlling and monitoring air pollution in the U.S. The Act authorizes the EPA to regulate all sources of air emissions from stationary (e.g., power plants and factories) and mobile (e.g., vehicles and vessels) sources to ensure the health and safety of humans and the environment. The CAA establishes four major air pollution regulatory programs: the National Ambient Air Quality Standards (NAAQS), State Implementation Plans (SIPs), New Source Performance Standards (NSPS), and National Emission Standards for Hazardous Air Pollutants (NESHAPs). Under the CAA, the EPA established NAAQS for common and widespread pollutants, and controls for specific hazardous pollutants. NAAQS set specific concentration limits for criteria pollutants in the outdoor air, and hazardous air pollutants are controlled by rules that limit emissions of hazardous air pollutants from specific industrial sources, which are typically much smaller than concurrent emissions of criteria air pollutants. The six common criteria pollutants regulated by NAAQS are nitrogen oxides (NO_x), sulfur dioxide (SO_2), particulate matter ($PM_{2.5}$ and PM_{10}; particulate matter with a diameter less than or equal to 2.5 and 10 microns [μm], respectively), carbon monoxide (CO), volatile organic compounds (VOC), ozone (O_3), and lead (Pb). SIPs provide a plan for implementation, maintenance, and enforcement of the NAAQS in each state including measures to control emissions that could drift across state lines and potentially harm air quality in downwind states. The CAA has provisions to minimize pollution from motor vehicles. The EPA periodically reviews and sometimes revises the standards based on the best available science. The agency examines air quality data from a network of monitors to ensure a region/area is within the NAAQS.

The CAA established two types of NAAQS: (1) primary standards, which set limits to protect public health, including the health of "sensitive" populations (e.g., asthmatics, children, the elderly); and (2) secondary standards, which set limits to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. The NAAQS are set forth in 40 CFR Part 50. Table 1 lists the National and California ambient air quality standards (NAASQS and CAAQS) that may be helpful for any site-specific NEPA analyses in the future.

Table 1: National and California Ambient Air Quality Standards (NAAQS and CAAQS)

CRITERIA POLLUTANT	STANDARD	AVERAGING TIME
1-Hour Ozone	NAAQS	1979 1-Hour (0.12 ppm)
	CAAQS	1-Hour (0.09 ppm)
8-Hour Ozone	NAAQS	1997 8-Hour (0.08 ppm)
	NAAQS	2008 8-Hour (0.075 ppm)
	NAAQS	2015 8-Hour (0.070 ppm)
	CAAQS	8-Hour (0.070 ppm)
Carbon Monoxide	NAAQS	1-Hour (35 ppm) 8-Hour (9 ppm)
	CAAQS	1-Hour (20 ppm) 8-Hour (9 ppm)
Nitrogen Dioxide	NAAQS	1-Hour (0.10 ppm)
	NAAQS	Annual (0.053 ppm)
	CAAQS	1-Hour (0.18 ppm) Annual (0.030 ppm)
Sulfur Dioxide	NAAQS	1-Hour (75 ppb)
	NAAQS	24-Hour (0.14 ppm) Annual (0.03 ppm)
Particulate Matter PM10	NAAQS	1987 24-hour (150 $\mu g/m^3$)
	CAAQS	24-hour (50 $\mu g/m^3$) Annual (20 $\mu g/m^3$)
Particulate Matter PM2.5	NAAQS	2006 24-Hour (35 $\mu g/m^3$)
	NAAQS	1997 Annual (15.0 $\mu g/m^3$)
	NAAQS	2012 Annual (12.0 $\mu g/m^3$)
	NAAQS	2024 Annual (9.0 $\mu g/m^3$)
	CAAQS	Annual (12.0 $\mu g/m^3$)
Lead	NAAQS	3-Months Rolling (0.15 $\mu g/m^3$)
Hydrogen Sulfide	CAAQS	1-Hour (0.03 ppm/42 $\mu g/m^3$)

CRITERIA POLLUTANT	STANDARD	AVERAGING TIME
Sulfates	CAAQS	24-Hour (25 µg/m^3)
Vinyl Chloride	CAAQS	24-Hour (0.01 ppm/26 µg/m^3)

The EPA designates every area of the country as either in attainment, non-attainment, or unclassified for each criteria pollutant. Attainment is defined as an area where all criteria pollutant concentrations are within all NAAQS; non-attainment is an area that does not meet the NAAQS for one or more pollutants. Unclassified areas are locations where attainment status cannot be determined based on available information and are regulated as attainment areas. The EPA indicates an area can be in compliance (i.e., attainment) for some pollutants and non-attainment for others. A maintenance area is an area that was in non-attainment at any point in the last 20 years but is currently in attainment. The EPA requires non-attainment and maintenance areas to prepare a SIP, which is the region's program approach to attain and maintain compliance with the NAAQS. The CAA prohibits federal agencies from approving any action that does not conform to a SIP; however, this prohibition applies only to non-attainment or maintenance areas (i.e., areas that were previously non-attainment and a maintenance plan is required). Conformity to a SIP means adjusting to a SIP's requirement of reducing the severity and number of violations of the NAAQS to achieve attainment of the standards. The CAA applies to coastal waters within 3 nm of shore. The air quality geographic area of analysis includes areas that are unclassified as to the attainment status (including offshore areas outside of State waters (greater than 3 nm, and areas that are classified as nonattainment areas (e.g. South Central Coast Air Basin).

The CAA established requirements for the Prevention of Significant Deterioration (PSD) or the Haze Rule based on three types of class areas; the Act specified specific increments of SO_2 and the allowable particulate pollution in each class (CRS 2022). Class I are National Parks and wilderness areas (National Parks and wilderness areas 6,000 ac (2428 ha) and 5,000 ac (2023 ha) or greater, respectively that were in existence before August 1977) where very little degradation of air quality is allowed. Class II areas include all attainment and not classifiable areas (modest degradation allowed) and Class III are areas that individual States may designate for development; allowable increments of new pollution are large, but cannot exceed NAAQS. Projects subject to federal air quality permits are required to notify the federal land managers when Class I areas are within 100 km (62 mi) of a project. The nearest Class I area to Alternative 2 is the Channel Islands National Park, which is located about 16-19 km (10-12 mi) SSW. The nearest Class I area to Alternative 2 is the Santa Monica Mountains National Recreational Area, which is about 19-24 km (12-15 mi) NNW.

The CAA also directs the EPA to establish requirements to control air pollution from sources located beyond the state seaward boundary in the Outer Continental Shelf (OCS), with the exception of OCS sources located in the Gulf of Mexico west of 87.5° longitude (i.e. offshore TX, LA, MS, AL) and areas offshore the North Slope Borough of Alaska. Sources in the latter areas are under the authority of BOEM and BSEE. Specifically, the regulations require OCS sources located within 46.3 km (25 nm) of a state seaward boundary, commonly known as inner OCS sources, to comply with the air quality requirements of the corresponding onshore area (COA), which include New Source Review preconstruction permitting and/or Part 70 Title V operating permit program requirements and other state and local requirements that apply to OCS sources. OCS sources located beyond 46.3 km (25 nm) from the state seaward boundary are subject to only federal air quality requirements, but may need an OCS permit complying with the EPA's PSD preconstruction permit program regulations and/or the Part 71 Title V operating permit program requirements.

To help reduce global emissions, the North American Emission Control Area was implemented after being approved by the International Maritime Organization on August 1, 2012. It requires the reduction of emissions of nitrogen oxides, sulfur oxides and particulate matter for ships within 200 nm of the coasts of the United States and Canada through the burning of cleaner fuel and the installation of better air pollution control equipment on ships. The international law governing pollution caused by foreign ships is the International Convention for the Prevention of Marine Pollution by Ships ("MARPOL"). The annexes to MARPOL regulate pollution from ships, such as oil, noxious liquid substances carried in bulk, harmful substances, sewage, garbage, and air pollution. Within the United States, MARPOL requirements are codified in the Act to Prevent Pollution by Ships ("APPS").

The CAA authorizes the EPA to set NAAQS, but individual states are responsible for establishing procedures to attain and maintain the standards (CRS 2022). The states adopt SIPs, and must ensure plans are adequate to meet statutory requirements under the authority of Section 110. The CAA is implemented, monitored, and enforced primarily by states or local governments; they issue most air permits and conduct inspections. In California, the EPA designates the California Air Resources Board (CARB) as the authority to regulate emissions under Section 328 of the CAA. In California, four local permitting authorities (Santa Barbara, San Luis Obispo, South Coast and Ventura County) have delegated authority to administer OCS Air Regulations. Also, CARB issued their own regulations to control air pollution from ocean-going vessels in California ports, such as the Ports of Los Angeles and Long Beach, which are near the proposed AOAs. The regulations are aimed at reducing the emissions of particulate matter, nitrogen oxides, and sulfur oxides through the use of cleaner burning fuel. These regulations apply in addition to the Emission Control Area requirements mentioned above.

Aesthetics

Federal and state legislatures often incorporate scenic value, aesthetics, or community character with coastal management mandates (Kelty and Bliven 2003). Many individual states, including California, have specific language related to scenic or aesthetic value, but the primary federal law that considers scenic value is the CZMA. The CZMA states that one purpose of the Act is "to encourage and assist the states to exercise effectively their responsibilities in the coastal zone through the development and implementation of management programs to achieve wise use of the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and esthetic values as well as the needs for compatible economic development." NEPA also considers visual and aesthetics impacts.

Federal agencies have various standards, thresholds, and procedures for evaluating visual impacts. In general, an assessment considers the direct impacts of the proposed changes on views of the landscape because of intrusion or obstruction; the reaction of viewers who may be affected; and the overall impact on the view, which may range from degradation to enhancement (Kelty and Bliven 2003). Open/distance water views are a general concern and most people dislike commercial development in undeveloped coastal landscapes (Kelty and Bliven 2003). Assessments of potential visual impacts are conducted in various ways, but usually require a graphic illustration of how the proposed structure fits into the existing landscape, and consider where the general public could potentially view the project (Kelty and Bliven 2003). Mitigation and best management practices are often required by local, state, or federal agencies in permitting and consultation processes.

Stressors

Air pollution can impact not only humans, but terrestrial, aquatic, and marine species. Atmospheric deposition of nitrogen and sulfur resulting from air pollution around the world is a major stressor to natural ecosystems because it often causes acidification and eutrophication of terrestrial and aquatic ecosystems, which degrades water quality and can cause cascading ecological impacts (Walker and Beachley 2019). Ocean acidification is caused by the ocean absorbing anthropogenic carbon dioxide from the atmosphere, which lowers the pH and leads to low DO (Stallinga 2018). Ocean acidification can impede larval development in shellfish by causing the outer shell to become soft; this has been reported in Pacific and Eastern oysters and blue mussels (Gazeau et al. 2014). Greenhouse gasses trap energy in the atmosphere from the sun and the energy is absorbed by the ocean, causing the water temperature to rise, which can impact marine species (Friedland et al. 2019; Wang 2022; and Gevondyan et al. 2024).

Ocean acidification and low pH conditions associated with air pollution and climate change are ongoing stressors for marine ecosystems off the coast of California. Marshall et al. (2017) predicted, given the current conditions, a 0.2-unit drop in pH (55% increase in acidity) in the California Current during the summer upwelling season over a 50 year period (2013-2063), and a 0.9°C increase in the annual mean water temperature in the upper 100 m (328 ft). This pH drop would directly impact invertebrates (crabs, shrimps, benthic grazers, benthic detritivores, bivalves), and indirectly impact some demersal fish, sharks, and epibenthic invertebrates (e.g. Dungeness crab (Metacarcinus magister)). Increasing ocean acidification adds to naturally high levels of carbon dioxide in upwelled waters along the California coast (OEHHA 2022). In addition to seasonal meteorological patterns in California, longer term changes associated with El Niño and the PDO can alter the ability of oceanic waters to serve as either a sink or a source of carbon dioxide. Data from monitoring sites 140 miles off Point Conception, California, show that carbon dioxide and pH levels have increased and decreased over the past decade, respectively (OEHHA 2022). All of these anthropogenic and natural stressors are impacting the marine ecosystem along the coast of California.

As described above and required by the CAA, air quality is generally evaluated by comparing the ambient air concentrations of criteria pollutants to the NAAQS. Based on the geographical area, Alternative 2 and 3 are offshore of the three California air districts (Santa Barbara, Ventura, and South Coast). The Santa Barbara Channel AOA options are located between 10.02 and 19.72 km (5.41 and 10.65 nm) offshore of Santa Barbara and Ventura Counties and the Santa Monica Bay AOA options are located between 8.06 and 8.82 km (4.35 and 4.76 nm) offshore of Los Angeles County. Currently, Santa Barbara and Ventura Counties are in attainment for all federal ambient air quality standards, except ozone and PM_{10}. Similarly, the South Coast air district is in attainment for all federal ambient air quality standards, but is in non-attainment for ozone and two of the $PM_{2.5}$ standards. Historically, ozone has been a major air pollution issue for California. Ozone is formed in the atmosphere from precursor chemicals in the presence of sunlight. For instance, ground-level ozone forms when nitrogen oxides from mobile and stationary sources like vehicle exhaust and industrial emissions react with organic compounds in the presence of heat and sunlight. According to CARB, ozone is an important component of smog, and it is a highly reactive and unstable gas capable of damaging living cells, such as those present in the linings of the human lungs. Ground-level ozone typically forms in greater quantities on hot, sunny, calm days, which are common in Southern California; ozone concentrations in California metropolitan areas frequently exceed the health-protective standards in summer. Light or no wind can be a problem for air quality because of low dispersion, especially in urban areas that are surrounded by buildings or mountains which can trap pollutants (Kgabi and Mokgwetsi 2009).

Data and information describing the baseline air quality conditions and status within the AOA options for the six criteria pollutants are unavailable and therefore could not be incorporated into the Atlas during the spatial modeling process; however, wind speed and direction were examined for AOA options, which can significantly influence air quality. Wind velocity and direction can disperse air pollutants and impact a much greater area than a specific project footprint. To understand air pollution and associated impacts from a given point source, it is essential to have data describing the local and regional meteorology, and understand the dilution and dispersion of pollutants, which is often estimated through models (Kgabi and Mokgwetsi 2009). Under the federal permit review, the EPA could address and require any necessary best available control technology or other potential mitigation measures and modeling processes.

Offshore aquaculture may have visual impacts on the seascape. Visual impact on the coastal landscape is often a leading cause for public opposition, especially in areas with high-value properties, historically important scenic views, or when a project is in the vicinity of a cultural resource. Another potential impact associated with aesthetics is fixed lighting on the offshore facility.

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- air quality impacts due to installation, decommissioning and operation; and

- visual impacts of aquaculture sited in AOAs.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

This section discusses potential impacts on air quality, seascape, open-ocean, and landscape character and viewers should an aquaculture facility be sited. The air quality analysis, including estimates of GHG emissions or reductions, is qualitative due to the programmatic nature of this DPEIS and the unknown number of aquaculture facilities or types of operations that may eventually be sited. Project-level NEPA would consider impacts on air quality, including emissions of criteria pollutants, hazardous air pollutants, GHGs, and conduct a General Conformity analysis with the CAA if required; those analyses would be as quantitative as feasible and possibly involve modeling. The total direct and indirect emissions calculations should consider all emission increases and decreases that are reasonably foreseeable and are possibly controllable through permitting agencies' continuing program responsibilities to affect emissions.

Evaluations of potential direct impacts of offshore aquaculture on air quality are limited. Feed pellets distributed by hand or machine in finfish operations can sometimes create fine dust (Fisheries and Oceans Canada 2003). However, the risk and likelihood of this impacting air quality from feed is considered low. Air quality could be impacted by aquaculture vessel activities because they may use diesel engines, which emit pollutants. Marine vessels operating around the world produce a large portion of the greenhouse gas (GHG) emissions and contribute to ongoing climate change, especially large ocean-going cargo vessels and harbor craft. Exhaust emissions from marine diesel engines emit nitrogen, oxygen, CO_2, carbon monoxide (CO), SO_x, NO_x, hydrocarbons, water vapor, and smoke. Port of Long Beach activity-based (ocean-going vessels, harbor craft, rail locomotive, and heavy duty vehicles) emissions (PM, diesel particulate matter [DPM], NO_x, SO_x, HC, CO, and CO_2) are a major air pollution source (Starcrest Consulting Group 2023). The primary pollutant produced by ocean-going vessels using the port of Long Beach is NO_x followed by CO, HC, PM_{10}, $PM_{2.5}$, and DPM. To reduce emissions associated with marine vessels, the EPA has adopted exhaust emission standards for marine diesel engines installed in a variety of marine vessels ranging in size and application from small recreational vessels to tugboats and large ocean-going vessels. EPA has implemented best management practices that have reduced emissions in the port of Long Beach, such as reducing vessel approach speed, and switching fuel to liquid natural gas.

Most air pollutant emissions and air quality impacts from aquaculture projects would likely be generated by diesel-fueled vessels traveling to and from the offshore facility. Marine vessels could be used to transport personnel, equipment, and cultured species. The magnitude of emissions and the resulting air quality impacts would vary by the number of vessels and frequency of trips associated with each individual project. Emissions would also vary by vessel size, hull type, vessel age, equipment optimization, and other factors. Over time, it is likely technology may advance, which could reduce future emissions from vessel traffic traveling to an offshore facility (e.g. automated systems, electric motors, etc). It is likely the number of additional vessels would not constitute a meaningful change from baseline conditions and they would be similar in size to fishing vessels operating in the region. Vessels could be properly sized to meet the demands of the operation, but no larger than necessary to safely move equipment and personnel. Potential impacts to air quality associated with marine vessels is likely minimal, depending on the individual project. Given the size of the AOA options and the proximity to port, aquaculture operations may use medium size (9-23 m [30-75 ft]) fishing or work vessels, which produce minimal air emissions. Vessels could be equipped with gasoline-fueled outboard engines rather than diesel engines, which produce lower air emissions, especially new 4-stroke engines.

Research on potential impacts associated with GHG emissions from aquaculture is a growing area of study. MacLeod et al. (2020) found global aquaculture production for nine major culture groups (93% of global aquaculture production) accounted for approximately 0.49% of anthropogenic GHG emissions or 263 Mt carbon dioxide equivalents [CO_2e]) in 2017. Raul et al. (2020) estimated global aquaculture production emissions may increase to 3.83×10^{11} g CO_2e by 2030. Still, the proportion of GHG emissions from aquaculture is significantly less than emissions from land-based production of livestock and crops or those produced by wild-capture fisheries (Halpern et al. 2015). Differences and variability in GHG emissions from aquaculture are greatly influenced by the type and volume of species reared, facility location, type of production system, and associated environmental factors (Jones et al. 2022, Zhang et al. 2023, and Cheng et al. 2023). Typically, GHG emissions are closely linked to the level of production, except in bivalves where there is an inverse relationship (MacLeod et al. 2020). GHG emissions in the aquaculture production cycle come from various sources, including feed processing, production and egg supply, larvae, other propagules, on-site energy use, processing, storage, and shipment. Upstream and downstream processes have been found to contribute a significant proportion of overall GHG emissions from aquaculture, often more than on-site operations themselves (Jones et al. 2022). However, differences in these processes (i.e., downstream shipping methods) make it difficult to estimate emissions from any one "typical farm". Also, many GHG estimates are regional in scope or from countries outside of the U.S. (e.g., Robb et al. 2017, Raul et al. 2020, Zhang et al. 2023, and Cheng et al. 2023); differences in production practices, policy, and regulatory frameworks make it difficult to use these sources to assess what may be expected from AOAs. New assessment methods are emerging to estimate GHG emissions associated with aquaculture operations, such as the Life Cycle Assessment (TNC 2022). TNC (2022) estimated the GHG emissions for *Forever Oceans* production of longfin yellowtail (*Seriola rivoliana*) in the Bay of Charco Azul, on the Pacific Coast of Panama was 7.13 kg CO_2 equivalent per 1 kg of edible product, including of GHG emissions to the site and land use, basic processing, and distribution to international markets. The assessment found 12% was associated with on-site operations, 48% with upstream activities (i.e, feed production), and 40% with downstream activities, mostly because of the use of fresh fish and air freight to markets. The report indicated that a reduction in the feed conversion ratio and shipping frozen products would reduce GHG emissions by 2.99 kg CO_2 equivalent per kg fish.

In general, there are some basic patterns and GHG emission estimates from different aquaculture operations that can be used to infer potential impacts. Finfish operations generally produce more GHG emissions than bivalves because of the amount of food needed to produce live weight gain, energy use for onshore operations, feed transfer, and product delivery. In contrast, bivalves (oysters, mussels, and clams) have lower emissions because no energy is used for feed production once they enter the growing environment. Compared to finfish and bivalves, seaweed aquaculture generates the lowest emissions. Meta-analysis has estimated that fed finfish averaged around 3,271 kg of CO_2e/ton wet weight produced, but varied from 1,382 to 44,400 kg of CO_2e/ton wet weight, depending on production system (coastal net pens vs. closed or recirculating systems) (Jones et al. 2022). Bivalves are estimated to generate 392 kg of CO_2e/ton wet weight produced, but the estimated amount also varies by production system. Seaweed operations generate around 22 kg of CO_2e/ton of seaweed produced, but varies from 11.4 to 28.2 kg of CO_2e. Overall, it is possible that future aquaculture operations in the proposed AOAs could produce minor impacts to air quality associated with GHG emissions.

Aquaculture emissions and resource usage (i.e, space, water, and energy) are orders of magnitude less than traditional land-based agriculture (MacLeod et al. 2020, Halpern et al. 2015). With or without AOAs being identified, aquaculture emissions are still likely to remain lower than other agriculture production already happening in the region, even after accounting for the rapid annual growth happening in the aquaculture sector. Assessing potential impacts are dependent on various factors and current tools for measuring GHG emissions are not specific to aquaculture; however, aquaculture has the potential to produce food with fewer input resources, less GHG emissions, and fewer climate change consequences than traditional land-based agriculture. Ray et al. (2019) note that "oyster aquaculture has less than 0.5% of the GHG-cost of beef, small ruminants, pork, and poultry" and estimate that "if 10% of the protein from beef consumption in the United States was replaced with protein from oysters, the GHG savings would be equivalent to 10.8 million fewer cars on the road."

Visual impacts could be a contentious issue in Southern California. Impacts are mediated by the distance from shore, height of the structure, and the general meteorological conditions in the area. However, the human eye can only see about 5 km (2.7 nm) offshore in clear conditions when standing on the beach. Additionally, aquaculture operations that use submersible cages would likely reduce visual impacts. In Hawaii, cage placement near Keahole point was determined to have no effect on the seascape of the area (HI DLNR 2014). In previous planning studies conducted by NOAA's National Ocean Service (NOS) NCCOS for southern California (San Diego), it was determined through modeling and photo-realistic simulations that offshore fish aquaculture would have minimal impact on the seascape when facilities are sited greater than 9 km (5 nm) from the shoreline (Aquarium of the Pacific 2015).

The USCG (14 U.S.C. 83 et seq.) requires that aquaculture structures located in navigable waters must be marked with lights and signals for navigational safety, which could be seen a greater distance at night. The number and type of lights would be project-specific. Surface work lights are often down-shielded to prevent light pollution. Without shielding, a strong white light is visible for 33 km (18 nm) (Cicin-Sain et al. 2004); however, most beacon lights are red or green, which are visible for 22 km (12 nm). Besides potential general visual concerns for the public, artificial lights at night can have adverse impacts on variety of marine life from corals to sea birds (Marangoni et al. 2022) for additional discussion on the impacts of artificial light on biological resources, see Chapter 3, Sections C. Potential impacts associated with artificial light could depend on various factors, including the color, intensity, and duration of the lighting. A short-duration synchronized flashing navigational safety light could have less anticipated impacts on the human and natural environment than a bright long-duration non-flashing light.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The Santa Barbara Channel AOA options are located between 10.02 and 19.72 km (5.41 and 10.65 nm) offshore of Santa Barbara and Ventura Counties, which are currently in attainment for all federal ambient air quality standards, except ozone and PM_{10}. The wind velocity (10m above the sea level) in the AOA options averaged around 4.8 m/s, with a minimum of 0 m/s and a maximum of 19.5 m/s. In general, the higher the wind speed, the more contaminants are dispersed. The predominant wind direction is from the west, but it is unlikely air emissions would reach the coast given the low levels of emissions being generated. Diesel-powered vessels can impact air quality and increase greenhouse gasses. Emissions are directly correlated with fuel consumption and operating hours (Greer et al. 2019). Given the proximity between the AOA options and the local ports, it is unlikely potential impacts on air quality would be detectable compared to baseline conditions. Some or all of the fleet may use gasoline outboard engines, which are better for the environment, especially new efficient 4-stroke engines that produce minimal CO_2 emissions and other pollutants; petroleum generates lower emissions than heavier, less refined, marine diesel (Greer et al. 2019). Anticipated impacts on air quality from activity emissions would be transient, small in magnitude, and localized. Projected emissions would be minimal in scale when compared to other industries in the region, such as marine shipping. Given the distance from shore, it is unlikely there would be any visual impacts during the day, but there might be some minimal impacts at night. Atmospheric and environmental factors (e.g., haze and fog) would reduce visibility and perception of hazard lighting from sensitive viewing locations.

a) Shellfish and Macroalgae

Vessel activities associated with macroalgae aquaculture would emit GHGs, but on a minimal scale compared to other industries in the region and compared to global emissions. The changes to air quality during vessel activities would be local and temporary. Macroalgae aquaculture facilities could be sources of GHGs, such as methane, or sinks of GHGs, such as carbon dioxide. Impacts are expected to be minimal at the scale of an AOA and may present both beneficial and adverse contributions of GHGs. There is no likely meaningful difference in visual impacts between impacts reflected under Alternative 2a and 2b.

b) All Types of Commercial Aquaculture

As compared to impacts reflected under Alternative 2a, without finfish, Alternative 2b could result in higher air quality impacts due to 1) increased vessel traffic due to feeding operations, or 2) increased emissions due to feed barge or automated feeder activity. The manufacture of feed could also be a source of emissions. There is no likely meaningful difference in visual impacts between impacts reflected under Alternative 2a versus 2b.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The Santa Monica Bay AOA options are located between 8.06 and 8.82 km (4.35 and 4.76 nm) offshore of Los Angeles County. Currently, the South Coast air district is in attainment for all federal ambient air quality standards, but it is nonattainment for ozone and two of the $PM_{2.5}$ standards. The wind velocity (10 m above the sea level) in the AOA options averaged 4.5 m/s, with a minimum of 0 m/s and a maximum of 16.8 m/s. Wind direction was predominantly from the west-southwest. Given the wind direction, air emissions could reach the coast, but is doubtful given the low level emissions expected. Similar to Alternative 2, anticipated impacts on air quality from activity emissions would be transient, small in magnitude, and localized. It is likely potential total emissions from vessels operating between shore and Alternative 3 would be lower than Alternative 3 given distance to shore. Again, it is unlikely there would be any visual impacts during the day because aquaculture finfish structures would be outside the maximum range the naked eye can see, but visual impacts at night would be greater since the AOA options are closer to shore than Alternative 2.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

Alternative 4: Combination of Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. Under this alternative, AOAs would be identified in the Alternatives 2 and 3. In theory, potential air impacts would be higher compared to Alternatives 2 and 3; however, impacts could be similar to Alternative 1 should aquaculture projects be sited anyway. It is unlikely potential air impacts or aesthetics would be much different than Alternatives 2 and 3 given the low probability that future aquaculture projects would emit large quantities and concentrations of pollutants. Although the wind direction is toward shore, it is unlikely any air emissions would reach the coast given the average wind speed. Anticipated impacts on air quality from activity emissions would be transient, small in magnitude, and localized. Marine vessel traffic and associated air emissions would increase, but it is likely the magnitude and severity would be minimal and not a meaningful change to baseline given predicted vessel size and proximity to shore at both locations. Potential visual and aesthetic impacts would likely not be any different than Alternatives 2 or 3 given the distance from shore; however, visual impacts at night could be compounded depending on various factors, including, but not limited to the number of aquaculture operations, types, color, duration of lights, and whether light shields were incorporated into design. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

vi. Acoustic Environment

Affected Environment

This section focuses on noise in relation to the physical environment. The effects on living resources (Section C) and human health (Section D.iii. (Public Health and Safety)) are described elsewhere. Vessel traffic and its potential impacts is described in more detail in Section D.v. (Tourism and Other Recreation) and D.vi. (Transportation and Navigation). Potential impacts to other resources are covered in Chapter 3, see Section C.i for Level B and Level A ESA disturbance from underwater noise on protected resources, Section C.ii. for noise disturbance impacts on wild fish stocks, and Chapter 4, Section B for cumulative socioeconomic impacts.

On a national level, noise in air is regulated pursuant to the Clean Air Act, Noise Control Act, and the Quiet Communities Act. Most in-air noise regulation occurs at state and local levels. Occupational noise hazards are addressed in OSHA standards pursuant to the Occupational Safety and Health Act, and meeting standards for employees is the responsibility of the employer. Noise in the air and in the water may be regulated due to its effects on animals, habitats, and other resources by many statutes including the MMPA, ESA, MSA and CZMA.

Noise in the ocean comes from natural and anthropogenic sources (Joseph and Margolina 2014), has increased in recent decades, and can be considered a pollutant (Duarte et al. 2021). Anthropogenic noise comes from commercial and recreational boats and ships, military activity, sonar (e.g., navigation, seafloor mapping, research), development and maintenance activities (e.g., dredging, pile driving, construction), energy infrastructure (oil and gas, wind), scientific research, communication and transmission of data, acoustic deterrents, and onboard machinery (Hildebrand 2009; Chou et al. 2021). Commercial shipping is a primary source (ZoBell et al. 2024). Overwater noise, like from aircraft or traffic nearshore, can penetrate underwater. The properties and physics of sound are explained more in the BOEM Sounds Source List document (BOEM 2023a) and NOAA NOS (2022).

Southern CA waters have chronic noise caused by busy ports of Los Angeles and Long Beach and shipping activity (Redfern et al. 2017). Military operations, training, and testing produce overwater and underwater sound in the SCB region (U.S. Navy 2013; Krumpel et al. 2021), though military transits have historically been rare in the AOA alternative areas (Morris et al. 2021). Seal deterrents have been a source of noise in the region (Krumpel et al. 2021). Vessel speed reduction programs to reduce air pollution and interactions with whales have had the ancillary effect of reducing noise levels in Southern CA.

Stressors

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- in-air noise generated by vessel traffic, activities, and machinery; and
- underwater noise generated by activities, systems, and acoustic devices.

For typical offshore aquaculture operations, noise occurs during BES's, construction (vessels, anchoring, pile driving in limited cases), operation (vessels, other sources), and decommissioning (vessels, equipment removal) (Burella et al. 2019). Sound generating devices used in BES's include side scan sonar, single-beam echo sounders (sub-bottom profilers), multi-beam echo sounders, and magnetometers as well as crewed vessels, Remotely Operated Vehicles, autonomous vehicles, and Acoustic Doppler Current Profilers. These devices, and the sounds emitted are described in NOAA NOS (2022), BOEM (2023a) and Sea Grant (2023). Aquaculture facilities may also use acoustic deterrent or harassment devices to deter marine mammals. No substantial sources of vibration are expected to be associated with offshore aquaculture activities except when pile driving is used, which would only occur in limited circumstances.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Only noise at sea is discussed here, however, any future aquaculture project sited within an identified AOA may be required to consider shore side components to the project and its impacts as part of permitting decisions (e.g., occupational noise or impacts on coastal communities from shore side facilities).

Background noise in the open ocean is lower frequency and not as intense as in coastal areas (Olesiuk et al. 2012). The offshore environment, due to deeper waters and more open space, may help mitigate some adverse impacts from noise associated with aquaculture. Projects sited in an AOA may be subject to additional compliance requirements or mitigation measures designed to minimize impacts to biological resources if they propose to generate more impactful types of noise (e.g. pile driving or the use of acoustic deterrents), for additional discussion see Chapter 3, Sections C (Biological Resources).

Noise impacts could occur during BES, construction, operation, and decommissioning (Burella et al. 2019). Project-specific factors that may affect sound production include the number of lines, pens, anchors, and vessels associated with an activity as well as use of deterrents (Bath et al. 2023). The magnitude and duration of use of different technologies during the BES phase could have limited temporal and spatial impacts depending upon the location (NOAA NOS 2022). Noise from construction and operations may be impulsive (e.g. pile driving, limited instances in offshore context) or continuous (e.g. mechanical operations, engines), and generated by vessel and human activity (e.g, sonar, anchoring, on-board noise), fixed-bottom foundations, and floating structures.

Once constructed, offshore aquaculture facilities are not expected to make a meaningful contribution to ambient noise levels. During normal operations, aquaculture equipment is not generally louder than existing vessels in California's coastal waters (CDFW 2019, HI DLNR 2014). Vessel sounds associated with aquaculture operations would likely be in similar frequency and intensity ranges as those of commercial fishing and transport operations (Olesiuk et al. 2012). Safety buffers may be set up around project sites, which may slow vessel traffic and reduce noise (Findlayet al. 2023). Human activity at an aquaculture site would likely be within confined areas like a net pen. The majority of human activity in the water would be for observation and inspection dives. Normal operations are unlikely to create hammering, drilling, or loud noises. Operators may use hand tools and lift bags and these create little to no noise. While feeding operations may require heavier equipment, it is unlikely to add much to the ambient noise in the environment. Few studies have examined the potential impacts of occupational noise exposure in the aquaculture industry (Stone and Morro 2022). Above water noise from vessel activity and onboard machinery has the potential to affect onboard personnel, but standard occupational health requirements would be instituted in specific projects to limit the intensity and duration of noise associated with vessel and machinery operation.

Existing NEPA documents for aquaculture facilities reinforce that noise is unlikely to cause an impact to the physical environment. The Kampachi Velella Project stated that noise generated from the feed barge is equivalent to a single fishing boat for one hour. The associated EA concluded that their operation would impart an imperceptible impact due to noise (EPA 2019). Further, the Blue Ocean Mariculture EA concluded that the facility would have no effect on ambient noise levels (HI DLNR 2014). Similarly, the Ocean Era facility was not expected to make a significant contribution to ambient noise.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The Santa Barbara Channel is a major shipping and transit corridor and noise hotspot (Redfern et al. 2017, ZoBell et al. 2024). The Santa Barbara Channel basin is shielded from deep ocean noise by the presence of the Channel Islands and has abundant low-frequency ambient noise due to commercial vessel traffic (ZoBell et al. 2021). Underwater noise propagation changes with season, with a decrease in radiated noise during the fall due to warm surface waters. One additional single ship transit in the Santa Barbara Channel can increase ambient noise levels averaged over a day by 1 dB (ZoBell et al. 2021). Vessel traffic does occur in Alternative 2 with the majority from passenger vessels, followed by pleasure and sailing, then other vessel transits (Morris et al. 2021); these smaller vessel types are generally quieter than larger cargo ships that frequent the shipping lanes outside the Alternative. Sites in the N2 cluster overlap with a military training route, but historically military transits have been rare (Morris et al. 2021). There is existing energy infrastructure and known scientific survey sites within 5 km (2.7 nm) of the AOA options that contribute to the baseline noise levels. Site and project specific characterization would be considered in project-level NEPA.

a) Shellfish and Macroalgae

An example of noise from typical shellfish construction and operations is provided in Table 3-3 on p. 257, and described in detail on pp. 258 through 262 of the NPS Final Environmental Impact Statement (FEIS) for Drake's Bay Oyster Company Special Use Permit (NPS 2012). While this facility was located nearshore, it was permitted in California and describes typical noise levels from gear types used in construction, oyster cultivation, and associated vessels. Potential impacts from those sound levels were predicted in this example to affect special-status species and wildlife habitat, as well as the natural soundscape of the surrounding area.

b) All Types of Commercial Aquaculture

The impacts reflected under Alternative 2b may generate more acoustic impacts compared to Alternative 2a, because finfish aquaculture operations require additional vessel trips or vessels for feeding purposes or the addition of automated feeders that could generate noise. Considering the distance from shore, remote monitoring and feeding may be used.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Noise from underwater explosions associated with the use of acoustic deterrents has been documented as considerable in Santa Monica Bay (Krumpel et al. 2021). Vessel transit within this area is highest from pleasure and sailing vessels, followed by other vessel and passenger transits (Table 3.18 Morris et al. 2021, p. 188; Table 3.19, Morris et al. 2021, p. 191); generally vessel traffic is low. Compared to Alternative 2, baseline noise levels are relatively lower and the total number of potential sites and footprint that may generate noise is lower. Therefore, siting aquaculture in Alternative 3 may be less impactful on the overall acoustic environment, but may represent a larger proportional change relative to baseline.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section. Compared to Alternative 3a, impacts reflected under Alternative 3b may generate more noise because of the use of feed barges or automated feeders.

Alternative 4: Combination of Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified. Potential impacts to physical resources from noise are greater with more development. Given the baseline condition in Southern CA, it is unlikely that aquaculture development would cause appreciable noise impacts.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

C. Biological Environment and Potential Impacts

i. Federally-Protected Species and Habitat

Affected Environment

The SCB, within the CCE, is known for its productive and biodiverse marine communities. Areas of converging currents, eddies, and upwelling within the SCB are important foraging habitat due to physical processes that concentrate prey (Bearzi 2005, USFWS 2005, Benson et al. 2011, Santora et al. 2012, Huff et al. 2013, Becker et al. 2014, and Kramer et al. 2015). The pelagic waters of the Alternatives provide foraging habitat for all of the protected species groups described in this section of the DPEIS. Many marine mammals, seabirds, sea turtles, and fish also make annual migrations between feeding and breeding sites. The specific species abundance in the SCB varies both seasonally and inter-annually. The most highly vulnerable federally-protected species were incorporated into the Atlas spatial modeling, with suitability scores based on species status, population size, and population trajectory; the ranking for each species/stock used to develop the AOA options considered factors that were more or less likely to affect their ability to withstand mortality, serious injury, or other impacts that could affect the species' ability to survive and recover (Morris et al. 2021). Only the most highly vulnerable protected species were explicitly incorporated into the development of the AOA options, see footnote in Table 5, which indicates which species in the table were not incorporated into the development of AOA options. Data resources used and the Atlas modeling methods are detailed on pp. 23 through 26 and in Table 2.7 on p. 36 of the Methods Section, as well as in Appendix A of the Atlas (Morris et al. 2021).

The Fish and Wildlife Coordination Act (FWCA) directs Federal agencies to conserve nongame species and their habitats, and assist state implementation of conservation plans (16 U.S.C. 2901 et seq.). In addition to coordination required by NEPA, FWCA requires Federal agencies to consult with each other on potential impacts of Federal actions on the environment, species, and habitat in accordance to the laws described in this section. Under Section 662 of FWCA, whenever any body of water is proposed or authorized to be controlled or modified for any purpose, by any department or agency of the U.S., or by any public or private agency under Federal permit or license, consultation is required with the USFWS representing the Department of the Interior (DOI), and with the head of the agency exercising administration over the wildlife resources of the particular state where the activity takes place. Some species have additional federal protections, discussed below. California has state-level protections for many of the same species and some additional conservation concerns, discussed in Chapter 3, Section C.iii. (Ecologically-Important Marine Communities).

Threatened and Endangered Species

The Endangered Species Act (ESA) is the regulatory regime for species that are in danger of extinction throughout all or a significant portion of their range. Species listed as threatened or endangered under ESA have been determined by a petition and a formal agency population review, based on available scientific and commercial data, to be under at risk of extinction due to the present or threatened destruction, modification, or curtailment of its habitat; due to the overutilization or harvesting; or due to disease or predation. Section 7(a)(2) of the ESA mandates that actions that are authorized, funded, or carried out by Federal agencies do not jeopardize the continued existence of plants and animals that are listed, or result in the adverse modification or destruction of designated critical habitat. Designated critical habitat is defined at 16 U.S.C. §§ 1532(5).

NMFS is responsible for implementing the ESA for marine and anadromous species, with a few exceptions that are managed by USFWS (e.g. southern sea otter). For aquaculture facilities sited in an AOA, NMFS has regulatory responsibility under the ESA for protected species of most marine mammals, sea turtles (in the offshore marine environment), fishes, sharks, rays, and invertebrates; USFWS would implement the ESA for protected species of birds and some marine mammals. USFWS also assesses U.S. migratory, nongame bird populations under the Fish and Wildlife Conservation Act for whether they are likely to become designated as threatened or endangered under the ESA, and designates those species likely to become ESA-listed without directed conservation measures as Birds of Conservation Concern (BCC) (USFWS 2021). BCCs are listed in Appendix 1 on pp. 36 through 46 of the most up to date USFWS Birds of Conservation Concern (USFWS 2021). This programmatic NEPA analysis would support permitting agencies' decisions for any future aquaculture facilities sited in an AOA, in addition to more detailed information that may be required to consult with NMFS and USFWS on specific activities associated with project designs and alternatives. Section 9 of the ESA additionally prohibits the "taking" of any protected species, defined at 16 U.S.C. § 1532(19)). Prohibited take activities include those which actually kill or injure fish or wildlife, and may include significant habitat modification or degredation which actually kills or inures fish or wildlife by significantly impairing essential behavioral patters, including, breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR § 222.102). Measures to avoid take pursuant to Section 9 would be developed with NMFS and USFWS during ESA Section 7 consultations.

Federally-protected species that have the potential to occur in the AOA alternative areas, their designated critical habitat, characteristics of habitat use, and conservation concerns, are summarized in Table 5. Critical habitat for humpback whales (*Megaptera novaeangliae*) overlaps all Alternative 2 AOA options except N2-D and N2-E, as shown in Figure 3.48 on p. 116 and Figure 3.66 on p. 143 of the Results Section of Morris et al. (2021). There is no designated critical habitat for any protected species within Alternative 3. The ways in which climate change may impact critical habitat in the marine environment is addressed in Chapter 4, Section A.i. Detailed life history information for Federally-protected species is not provided at length in this DPEIS, but may be found online on the NMFS ESA Species Directory, and in the USFWS Environmental Conservation Online System (ECOS), web addresses provided below:

- https://www.fisheries.noaa.gov/species-directory/threatened-endangered
- https://ecos.fws.gov/ecp/

Sea Turtles

Three of the four species of sea turtles featured in Table 5 are thought to occur rarely in coastal waters of the SCB, and have been sighted in the offshore environment of the SCB. Leatherback sea turtles use eddies and persistent fronts to forage, but usually avoid the warm waters of the SCB (Benson et al. 2011, NMFS 2012, and CBD 2019). Olive ridley sea turtles inhabit warmer, more subtropical waters off the coast of Mexico, but may shift north during ENSO periods when the SCC strengthens; and there are stranding records in the CCE (82 FR 48674, Peavey et al. 2017). Juvenile loggerhead sea turtles may be found within or in proximity to the alternative areas, based on telemetry data and documented fisheries interactions (Eguchi et al. 2018, CA Herps 2024, and NOAA 2024a). Green sea turtles have resident populations in southern portions of the SCB and close to shore, with primary habitat in seagrass beds and estuarine waters warmer than 15°C (82 FR 48674, Crear et al. 2016, and Hanna et al. 2021). Green sea turtles have been captured at Stearns Wharf in Santa Barbara harbor, and at the Channel Islands (VPD 2018). Of these four species, Loggerhead sea turtles are the most likely to be found near the Alternatives; but presence is thought to be sporadic and correlates with warm water periods (Eguchi et al. 2018, Morris et al. 2021). Both Green sea turtles and loggerhead sea turtles have stranded on nearby beaches within the last decade (VPD 2018). Some of these species have designated critical habitat, but none of it overlaps any of the Alternatives.

Marine Mammals

In addition to the marine mammals protected under ESA, all marine mammals are protected under the Marine Mammal Protection Act (MMPA) MMPA-protected species that have potential to occur in the AOA alternative areas are included in Table 5. Intentional or directed take of any marine mammal is prohibited (16 U.S.C. §1362). Most activities that have the potential for incidental take of marine mammals require case-by-case approval upon request from the Secretary of Commerce. Sections 101(a)(5)(A) and (D) of the MMPA detail the authorization for a specified activity that may cause take other than commercial fishing, within a specified geographical region, with public notice and review. An example of an incidental take from activity other than fishing is seismic surveys. Depending on specific project design, applications for permitted actions for projects sited in an AOA may require authorization if there is potential to disturb marine mammals during baseline environmental surveys, construction, operations, or decommission. NMFS has authority under the MMPA over cetaceans and pinnipeds; USFWS is responsible for select other marine mammals, including sea otters and Steller sea lions. Any incidental take of marine mammals during activities would be reported in procedures determined during permitting decisions.

Pinnipeds (seals and sea lions) that are most likely to occur in the alternative areas are presented in Table 5. The most common species in the SCB is the California sea lion. Northern elephant seal and Pacific harbor seal are also both common throughout the region. Sea lions and seals have rookeries (breeding/pupping sites) and haul out areas throughout the Channel Islands, especially on the northern islands, along with multiple mainland shores (Schiff et al. 2000, NCCOS 2005, Morris et al. 2021, and SWRCB 2021). Fur seals are less common than the other pinniped species in the SCB; but there is a small rookery on San Miguel Islands and populations are thought to be increasing, according to stock assessments from the Channel Islands, and on the Farallon Islands in central California (NCCOS 2005, Caretta et al. 2023 (Northern Fur Seal last revised 2015)). Some of the largest pinniped rookeries on the west coast are on San Miguel Island (Schiff et al. 2000, NCCOS 2005). Seasonal abundance of elephant seals, harbor seals, and sea lions within Santa Monica Bay is shown in Fig. 5 on p. 8 of Bearzi et al. (2008).

Cetaceans (dolphins and whales) are also diverse and abundant in the SCB. Multiple dolphin species are prominent, including Common (*Delphinus delphis*), Bottlenose (*Tursiops truncatus*), Long- and Short-beaked (*Delphinius capensis*) and (*Delphinius delphis*), Risso's (*Grampus griseus*), and Northern Right whale (*Lissodelphis borealis*). The most observed baleen whales near the alternative areas are the Gray whale (*Eschrichtius robustus)* and Humpback whale. Blue (*Balaenoptera musculus*), Fin (*Balaenoptera physalus*), and Minke (*Balaenoptera acutorostrata*) whale are all observed commonly in the SCB, depending on season and oceanographic conditions (Becker et al. 2020, Carretta et al. 2023). The following resources provide more species-specific information on cetacean habitat use in the areas of analysis:

- Habitat models in the SCB for 14 cetacean species are provided in Section 6.1 on pp. 167 through 186 of the CJNMS BGA (NCCOS 2005).
- Seasonal abundance of three resident species of dolphins in Santa Monica Bay is shown in Fig. 2a,b,c of Bearzi (2005).
- Seasonal occurrences of marine mammals in the SCB are provided in Table F-2 of Appendix F in the Cabrillo Power LLC Marine Wildlife Contingency Plan (CSLC 2015).
- Becker et al. (2020) provides distribution models for multiple cetacean species in the CCE. Those that indicate high predicted density near the AOA alternative areas are Figure 2a-d and 32; Figure2g; Figure 2j; Figure 2k-n.
- Ecologically-important areas for protected resources relative to Alternative 2 are shown in Figure 3.48 on p. 116 and Figure 3.66 on p. 143 of the Results Section of the Atlas (Morris et al. 2021).
- Ecologically-important areas for protected resources relative to Alternative 3 are shown in Figure 3.86 on p. 175 of the Results Section of the Atlas (Morris et al. 2021).

In addition to designated critical habitat under ESA, NMFS has identified cetacean Biologically Important Areas (BIAs). The aim of delineating BIAs is to use the best available science to characterize important areas for specific species, populations, or stocks that can aid managers in cetacean impact assessments or other conservation efforts; BIAs are not regulatory. Phase I BIAs were considered in the Atlas. Recent updates to the methods and BIAs identified in marine waters of California were published after the spatial modeling in the Atlas (Calambokidis et al. 2024). These Phase II BIAs and any future updates should be considered in future site-specific environmental planning.

Birds

Most birds that occur in the EEZ are protected under the Migratory Bird Treaty Act (1918) (MBTA) (16 U.S.C. §703-712, 50 C.F.R. §10.13). The list of species protected under the MBTA may be found at 50 C.F.R. §10.13. USFWS is the responsible agency for MBTA, including seabird management and colony monitoring. E.O. 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds" (E.O. 13186, 2001), strengthens interagency efforts under MBTA and ESA and the implementation of international, bilateral conventions for the conservation of migratory birds. Although E.O. 13186 refers to interagency MOUs with USFWS outside of the AOA planning process, the conservation measures may still apply as practicable mitigation for Federal agency actions in the absence of an MOU (USFS 2022). Seabird population monitoring in the CCE is coordinated with the USGS, the NWR system, as well as state and local-level groups (USFWS 2005). USFWS also works with agency and organization partners to implement the Waterbird Bycatch Policy, which promotes public awareness on conservation issues or violations of MBTA at sea, along with the gathering of scientific information to inform guidelines for management, regulation, and compliance (USFWS 2000).

It is estimated that several million seabirds, representing over 100 species, occur off the coast of California (USFWS 2005). The range of many of these species is the greater Pacific region, for foraging or nesting. Table 5 includes the species of birds that are protected under the ESA only. Additional MBTA-protected species that may occur in the SCB are numerous. Species and detailed life history information may be found in the USFWS Pacific Region's Regional Seabird Conservation Plan (USFWS 2005). The following resources provide more species-specific information on seabirds:

- Seabird species that may occur in U.S. West Coast EEZ are listed on pp. 40 and 41 of PFMC's Environmental Assessment for the Comprehensive Ecosystem-Based Amendment 1: Protecting Unfished and Unmanaged Forage Fish Species of the U.S. Portion of the California Current Ecosystem (PFMC 2016).
- Breeding seabirds of coastal California are listed in Table 1 on pp. 18 and 19 of the USFWS Pacific Region's Regional Seabird Conservation Plan (USFWS 2005).
- More information on habitat use by commonly-sighted seabirds in the SCB, with additional literature review, in the SCB is provided in Figure 5.0.1 on pp. 136 and 137 of the CINMS BGA (NCCOS 2005).
- Six focal species thought to indicate foraging conditions in the CCE are featured in Table M.1. on p. S-61 in Appendix M of Harvey et al. (2023).

Temporal variations in seabird populations are associated with reductions in food supply caused by natural factors such as El Niño events. Seabird density and diversity is higher in the spring and fall during migration seasons than in winter (USFWS 2005). Nesting colonies are monitored throughout the California Coastal National Monument and Corridor, on the Channel Islands, and NWR lands near San Diego (USFWS 2005). San Miguel, Santa Cruz, Santa Rosa, Anacapa, and Santa Barbara Islands are important nesting colonies for many species, and the NWR lands near San Diego are important for gulls and terns (NCCOS 2005, USFWS 2005). It is likely that birds from these nesting colonies would use waters throughout the SCB.

The California Least Tern and the Snowy Plover are included in Table 5 due to the species' ESA protected status. The southern portion of Terminal Island, at the Port of Long Beach, hosts approximately 13% of the state's total California Least Tern population (MESC 2023). Snowy plovers have ceased breeding on most of its historic habitat, which includes beaches north from Santa Barbara, south through San Diego County (USFWS 2007). There are nesting colonies of Snowy plover on the Channel Islands (NPS 2016). These two species use coastal habitat only for breeding and foraging, and are not thought to migrate between the mainland and the Channel Islands (NPS 2016). It would be rare for either species to occur over offshore waters. Some of these species have designated critical habitat, but none of it overlaps any of the Alternatives.

Fish and Shellfish

ESA-protected fish species in the SCB include the Oceanic Whitetip shark (threatened), Scalloped hammerhead shark (endangered), Giant manta ray (threatened), and Steelhead trout (threatened). Protected shellfish species include the green and white abalone. Some of these species have designated critical habitat, but none of it overlaps with any of the Alternatives and all of these species are considered unlikely to occur.

Other

Some additional Federally-protected species are also acknowledged to have historic range, or rare sightings in the SCB, but the region is not managed as current habitat for the species. These species are not addressed further in the text of this DPEIS, but may need to be considered under site-specific NEPA analysis, depending on new population trends or specific project plans at the time of permitting. Examples include:

- Bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*) exist on the mainland and on the Channel Islands, and are sometimes observed over the ocean; but both species are thought to forage close to their nesting territories, therefore it is unlikely either species would forage in offshore areas (Wiemeyer et al. 1993, Dekker and Bogaert 1997, Dooley et al. 2005, and NPS 2024a,b).
- California Condors (*Gymnogyps californianus*) are scavenger species that are sometimes observed in coastal habitat and very rare historic accounts of foraging live prey (Tyner et al. 2013, USFWS n.d.). The species relies on cliffs or other areas of reliable air currents to take off and fly, and is not known to ever fly between the mainland and offshore islands (Cornell Lab 2024, D'Elia and Haig 2013). Therefore, it is unlikely that condors would occur in offshore areas.
- There are historic populations and recorded occurrences of at least 14 bat species across the eight Channel Islands (Brown and Rainey 2018). The species are listed in Table 1 on p. 475 of Brown and Rainey (2018). Bats use the Channel Islands as a stop-over during migrations (Brown and Rainey 2018, NPS 2020). Bats are also shown to be affected by artificial light, including during foraging and migration (Buchler and Childs 1982, Rydell 2006, Lewanzik and Voigt 2014, and Brown and Rainey 2018). The potential for bats to occur in the offshore environment is low, so they are not included in Table 5. However, there are ongoing survey and monitoring efforts as a part of offshore wind leasing (Solick and Newman 2021, SEER 2022, BOEM 2023b, and Kennerley 2024).
- Killer whales (*Orcinus orca*) thought to be from the Eastern Tropical Pacific stock were sighted recently by whale watching ventures operating offshore between Oxnard and San Diego; and the recent activity may have been concentrated around Long Beach and Newport Beach (Fudge 2023, Sternfield 2024, and Waterhouse 2024).
- Historic range of the Southern sea otter (*Enhydra lutris nereis*) includes the SCB; and there is a very small translocated population at Nicolas Island far offshore (USFWS 2022). However, Southern California is not an area thought practical or achievable for reintroduction (77 FR 75266, USFWS 2022); and the species does not tend to use open offshore EEZ waters, primarily preying upon benthic invertebrates in state waters nearshore (Lafferty and Tinker 2014).
- Steller sea lion (*Eumetopias jubatus*) Western DPS had historic rookies on San Miguel Island; but the rookeries have not been occupied since the 1982 El Niño event (NCCOS 2005, NMFS 2023b).

Stressors

Existing conservation concerns for ESA, MMPA, and MBTA protected species in the SCB include fisheries bycatch, vessel strikes, invasive species, human disturbance, habitat degradation, and pollution. Species-specific conservation concerns are included in Table 5. Infectious disease is one of the top five stressors attributed to species extinction (Smith et al. 2006, Mashkour et al. 2020). See Chapter 4, Section

A.i. for more of a discussion related to climate change. Environmental changes can act as a stressor; and certain life history characteristics can exacerbate the impacts when combined with these changes. For example, species with low fecundity such as marine mammals and seabirds are especially vulnerable to population declines if factors such as diminished food supply during El Niño events reduce survival of offspring.

Sometimes multiple animals are found stranded or dead within a certain timeframe or defined area, which can indicate environmental and ocean health issues, called a "mass mortality event" or "unusual mortality event (UME)" (NMFS 2024a,b). These types of events are sometimes attributed to past and ongoing activities that contribute to the baseline conditions of populations and habitat. UMEs that have occurred within the last 10 years are listed with associated species, probable cause, and NOAA Fisheries news feature or other source in Appendix 2.

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- fixed gear and other equipment placement in the water column and at the surface (leading to risk of entanglement, interference with migration, or foraging);
- increased vessel and human activity;
- noise generated by systems, equipment, activities;
- use of deterrents, artificial light;
- wildlife aggregations;
- risk of effluents;
- risk of marine debris; and
- risk of disease.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The risk and severity of interactions with Federally-protected species would need to be analyzed for each project sited in an AOA, based on survey and operation needs, the gear, footprint, and specific location. Operational procedures and the timing of operations also influence the degree of impacts (Young 2015). Uncertainty amplifies the risk of impacts; and there is a lack of available information on aquaculture impacts to Federally-protected species in the SCB. These risks are discussed in more detail below. The analysis includes proxy information from aquaculture interactions outside the region, and from interactions in the region from other marine industries. Methods and criteria to rate the risk of interactions include likelihood of exposure, the rate or duration of exposure, sensitivity of consequence (e.g. lifestage), and resilience to consequence (e.g. population size or reproductive strategy) (Verutes et al. 2020). An example of how to define and score exposure and consequence in a spatially-explicit area is summarized in Table 3 on p. 11 of Verutes et al. (2020). Generally, impacts to protected species and habitat may be thought of as animal disturbance and take, habitat disturbance and changes to habitat use, as well as impacts from an ecological perspective. All impacts would be species- and scenario-specific. Many types of impacts may interact, e.g., additional entanglement risks may be created due to changes in habitat use and aggregations, or marine debris snagging on underwater aquaculture structures.

Offshore aquaculture activities have the potential to cause "take" of protected species during site assessments, construction, operations, and decommissioning. The definitions of take under the ESA, MMPA, and MBTA are included in Appendix 3. Any project sited in an AOA may be required to apply for an incidental take authorization, and/or may be the subject of take coverage through consultation on federal actions related to the project. An individual's behavior and movements through an area can change due to gear in the water, increased vessel and human activity, noise, and artificial light. Individuals could be injured or killed by seafloor disturbance, behavioral disturbance, entanglement, or vessel strikes. Any species' ability to detect disturbances or objects in the water to navigate or forage may be compromised in certain environmental conditions, such as low light conditions, storms, or turbid waters (Benjamins et al. 2014, Young 2015). These scenarios may result in population-level impacts, depending on incidental or chronic exposure, as well as the size and range of the population.

Section 118 of the MMPA classifies all U.S. commercial fisheries into one of three categories (I, II, III) based on the level of incidental serious injury and mortality of marine mammals that may occur in each fishery (e.g. Category I = frequent, Category II = occasional, Category III = remote likelihood). These categories are included in Table 6. The categorization of a fishery determines the application of certain provisions of the MMPA, such as registration with NMFS, observer coverage, and take reduction plans. Marine aquaculture operations in the California EEZ are listed under Category III (CDFG 2010, NMFS 2023c).

Entanglement

Globally-documented entanglement cases in shellfish and finfish aquaculture facilities are summarized in Table 3.2 of Mori and Riley (2021), and in Bath et al. (2023). Entanglement reports from macroalgae aquaculture were not found in preparation of this DPEIS. In general, better assessment of the entanglement monitoring processes and reliability in assessing aquaculture operations globally is needed to determine if the few recorded events are an accurate representation of the potential for entanglement (Mori and Riley 2021). The uncertainty in records from both aquaculture and from fisheries bycatch is high, due to the following considerations from Knowlton and Kraus (2001), Saez et al. (2021), Mori and Riley (2021), and Bath et al. (2023):

- incidents can be difficult to detect when they occur below the surface of the water;
- carcasses often sink when the animal dies and are not detected or recovered;
- observer(s) not likely to present at all times;
- gear goes missing and the reason for damages are unknown;
- lack of documentation and public awareness for information sharing;
- documents or other sources are missed due to limits on information sharing, language barriers, or policy relevance;
- patterns in animal interactions (more entanglement events) or in human activity at sea (more observations) could cause increases in reports; and
- reports may be biased for proximity to human activity and weather conditions.

Baleen whales may be at higher risk for entanglement, compared to smaller cetaceans that use echolocation to navigate their environment and feed (Swartz and Jones 2016, Saez et al. 2021, Mori and Riley 2021, and Bath et al. 2023). Based on reports globally, juvenile whales seem most likely to be at risk for entanglement (Benjamins et al. 2014, Swartz and Jones 2016, Price et al. 2017, and Bath et al. 2023). Gray whale cow-calf pairs pass through the SCB in high frequency March through May, and Humpback cow-calf pairs migrate through the SCB in summer and fall. Cow-calf pairs of both species tend to stay close to shore, near shallow waters, bays and lagoons (Swartz and Jones 2016, Guazzo et al. 2017, Swartz 1986, VPD 2018, and Jones et al. 2023). One local monitoring group noted in survey data from 2007 through 2017 that it was rare to see a Gray whale cow-calf pair more than 0.75 miles from shore (Gray Whale Count 2017). Many cow-calf pairs of other cetacean species are observed throughout the SCB, included in Table 2 on p. 7 of Smultea et al. (2017). Entanglement of female protected species with offspring, or pregnant, would be more risk of population implications (Clement 2013). In addition, whales' larger bodies make them less agile, and their feeding strategies to engulf large volumes of water make them more susceptible (Price et al. 2017). Sea turtles are also thought to be susceptible to entanglement as a result of their body configuration and behavior (Seminoff et al. 2015, Upite et al. 2019). Based on fisheries entanglement records, Leatherback sea turtles may be the most vulnerable to interactions generally, due to a widespread species distribution and broad potential foraging grounds (Young 2015, Mori and Riley 2021). Many bird species may be attracted to floating aquaculture gear, as roosting or feeding sites, and can become entangled, which can cause them to drown, starve, or suffer physical trauma (Bath et al. 2023, Barnes 2019). Larger sharks could become entangled in predator-control nets, but are not likely to be at risk for other gear interactions. Benthic species and pelagic fishes are not likely to be at risk for entanglement.

While the presence of highly mobile species are difficult to predict, the habitat compression index (HCI) can describe how much cool, productive water is available in the ecosystem, from 0 (complete coverage of warm offshore water in the region) to 1 (cool water fully extending 150 km (81 nm) from the coast) (Santora et al. 2020). HCI values closer to 0 compress prey community composition and distribution, which in turn can help forecast spatial aggregation patterns of top predators (Harvey et al. 2023). This physical-based index has been used to forecast increased rates of whale entanglements in fixed fishing gear along the west coast, and could potentially be applied to aquaculture in the region. See ongoing monitoring and coordination below for current resources of physical-based forecast tools used in the west coast EEZ. These and other spatial variability models based on patterns in upwelling and associated hydrographic fronts could be used to address entanglement risk.

A proxy to assess risk to protected species in the SCB may be considered from reviewing regional reports of entanglements in derelict fisheries gear. Fixed gear is a major source of mortality and injury for cetaceans along the west coast (Saez et al. 2021). In data analyzed from 1982 through 2017, and 2015 through 2018 (during what was considered to be peak years for entanglements), Gray whales and humpback whales were the most frequently reported species; incidents with Blue whales, fin whales, minke whales, killer whales, and sperm whales (*Physeter macrocephalus*) were also reported (Seaz et al. 2021, Harvey et al. 2023, and NMFS 2023d). Entanglement reports increased during March and April (Saez et al. 2021). Perspectives are divided on whether or not fixed gear fisheries bycatch should be used as a proxy to estimate risk of longline aquaculture entanglement. A noted difference are the diameter of lines, (typically 12 mm in diameter in fisheries versus 20 mm to 50 mm or greater in shellfish longline aquaculture); however lines to surface marker buoys and spat collecting ropes are typically thinner 12 mm or less and may pose a comparable entanglement risk (Lindell and Bailey 2015, Young 2015, Knowlton et al. 2016, and USACE 2021). In data analyzed from 2015 through 2018, nine out of 16 entanglements with gear from an unknown source had buoys attached (NMFS 2023d). Another notable difference between fixed fisheries gear and aquaculture gear is that shellfish longlines tend to be under greater tension (e.g. 800lbs) (Young 2015, VPD 2018, and Mori and Riley 2021). See referenced engineering documents under Chapter 3, Section D.viii. (Public Health and Safety) for more examples and modeled recommendations for aquaculture line tension. The breaking strength of lines in the water would pose a tradeoff: greater strength for keeping gear integrity may also decrease the risk of entanglement because the lines would be too taught to wrap around an animal; but upon impact, the risk of injury to the animal may increase (Knowlton et al. 2016, VPD 2018).

Additional adverse impacts may occur when an animal that is already entangled encounters aquaculture gear and gets further entangled, which is known as secondary entanglement. Secondary entanglement may occur if an animal is already dragging derelict gear , such as weather buoys, nets, or pot/traps and that material interacts with aquaculture gear (Benjamins et al. 2014, Saez et al. 2021, and Bath et al. 2023). Or, if aquaculture gear collects marine debris from other sources, wildlife may become entangled in the debris (SEER 2021). Injuries from primary or secondary entanglement can permanently impair an animal's ability to swim, forage, or breathe – all of which may result in injury or death. Injuries to protected species may also occur during human interactions as part of rescue efforts, or because they get tangled in anti-predation measures (CDFW 2010, Bath et al. 2023). Primary and secondary entanglements may also lead to damaged gear, loss in revenue, and human health and safety risks (discussed in other sections of this DPEIS).

Marine Debris

Accidentally-discarded or lost gear or other supplies from an aquaculture facility could result in marine debris interacting with Federally-protected species and critical habitat. Types of marine debris associated with aquaculture gear and the reported adverse impacts to wildlife are summarized in Section 3.5 on p. 21 of Bath et al. (2023). Debris that makes it to the seafloor accumulates near coastlines and submarine canyons (Spykra 2017). Protected benthic species may be more susceptible to impacts from marine debris directly around a project footprint. Behaviors observed in pelagic species related to marine debris include interacting with marine debris for reasons that imply play, socio-sexual displays, and tool use (Owen et al. 2012). There are reports of birds in Australia incorporating rope lines from mussel aquaculture into nesting material (Lloyd 2003). These interactions may not be adverse, but exposes individuals to risks associated with adverse impacts from marine debris, including entanglement, suffocation, or starvation if ingested (EPA 2011a, CalOPC 2018, ONMS 2019, and Bath et al. 2023). When tangled, it leaves animals more susceptible to other threats including injury, infections, and vessel strikes (ONMS 2019). When ingested, marine debris may also increase tissue contamination with POPs and heavy metals (USFWS 2005, Spyrka 2017). The effects of marine debris may also diminish surrounding habitat condition and function, in support of protected resources needs (discussed further in Chapter 3, Section C.iii. (Ecologically Important Marine Communities).

Vessel Strikes

Vessel strikes could occur for any pelagic species and diving seabirds. Impacts from vessel interactions range from behavioral disturbance to injury or death. Vessel interactions may also lead to damaged gear, loss in revenue, and human health and safety risks. Disturbance caused by motorboats is also related to behavioral responses in marine mammals and birds, in which animals stop foraging or resting activities and move away from what is perceived to be a threat (NPS 2012). Factors that may be considered include vessel speed, the number of vessel trips needed to install and tend to gear, existing volume and density of vessels in the action area, as well as the density of protected species and their behaviors, especially for the seasonality or timing of vessel operations. These factors would likely be incorporated into permit conditions for in-water work.

Historically, the risk of vessel strikes in aquaculture projects has been generally considered discountable, even in riverine or nearshore environments, provided mitigation requirements (VPD 2018, Mori and Riley 2021). Smaller boats have the potential to injure or kill marine wildlife when traveling at high speeds (Ritter 2012).

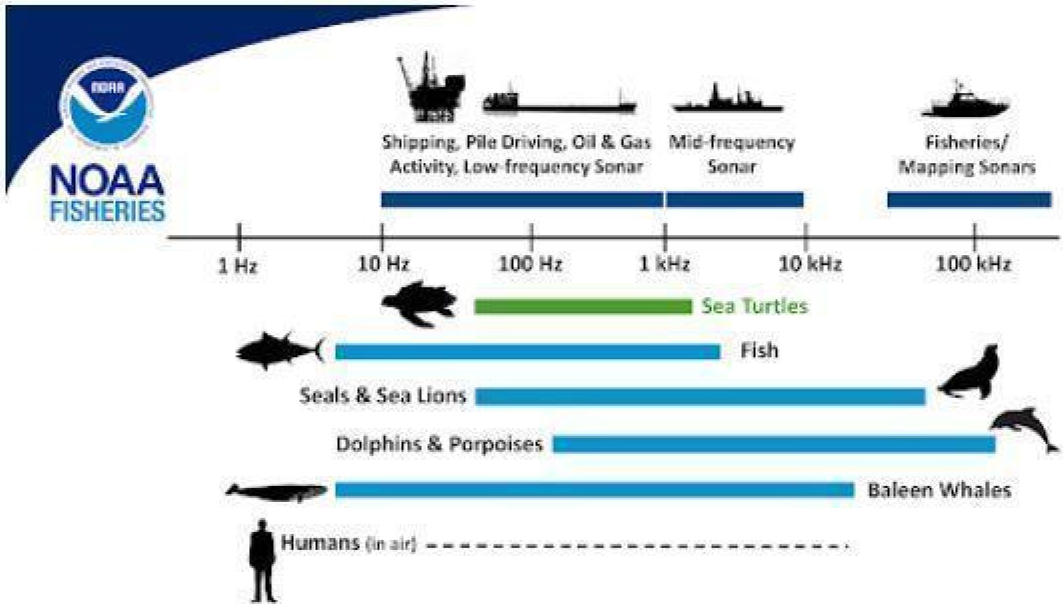
The expansive pelagic habitat of the offshore environment is thought to help mitigate risk for vessel strikes given the space for animals to disperse away from an action area (Moore and Wieting 1999, Mori and Riley 2021). However, the SCB has a very high volume of vessel traffic, ranging from sailing and pleasure craft to major shipping, oil tankers, and military vessels (see Chapter 3, Section D.vi. (Transportation and Navigation). The baseline conditions may create a high risk of vessel strikes in the SCB, where whale mortalities due to vessel strikes have been some of the highest in the U.S. (Rockwood et al. 2017, Rockwood et al. 2021, Cusato 2021). Most cases where whales were known to be hurt or killed occurred at vessel speeds of 14 knots or more, and caused by large ships of 80 meters or more in length (Laist et al. 2001). Similar to entanglement mortalities, these recorded events are thought to be underestimated since the carcass would likely sink (Rockwood et al. 2021). Maritime shipping lanes that concentrate traffic of large vessels were considered not suitable for aquaculture and do not overlap with any AOA options (Morris et al. 2021). Vessel speed reduction (VSR) programs are a proven effective conservation technique (Rockwood et al. 2021, Cusato 2021). More information about vessel traffic may be found in Chapter 3, Section D.vi. (Transportation and Navigation).

Increased vessel traffic and changes in traffic patterns due to AOA-associated maritime traffic may increase strike risks. Should animals avoid an AOA due to increased aquaculture activity within the AOA, they may end up closer to the shipping lanes or further offshore, and at higher risk to be in the way of large ships and fishing vessels. Buffers were applied to transportation and navigation considerations in the Atlas, and different AOA options are different distances from existing maritime traffic; this potential impact would be considered in more detail in future site-specific environmental planning if necessary. Siting multiple facilities within an AOA (versus a No Action Alternative where proposed facilities would not benefit from long-term planning and environmental review) could help permitting agencies and biologists assess the risk of increased vessel traffic that may be more specific for a coordinated, predictable area, rather than a generalized cumulative impact assumed for a region with multiple, uncoordinated uses.

Noise and Light Pollution

Sound is more important for some species' than others to navigate and interpret their environment. This, combined with variations in sensory capabilities, result in different reactions to sounds. Species may be exposed to underwater noise with no impact or habituate to the sound over time. They could be attracted to the source out of curiosity; or they could startle and avoid the sound source, or even experience internal injuries (NMFS 2018, NMFS 2021a). Disruptions to the baseline acoustic environment can impact individual behavior, as well as community structure or even biodiversity for marine mammals, sea turtles, fishes, and invertebrates (Mooney et al. 2020, NMFS 2021a). Regulatory mechanisms to monitor and mitigate adverse impacts from underwater and overwater noise are discussed in Chapter 3, Section B.vi. (Acoustic Environment).

The risk of injury to marine life from anthropogenic noise depends on the specific activity and the hearing capability of the species present, as well as the distance from the sound source (Clement 2013, NMFS 2018, SEER 2021, and NMFS 2021a). The general hearing range of marine mammal species groups is summarized in Table ES1 on p. 3 of the most recent NMFS Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NMFS 2018). Many fishes and benthic invertebrates produce low frequency sounds (Mooney et al. 2020). Sea turtles also have a hearing range in lower frequencies (NMFS 2023e). Figure 9 shows the overlap of general hearing ranges with common anthropogenic noise in the marine environment. There is potential for diving seabirds to be affected by underwater noise as well; but more likely, seabirds may be attracted to an area due to overwater noise and activity. There are many established mitigation methods required for marine industries under ESA, MMPA, and MBTA that would be incorporated into project designs and operations plans through the permitting process.



The range of frequencies sea turtles can hear overlaps with the general hearing ranges of many other marine species and sources of human-caused sound. 1 kHz is equal to 1,000 Hz. Credit: NOAA Fisheries.

Figure 9: Hearing Ranges and Common Anthropogenic Sounds in the Marine Environment

Underwater noise has the potential to occur at all stages of an aquaculture project. Project specific factors that may affect sound production include the number of lines, pens, anchors, and vessels associated with an activity (Bath et al. 2023). Any required seafloor mapping during baseline environmental surveys may also impact the underwater acoustic environment (NOAA NOS 2022). A comparison of how sound travels and refracts in shallow versus deep ocean water is described in Section 2.2.5 on pp. 9 and 10 of Olesiuk et al. (2012). Noise from construction and operations may be impulsive (e.g. anchors, chains) or continuous (e.g. engines), generated by vessel and human activity, fixed-bottom foundations (e.g. pile driving), floating structures (e.g. mooring lines), or mechanical operations. Vessel sounds associated with aquaculture operations would likely be in similar frequency and intensity ranges as those of commercial fishing and transport operations (Olesiuk et al. 2012). Background noise in the open ocean is lower frequency and not as intense as in coastal areas (Olesiuk et al. 2012). The offshore environment, due to deeper waters and more open space, may help mitigate some adverse impacts from noise associated with aquaculture.

Artificial light could impact pelagic species and birds at any stage of an aquaculture project. It is not likely that benthic species would be impacted by lighting systems. Impacts could range from no impact to disturbance or injury, or an increase in predation activity (Clement 2013). Artificial light under barges, around oil and gas platforms, and other structures in the water can influence the behavior and community structure of plankton, nektonic invertebrates, fishes, and marine mammals (Nightingale et al. 2006, Ono et al. 2010, Barker 2016, Bassi et al. 2022, Simons et al. 2021, Marangoni et al. 2022, and Oyabu et al. 2024). A review of the impacts of artificially-lit coastal infrastructure on movements of juvenile salmonids is summarized in Table 1 on pp. 9 and 10 of Ono et al. (2010). Impacts observed in the marine coastal environment may be similar to what could occur in the offshore environment of the SCB. Predatory fish and marine mammals that may occur in the alternative areas may be drawn towards lighting systems, which could increase foraging opportunities. Seabirds and sea turtles would likely be most at risk for adverse impacts from artificial light. Documentation from fisheries shows that lights disorient birds and can cause them to fly into ships, causing injury or death (USFWS 2005). Light pollution is known to be one of the leading threats for sea turtles (Seminoff et al. 2015, Fisher 2021, and NMFS 2021b). In addition, Thums et al. (2016) found that Green sea turtle hatchlings were also attracted to light after entering the ocean. Attraction or disorientation associated with light may lead to sea turtles being more susceptible to predation, or changes in foraging success and fitness.

The potential is low for any shorebird species to occur in any of the Alternatives. However, shorebirds are known to be impacted by artificial light in the coastal environment (Simons et al. 2021). If an individual (e.g. California Least Tern, or other ESA-listed shorebirds included in Table 5) were to fly between the mainland and the Channel Islands it may be disoriented by a concentration of lights in an AOA.

Similar to vessel strikes, a potential benefit to siting multiple facilities within an AOA (versus a No Action Alternative where proposed facilities would not benefit from long-term planning and environmental review) could help permitting agencies and biologists assess the risk of increased noise and light for a coordinated, predictable area, rather than a generalized cumulative impact assumed for a region with multiple, uncoordinated uses. Potential noise and light generated by other marine industries interacting with aquaculture facilities is included in Chapter 3, Section B.v. (Air Quality and Aesthetics), Section B.vi. (Acoustic Environment), and Chapter 4, Section A.ii. (Other Ocean Uses).

Habitat Use

Offshore aquaculture activities during site assessments, construction, operations, and decommissioning have the potential to impact habitat characteristics and habitat use. Changes to habitat use may include exclusion, avoidance, or attraction. Changes could occur due to the gear in the water, or from human activity. Behavioral impacts may be limited to individuals or during the time of a certain activity, or local populations may become habituated to aquaculture activities within an AOA and change foraging success or migration patterns, based on more continuous aquaculture activities. Habituation could range from no impact or beneficial impacts if it increases foraging success. In contrast, a population could be adversely impacted if individuals experience long-term foraging, navigation, or communication obstacles that may lead to decreased reproductive success in local populations. Adverse impacts can also occur if individuals are forced to move, even temporarily, to areas with higher vessel traffic, more congestion, and so forth.

The spatial scale of behavior and habitat use modification is thought to affect not only a project footprint, but the surrounding geographic area (Clement 2013, Price et al. 2017). This effect would likely be amplified by siting multiple aquaculture facilities in an AOA. The temporal scale of impacts may vary according to lifetime of the project, and if the affected species are resident, transient, or migratory (Clement 2013). It is not likely that all projects sited in an AOA would have the same or similar lifespans, therefore, the temporal scope of impacts would likely extend past what would be considered for an individual facility. Adverse indirect impacts from changes in habitat use could be interspecies interactions, changes in breeding success, and localized population depletion (Bath et al. 2023). Individuals may be more likely to be impacted by short term changes associated with disturbance or wildlife aggregations. Populations may be more likely to be impacted by long term or permanent changes associated with marine habitat connectivity. Components of a project that could be used to analyze changes in habitat use include the distance across the longest length of gear, accessibility to prey, exclusion methods or structures, and interactions to modify behaviors (e.g. deterrents, predator mitigation) (pers. comm. NMFS 2021a).

Changes to pelagic habitat could occur from effluents. The offshore environment is thought to mitigate any significant impacts to benthic habitat from effluents (Price and Morris 2013). The types of effluents that would likely be considered in permitting decisions are described in Chapter 3, Section B.iv. (Water Quality), and Section B.iv. (Potentially-Farmed Species). Potential impacts to protected species from effluents are included under each sub-alternative in this section.

Aggregations of marine mammals, seabirds, predatory fish and schooling fish are observed near marine aquaculture facilities worldwide (Rensel and Forster 2007, Bath et al. 2023, and Rhodes et al. 2023a). Aggregating cues include predation opportunities, physical protection by floating structures, and conditioned responses to sounds, lights, and aquaculture operations (Rhodes et al. 2023a). Prey may use structures to escape predators and alternatively, facility structures may aggregate prey and provide novel foraging opportunities (Duprey et al. 2007, Kramer et al. 2015, and Bath et al. 2023). Although some marine mammals and seabirds in the SCB prefer specific types of prey, most are opportunistic feeders (PFMC 2016). Sea turtles could also be drawn to new feeding habitat, if certain algal species and invertebrates that may be found near gear. Aggregations around aquaculture facilities offer alternative opportunities for food sources that could become a more attractive option than hunting wild prey over wide spatial ranges (Rhodes et al. 2023a). Aggregations around aquaculture facilities within an AOA may create a predictable, if not reliable, food source that could alter predatory behavior due to the baseline boom/bust characteristics of the SCB food web. Sea lions are known to haul out on man-made structures such as barges and stern ramps of vessels. If females of any species are drawn away from better foraging grounds, it could have population implications if it affects reproductive success or they are not able to support offspring.

Disease

Increased wildlife aggregations, on top of the baseline proximity and geographic overlap of protected species habitat, creates a potential risk for increased spread of pathogens and disease. Infectious diseases require a pathogen and host; the spread requires a third factor: a favorable environment, which makes a pathogen capable of infecting (e.g. temperature) and a host susceptible (e.g. poor nutrition) (Rhodes et al. 2023a). These three factors influence and may help identify the likelihood of disease and to identify mitigation. Many disease-causing agents routinely occur on a host or in the environment naturally, without causing disease. The focus in this DPEIS is on those that do infect and cause disease, including compromised immune systems and other health issues, damage tissues, or death. Potential impacts to protected species from diseases that may be transmitted from different types of aquaculture projects are considered under each sub-alternative, below.

Most offshore aquaculture systems would likely have free seawater interchange with few barriers to flow between the culture system and the open ocean. The spread of disease to protected species may occur from wild populations to cultured, or vice versa. It may also spread within wild populations due to intra- and inter-specific proximity in wildlife aggregations around an aquaculture operation. Detailed descriptions of each transmission method are provided on pp. 5 through 7 of Rhodes et al. (2023a). Transmission methods include:

- waterborne transmission by release from an infected host into water and uptake directly from water by a susceptible host;
  - direct or physical contact between infected and susceptible individuals, including predation, ingestion of shed material such as feces or mucus, and feeds;
  - association with organisms that can carry pathogens, either as reservoirs or as intermediate hosts;
  - association with contaminated inanimate materials (fomites) such as substrates and structures (e.g., equipment, sediments) contaminated with a pathogen; and
  - active pathogen movement from infected host to susceptible host (e.g., motile stages of parasitic copepods).

Disease can affect individuals, populations, and habitat quality. Some pathogens have the ability to infect hosts of different species (Rhodes et al. 2023a). Withering syndrome is a top concern for abalone and other invertebrates in the SCB (Crosson et al. 2014, Moore et al. 2019). Sea lice, which have the potential to infect salmonids as well as other fishes, are a high-priority pathogen to control for fish health (Costello 2009, Thorstad et al. 2015, Guragain et al. 2021, Mordecai et al. 2021, and Rhodes et al. 2023a,b).

Literature was not found on associations between sea turtles and commercial aquaculture; but it is known that sea turtles are susceptible to viruses when raised in captivity, and susceptible to bacterial infections in the marine environment (Haines 1978, Ebani 2023). Turtles are considered a risk to spread bacterial infections to other species, including humans (Warwick et al. 2013, Mashkour et al. 2020, and Ebani 2023). Birds would likely pose a risk to cultured populations through bacteria or parasitic infections (Rhodes et al. 2023a). Similar to birds, marine mammals may have the potential to introduce bacteria or share parasites with a cultured population. Baleen whales are hosts to many skin parasites, and all cetaceans are prone to internal parasites (Swartz and Jones 2016). The impacts on marine mammal health related to aquaculture projects has not been researched (Rhodes et al. 2023a). Due to behavioral influences on birds and marine mammals to aggregate near facilities and display intra- and inter-specific interactions, there may be higher potential for the spread of pathogens among seabird and marine mammal populations than between a cultured population and the predators. HABs (discussed in more detail in Chapter 3, Section B.iv. (Water Quality)), can also sicken and kill marine organisms at all trophic levels.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

There is high potential for aquaculture facilities that are sited in an AOA within Alternative 2 to have geographic overlap with breeding, feeding, migrating areas for protected species. The amount of pelagic habitat overlap that could occur for each AOA option in Alternative 2 is shown in Table 2. The largest option at 2,000 acres (8.09 km^2) is less than one percent of comparable habitat in Federal waters of the Channel, and about one-hundredth of a percent of surrounding habitat in the SCB. If multiple AOAs were identified in Santa Barbara Channel, it would increase the total potential acreage of 2,000 acres (Alternative 2) to 15,000 acres (60.7 km^2). The total amount of habitat overlap that could occur would be about 1.2% of the total habitat in Federal waters of the SCB, and less than one-tenth of a percent of the total area of the SCB. It is important to note that habitat overlap by itself doesn't represent an impact, rather all the stressors that may occur within that overlap. Site-specific surveys to characterize bottom habitat would be necessary to analyze potential impacts on protected benthic species. Highly mobile, pelagic protected species may be less at risk of impacts from habitat overlap.

Table 2: Alternative 2 Santa Barbara Channel AOA Option Footprints

AOA Option Name	Acres (km^2)	Percentage of Santa Barbara Channel (total 5,179 km^2)	Percentage of Southern California Bight (total 78,000 km^2)
N1-A	2,000 (8.09)	0.16	0.010
N1-B	1,500 (6.07)	0.12	0.008
N1-C	1,500 (6.07)	0.12	0.008
N2-A	2,000 (8.09)	0.16	0.010
N2-B	2,000 (8.09)	0.16	0.010
N2-C	2,000 (8.09)	0.16	0.010

AOA Option Name	Acres (km^2)	Percentage of Santa Barbara Channel (total 5,179 km^2)	Percentage of Southern California Bight (total 78,000 km^2)
N2-D	2,000 (8.09)	0.16	0.010
N2-E	2,000 (8.09)	0.16	0.010
Total	15,000 (60.7)	1.20	0.076

Aquaculture projects sited in Alternative 2 may have potential impacts on habitat connectivity for the Southern California Distinct Population Segment (DPS) of steelhead. Critical habitat for the Southern California DPS of steelhead includes the Ventura River, Coyote Creek, and the Santa Clara River. The close proximity of the North Study Areas AOA options to the mouths of those rivers could impact the steelhead's abilities to return to the river to spawn (PFMC 2022a). Site-specific NEPA analyses may need to consider the condition of the stock at the time of permitting decisions to better analyze if this impact could affect steelhead at an individual or population level.

Composite species distribution models for invertebrate, fish, bird, and mammal data show high ecological importance in the areas around Alternative 2 (see Figure 7.2.5 and Figure 7.2.6 on pp. 204 and 205 of NCCOS (2005). Fin whale feeding and migration areas may also be impacted (VPD 2018). The area between Carpentaria and Ventura is a high activity area for coastal Bottlenose dolphins (NCCOS 2005). These habitat data imply interactions with protected species are likely to occur.

Marine mammals, seabirds, and sea turtles all have the potential to become entangled in aquaculture gear in the Santa Barbara Channel. There is no alternative location that could avoid the risk of a line or anchor separating; however, remote monitoring and response time should be considered for evaluating and mitigating entanglement impacts (USACE 2021). AOA options within Alternative 2 range from 5.7 to 14.4 km (3.1 to 7.8 nm) from shore, and from 8.5 to 20.7 km (4.6 to 11.2 nm) from the nearest port (Morris et al. 2021).

Vessel strike data and models of predicted mortality risk in the Santa Barbara Channel show that the risk of collisions with larger vessels is higher in the shipping channels than surrounding areas (Laist et al. 2001, Rockwood et al. 2021). It is important to note that the geography of the Santa Barbara Channel creates a bottleneck for all vessel activity, regardless of size, between the mainland and the Channel Islands. The combination of geography and the presence of shipping lanes may increase the risk of vessel strikes. Humpback risk seems to be concentrated in the northern extent of the shipping lanes, closer to Alternative 2 than Alternative 3, and is higher during summer and fall during feeding (Rockwood et al. 2021, Cusato 2021). Blue whales may also occur in higher densities closer to Alternative 2, as they congregate to feed near the Channel Islands (Cusato 2021).The risk to any species of vessel strikes from operations in an AOA would depend on the number and size of vessels associated with a project. The type of aquaculture would likely be less of a consideration relative to project footprint and production size.

The proximity of Alternative 2 to existing offshore infrastructure that contribute noise and light to the baseline environment is provided in Chapter 3, Sections B.v. (Air Quality and Aesthetics), B.vi. (Acoustic Environment), D.vi. (Transportation and Navigation), and Chapter 4, Section A.ii. (Other Ocean Uses).

Predominant wind and ocean currents in the Santa Barbara Channel may help to alleviate pressures related to land-based marine debris and pollutants; but aquaculture projects would need to consider site location relative to other facilities and offshore infrastructure to properly assess risk of marine debris and effluents from other ocean-based sources. Localized changes to hydrology due to gear placement may also act to accumulate materials close to project sites, and close to wildlife aggregations. Significant and complex eddies in the Santa Barbara Channel can entrain and trap waters carrying contaminants, such as oil from natural seeps or anthropogenic sources (Rhodes et al. 2023a). Evidence from Channel Islands beach surveys show heavier debris, mostly associated with fisheries gear, gathers on offshore beaches more than on the mainland (Miller et al. 2018, Steele and Miller 2022). This type of gear would resent higher risk for secondary entanglement. Any pelagic species passing through the area during an accidental spill or discarding of materials would be subject to exposure to pollutants and marine debris. Hueneme Canyon is the closest bathymetric feature that may accumulate debris at the seafloor, but the nearest proximity is 14.8 km (8.0 nm) from Alternative 2. It is not likely that there would be any interactive effects from this bathymetric feature. Impacts to benthic protected species from marine debris from facilities sited within an AOA would likely occur within Alternative 2, under and close to a project footprint or associated vessels. BMPs for preventing marine debris and other spills are included under mitigation in Chapter 3, Section B.iv. (Water Quality).

Impacts to protected species due to changes in habitat use, wildlife aggregations, and disease may be more closely related to the type of aquaculture than geographic area within the SCB. These impacts are discussed for each sub-alternative.

a) Shellfish and Macroalgae

Potential impacts from changes in habitat use associated with shellfish and macroalgae aquaculture are evident. According to global reports from Iceland, Chile, Australia, and New Zealand, shellfish operations seemed to restrict habitat use for odontecetes (Lloyd 2003, Young 2015, Price et al. 2017, and Bath et al. 2023). Shellfish operations were also noted to take up more space across cetacean and sea turtle habitat than finfish operations (Young 2015). Global reports reviewed in Bath et al. (2023) imply shellfish operations attract seabirds. Based on longline fisheries bycatch data, the baseline behavioral conditions for seabirds include targeting floating longlines (Gladics et al. 2017). Reports from Washington show that seabirds may feed on biofouling organisms on gear as well (Nash et al. 2005). Loggerhead sea turtles feed on a wide variety of food items including mollusks and crabs and may investigate shellfish aquaculture sites (Mori and Riley 2021). Pinnipeds consume benthic organisms typically associated with mussel and other nearshore shellfish operations; but they do not commonly feed on shellfish and may be less likely to visit offshore operations in deeper water (Moore and Wieting 1999, Wursig and Gailey 2002, Price et al. 2017, and Bath et al. 2023). Similarly, Gray whales primarily feed on benthic crustaceans and invertebrates (Swartz and Jones 2016). Gray whales may be more likely to investigate shellfish aquaculture gear than other large whales, but unlikely to target facilities for foraging.

Microalgae systems are more likely to be used in nearshore, semi-protected areas and are outside the scope of this DPEIS. However, Hughes et al. (2014) provides a detailed, behavior-specific and species-specific study within the CCE (Monterey Bay) that may be a useful reference to assess interactions with protected species in the alternative areas. Marine mammals and seabirds observed around this aquaculture equipment showed foraging, resting, grooming, social, inspection, and direct interactions (e.g. pulling, pecking, biting, rolling) with gear. The number and durations of each species and behavior is summarized in Table 2 on p. 4 of Hughes et al. (2014).

Baleen whales, dolphin species, and pinnipeds may be drawn to macroalgae gear based on their behavior to investigate, play, and forage in kelp beds (Meynecke and Kela 2023). Humpbacks, Gray whales, and Right whales have been documented interacting with marine vegetation around the world (Owen et al. 2012, Meynecke and Kela 2023). Gray whales may also feed on seaweed and seagrass (Swartz and Jones 2016). Many cetacean species are thought to use marine vegetation and marine debris as tools and socio-sexual displays (Owen et al. 2012). Small cetaceans may also be drawn to macroalgae aquaculture facilities since these structures attract forage fish species (Bath et al. 2023). Pinnipeds and sea birds may also be drawn to macroalgae aquaculture for opportunistic feeding on schooling fish. Sea turtles sometimes forage around, or take advantage of marine vegetation rafts (Moore and Wieting 1999). Novel rafting habitat, or potential aggregations of biofouling organisms or nektonic invertebrates around macroalgae aquaculture could alter sea turtle behavior.

There are no reports of entanglement in existing macroalgae aquaculture gear in the SCB; but any line in the water column may pose an entanglement risk. There are no reports of entanglement in existing shellfish aquaculture gear in the SCB. Spat collecting ropes may pose a higher entanglement risk compared to other ropes used in mussel aquaculture (Moore and Wieting, 1999, Young 2015, Fujita et al. 2023, and Bath et al. 2023). Provided mitigation measures that would be applied in permitting decisions, this risk should be addressed (VPD 2018). It is unclear if entanglement in shellfish gear is due to attraction, or unawareness (Price et al. 2017, Bath et al. 2023). Species-specific behavior may play a role in entanglement risk. Documented entanglements of Federally-protected species in shellfish aquaculture gear in other areas have included cetaceans and sea turtles (Bath et al. 2023).

Continuous and impulsive noise may be generated underwater and overwater from construction and operations of offshore shellfish and macroalgae farms. Other aquaculture projects that have done acoustic modeling have predicted that underwater noise would be within acceptable thresholds for protected species, including both cetaceans and sea turtles, likely causing temporary disturbance, but not take of protected species (VPD 2018, NMFS 2016a, and USACE 2021). Potential impacts were expected to be avoidance of the area and therefore minor, since sounds would be temporary and the size of the action area was small compared to surrounding habitat of similar quality (VPD 2018, USACE 2021). Modeling has shown however that above-water noise generated by one shellfish operation may have potential significant impacts to birds from the continued use of motorboats and other noise-producing equipment greater than 41dBA more than 10% of the time, and some equipment that exceeded 60dBA at 50 feet (NPS 2012).

Predation around shellfish and macroalgae aquaculture, via interaction among aggregated wildlife, is likely to occur in the Santa Barbara Channel. Predation on shellfish operations from both diving and non-diving seabirds has been documented in Santa Barbara and in Tomales Bay (CDFW 2010). Impacts would likely be similar in offshore locations. Sea turtles may feed opportunistically on cultivated algae, but the impact would not likely be significant on population behavior.

Shellfish and macroalgae aquaculture practices have the potential to introduce invasive species, parasites, and pathogens into the environment via contaminated seed stock. The spread of disease is an ecological impact that could decrease individual fitness and populations (Purcell et al. 2023 (draft)). However, if projects comply with existing Federal and State regulatory mechanisms (discussed in Chapter 3, Section C.iv. (Potentially-Farmed Species) and other management measures, seed stock should not contain invasive species, parasites or pathogens of concern and this impact would not be significant. Invasive species, parasites, and pathogens may still infect protected species due to wildlife aggregations around an aquaculture project. A list of pathogens and diseases that have been identified by the World Organization for Animal Health with host type is provided in Appendix A of Rhodes et al. (2023a).

Macroalgae and shellfish aquaculture may not require inputs to the grow out system. Therefore, beyond accidental spills, there would not likely be any impacts from most effluents. If shellfish and macroalgae aquaculture projects are configured in such a way that it causes changes to localized flow, stratification, dissolved oxygen, or other characteristics of the water column, that may impact protected species. Pelagic species may change how they use the surrounding waters, and avoid the area. The offshore ocean depths are thought to minimize water quality and nutrient deposition impacts to benthic species.

b) All Types of Commercial Aquaculture

Changes in behavior and habitat use of marine mammals and seabirds have been documented around finfish operations. Examples from IMTA aquaculture were not found in preparation for this DPEIS. Based on reports reviewed in Bath et al. (2023), dolphins in the Mediterranean show site-fidelity, changed hunting tactics, and exhibited different social structures around finfish facilities. There are similar reports of dolphins changing social structures, as well as other odontocetes and seals associating with finfish aquaculture nearshore in New Zealand, Hawaii, and Scotland (Clement 2013, Northridge et al. 2013, NMFS 2021a, and Harnish et al. 2023). In Hawaii, marine mammal observations around finfish operations increased from about 550 between 2010 to 2016 to about 2500 from 2017 to 2020 (Sims 2013). Reports from Scotland, Australia, New Zealand, and Tasmania indicate pinnipeds also change behavior and social structures around finfish aquaculture (Kemper et al. 2003, Northridge et al. 2013, and Heredia-Azuaje et al. 2022). Diving seabirds are also drawn to finfish aquaculture (Lloyd 2003).

Entanglement has been documented for cetacean and pinniped species, as well as entrapment in offshore tuna ranching operations in Australia (Bath et al. 2023). Examples from IMTA aquaculture were not found in preparation for this DPEIS. In contrast to shellfish and macroalgae operations, bird mortalities due to entanglement have been reported from finfish operations (Bath et al. 2023). Lines being considered for finfish aquaculture operations would likely include fixed structures moored to the sea floor with thick metal cables or high tensile strength line, typically under high tension (Clement 2013, Price and Morris 2013, and NMFS 2021a). They may, however, pose a risk of collisions resulting in lacerations and other impact injuries (Winn et al. 2008; Baldwin et al. 2012).

A literature review of noise characteristics from construction, operation, and predator deterrence associated with finfish aquaculture is summarized in Table 1 on p. 47 of Olesiuk et al. (2012). An example NEPA analysis of predicted noise generated by typical vessels and gear that may be used in a finfish operation is described on p. 185 of the Pacific Islands Aquaculture Management Program Draft Programmatic Environmental Impact Statement (DPEIS) (NMFS 2021a). In that programmatic NEPA analysis, offshore locations were thought to mitigate impacts from noise. In acoustic modeling that has been done for finfish aquaculture that have either been proposed or are in operation in the U.S., the most noise generated from a finfish facility was associated with vessels, and noise did not exceed thresholds for protected species (BOM 2014, EPA 2019, and CDFG 2012). However, this modeling was for smaller operations and potential impacts of multiple finfish operations in an area up to 2,000 acres (809 ha) would be greater. Site-specific NEPA analyses for facilities sited in an AOA may need project-specific assessments, including cumulative additive effects if projects are sited close to one another.

The risk of injury or entanglement may increase due to structures such as anti-predator nets or acoustic devices (Bath et al. 2023). The primary frequencies of acoustic deterrents occur within the most sensitive range for all functional groups of marine mammals (Olesiuk et al. 2012). The main environmental concern associated with acoustic deterrents is the potential for far-range, chronic effects on non-target animals. Field measurements and sound movement models conducted for finfish operations in Canada imply that sounds spread in a spherical-cylindrical way in the open ocean, when the path is unobstructed by islets and land (Olesiuk et al. 2012). In addition, the results of a field study, Shapiro et al. (2009), showed a high degree of fine-scale variability due to sound propagation from surface-reflected and bottom-reflected rays that could have important biological implications, as it would make it difficult for an animal to discern the direction of the sound source without traveling some distance, hampering its ability to avoid the deterrents (Lawson 2009, Olesiuk et al. 2012). The literature review in Olesiuk et al. (2012) implies that odontocetes are displaced from habitat during and up to a few months after devices were in use; but the devices are not effective for pinnipeds. This is consistent with the literature review in Bath et al. (2023), which also implies that acoustic deterrents may not be effective for large whales. While observations varied by species, it was noted that Bottlenose dolphins and common dolphins showed strong evasive behavior. The energy spectrum was thought to be above the estimated hearing range of turtles and invertebrates.

Predation from marine mammals and seabirds are a documented issue for finfish facility operators (Wursig and Gailey 2002, CDFW 2010, Harnish et al. 2023, Sims 2013, Northridge et al. 2013, and Bath et al. 2023). While enhanced foraging and opportunistic predation could be considered a positive impact for marine mammals and seabirds, there are tradeoffs. Aggressive interspecific behavior has been observed among odontocetes associating with finfish aquacultures in Hawaii, including one species harassing and separating a cow-calf pair of another species (Harnish et al. 2023). Baleen whales, smaller odontocetes, pinnipeds, and salmonids are preyed on by killer whales in the CCE (Baldridge 1972, Goley and Straley 1994, Dahlheim and White 2010, Strange 2016, and Pitman et al. 2015). Smaller odontocetes have been observed in the CCE feeding opportunistically on larger fishes, including salmonids (Elliser et al. 2020). The rate of interactions could increase due to wildlife aggregations at aquaculture sites within an AOA. It could also increase the risk of injury to both predator and prey if the interactions occur in concentrated areas, close to operations or associated vessels. Predation may increase the risk of human interactions. Human interactions may occur from recreational dives around a facility, monitoring predation activities, or monitoring systems underwater (Harnish et al. 2023).

Special-case scenarios, analyzed and permitted in accordance to the MMPA, have resulted in take of protected species by lethal measures. There were 11 reported incidences of lethal take of a marine mammals (California sea lion) in OREHP finfish growout facilities in coastal State waters in the SCB between 1992 through 2010 (CDFG 2010). Sea lions are an ongoing issue for salmon and steelhead hatcheries in the Columbia River (NMFS 2024c). Outside the U.S. jurisdiction, there have been lethal take of marine mammals and birds predating on salmon aquaculture facilities in Canada (Wursig and Gailey 2002). Offshore fish aquaculture may be sufficiently far from major pinniped haul outs to help mitigate the concern of heavy predation from seals and sea lions; however interactions with other predators may still be a concern (Forster 2013, Fujita et al. 2023).

Finfish aquaculture practices have the potential to introduce invasive species, parasites, and pathogens into the environment. There is substantial correlative data between infection in net pen salmon and proximal wild fish infestations (Rhodes et al. 2023a, Purcell et al. 2023 (draft)). The spread of disease is an ecological impact that could decrease individual fitness and populations (Nash et al. 2005, Purcell et al. 2023 (draft)). Sea lice, which have the potential to infect salmonids as well as other fishes, are a high-priority pathogen to control for fish health (Costello 2009, Thorstad et al. 2015, Guragain et al. 2021, Mordecai et al. 2021, and Rhodes et al. 2023a,b). Any infection in a finfish cultured population has the potential to impact steelhead that may occur in the area. Impacts to wild fish populations is discussed further in Chapter 3, Section C.ii. (Federally-Managed Wild Fish Stocks). Existing Federal and State regulatory mechanisms and stringent management practices (discussed in Chapter 3, Section C.iv. (Potentially-Farmed Species) may decrease the risk. Bacterial infections, parasites, and invasive species may infect predatory animals due to wildlife aggregations around an aquaculture project. A list of pathogens and diseases that have been identified by the World Organization for Animal Health with host type is provided in Appendix A of Rhodes et al. (2023a).

Finfish and IMTA aquaculture may impact the water column via effluents. Impacts to protected species could occur due to exposure to effluents, sediment and nutrient flux, or other types of changes in water quality. Impacts could range from individual, localized, temporary disturbance, to risks to populations if chronic changes occur over the lifespan of a project. The offshore environment is thought to mitigate many of the adverse impacts to water quality in comparison to nearshore, more shallow and enclosed waters (Price and Morris 2013). However, some of the baseline conditions may amplify any risk of water quality changes. Sediments and organic matter that may occur as a result of waste, excess feed, or dead animals from a finfish project may cause localized nutrient enrichment. HABs are part of the natural ecosystem in the SCB; and their effects on protected species could be exacerbated by nutrient enrichment.

Any chemicals or husbandry materials that may be used in a finfish operation may need to be analyzed more closely for both pelagic and benthic habitat interactions. Site specific NEPA analyses would likely need to incorporate fine scale, site-specific data on species presence, hydrology, sedimentation and nutrient patterns to predict the risk of adverse impacts to protected invertebrates. If pollutants, nutrient, or sediment loads affect prey abundance, then protected species of higher trophic levels could also be impacted.

Bioaccumulation of DDTs and PCBs and ingesting marine debris are prevalent conservation issues that causes reproductive issues for many fishes and invertebrates (prey species for birds and marine mammals) as well as bird species in the SCB (Schiff et al. 2000, USFWS 2005, and LARWQCB 2011). The Brown pelican population in the SCB is especially-susceptible to tissue contamination (LARWQCB 2011). Longer-living species are at higher risk to exposure to pollutants due to bioaccumulation of heavy metals and tissue contamination over time and through the food web. SCB has long been documented to have elevated levels of chlorinated hydrocarbons, DDT, and PCBs in invertebrates, fishes, birds, sea turtles, and marine mammals, correlated with cellular damage (e.g. tissue erosion or tumors), decreased fecundity, and decreased fertilization success (Schiff et al. 2000, Komoroske et al. 2011). The existing trend in this baseline condition, however, is that contaminant levels detected in the tissues of fishes and benthic species are going down (Schiff et al. 2000, LARWQCB 2011). However, pressures from marine debris are increasing, with their own array of persistent organic pollutants that are harmful to wildlife (Spykra 2017). The spatial relationships on contamination are not clear, especially for highly-mobile predators, but the magnitude of bioaccumulation is generally consistent with the magnitude of sediment contamination, and observed in higher levels in animals that live or forage at the seafloor (Schiff et al. 2000, Deheyn and Latz 2006).

The risk of adverse impacts at a population level from chronic exposure to water quality changes is low due to existing regulatory mechanisms and protective measures, discussed in more detail in Chapter 3, Section B.iv. (Water Quality). Additional information on baseline conditions in hydrology, water quality and seafloor characteristics are also included in Chapter 3, Section B. Additional information on impacts to pelagic communities is provided in Chapter 3, Section C.iii. (Ecologically-Important Marine Communities). For more information on impacts to wild fish, sharks, and rays, see Chapter 3, Section C.ii. (Wild Fish Stocks). Resources are provided under Ongoing Monitoring and Coordination in Chapter 3, Sections B.iv. (Water Quality) and D.viii. (Public Health and Safety).

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Potential projects sited in an AOA within Alternative 3 would likely have geographic overlap with breeding, feeding, migrating areas for protected species. The amount of pelagic habitat overlap that could occur for each AOA option in Alternative 3 is shown in Table 3. The larger option at 1,000 acres (4.05 km^2) is under one-hundredth of a percent of comparable habitat in Federal waters of Santa Monica Bay, and even less of surrounding habitat in the SCB. If multiple AOAs were identified in Santa Monica Bay, the total potential acreage would still be under 2,000 acres (809 ha). It is important to note that it may not be the size of geographic overlap, but the combination of stressors that may occur within an area that may cause an impact. Site-specific surveys to characterize bottom habitat would be necessary to analyze potential impacts on protected benthic species. Highly mobile, pelagic protected species may be less at risk of impacts from habitat overlap.

Table 3: Alternative 3 Santa Monica Bay AOA Option Footprints

AOA Option Name	Acres (km^2)	Percentage of Santa Monica Bay (total 460 km^2)	Percentage of Southern California Bight (total 78,000 km^2)
CN1-A	1,000 (4.05)	0.009	0.00005
CN1-B	500 (2.02)	0.004	0.00003
Total	1,500 (6.07)	0.013	0.008

Composite species distribution models for invertebrate, fishes, bird, and mammal data show medium to high ecological importance in the areas around Alternative 3 (see Figure 7.2.5 and Figure 7.2.6 on pp. 204 and 205 of NCCOS (2005). More specifically, the overlap of Alternative 3 with protected resource important areas is shown in Figure 3.86 on p. 175 of the Results section of the Atlas (Morris et al. 2021). All of Alternative 3 overlaps with the Gray whale migration BIA; Fin whale and blue whales may also feed and migrate in these areas (VPD 2018, Morris et al. 2021). The area between Point Dume and Santa Monica is a high activity area for coastal Bottlenose dolphins (NCCOS 2005). Especially-high numbers of cetaceans are observed in the Bay in winter and spring (LARWQCB 2011). Pinnipeds are observed in high association with Santa Monica Canyon that runs just south of the alternative area at about the 100 m (328 ft) depth (Bearzi et al. 2008). These habitat data imply interactions with protected species are likely to occur.

Marine mammals, seabirds, and sea turtles all have the potential to become entangled in aquaculture gear in Santa Monica Bay. There is no alternative location that could avoid the risk of a line or anchor separating; however, remote monitoring and response time should be considered for entanglement impacts (USACE 2021). AOA options within Alternative 3 are 6.1 and 6.7 km (3.3 and 3.6 nm) from shore, and 11.3 and 9.8 km (6.1 and 5.3 nm) from the nearest port (Morris et al. 2021).

Vessel strike data and models of predicted mortality risk in the Santa Monica-San Pedro Basin show that the risk of collisions may be higher in the shipping channels than surrounding areas, due to the concentration of large vessels in those areas (Rockwood et al. 2021). Fin whale and Blue whale density is predicted to be higher in the western approaches towards Long Beach and Los Angeles than northern routes (Rockwood et al. 2021). The western approaches are within 9.3 km (5 nm) to Alternative 3. In addition, fin whales are often observed near the 200 m (656 ft) depth (VPD 2018). The deeper range of Alternative 3 is 145.6 m (478 ft) (Morris et al. 2021). The risk of vessel strikes would depend on the number and size of vessels associated with a project. The type of aquaculture would likely be less of a consideration relative to project footprint and production size.

The proximity of Alternative 3 to existing offshore infrastructure that contribute noise and light to the baseline environment is provided in Chapter 3, Sections B.v. (Air Quality and Aesthetics), B.vi. (Acoustic Environment), and D.vi. (Transportation and Navigation), and Chapter 4, Section A.ii. (Other Ocean Uses).

Marine debris and pollutants in Santa Monica Bay are attributed mostly to land-based sources, especially from the greater Los Angeles area and heavily impacted from urbanization (USGS 2003, LARWQCB (2011)). Predominant currents towards the southeast and swell from the west may help to alleviate pressures related to marine debris and pollutant from coastal resources; but NPDES data show that movement of discharge plumes in Santa Monica Bay during storms and high flow events is highly variable (LARWQCB 2011). Complex eddies in the Santa Monica Basin can entrain and trap waters carrying contaminants, such as oil from natural seeps or anthropogenic sources (Rhodes et al. 2023a). Santa Monica Canyon is the closest bathymetric feature that may accumulate debris at the seafloor, located south, within 3.7 km (2 nm) from both AOA options within Alternative 3. Higher concentrations of existing contaminants are concentrated near the Palos Verdes Shelf, which is a designated Superfund site by the EPA. Palos-Verdes shelf is south and down-current of Alternative 3.

Protected species occurring within Alternative 3 are likely impacted by these baseline water quality concerns. It is not likely that aquaculture projects would create a significant impact. However, existing conditions may make protected species particularly susceptible to human activities. Localized changes to hydrology due to gear placement may also act to accumulate materials close to facilities, and close to wildlife aggregations. BMPs and other regulatory management would be important to implement so that any water quality impacts from an aquaculture project in Alternative 3 do not create cumulative impacts. BMPs for preventing marine debris and other spills are included under mitigation in Chapter 3, Section B.iv. (Water Quality).

Impacts to protected species due to changes in habitat use, wildlife aggregations, and disease may be more closely related to the type of aquaculture than geographic area within the SCB. These impacts are discussed for each sub-alternative in this section.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section. Evidence taken from shellfish and macroalgae sites globally, the west coast, and California is the best available information to apply to both geographic areas under analysis, Santa Barbara Channel and Santa Monica Bay. More information is included here for shellfish and macroalgae water quality interactions, since water quality is an existing concern and baseline stressor in Alternative 3.

As noted under Alternative 2, shellfish and macroalgae aquaculture practices have the potential to introduce invasive species, parasites, and pathogens into the environment via contaminated seed stock; or infections could spread among protected species in wildlife aggregations. If projects comply with existing Federal and State regulatory mechanisms (discussed in Chapter 3, Section C.iv. (Potentially-Farmed Species and Appendix 1) any impact due to contamination should not be significant. Due to the baseline water quality conditions of Santa Monica Bay and the historic tissue contamination observed in benthic invertebrates and fishes, some individuals of protected species may be more susceptible to infection and disease. A list of pathogens and diseases that have been identified by the World Organization for Animal Health with host type is provided in Appendix A of Rhodes et al. (2023a).

Areas exhibiting large shellfish populations in Santa Monica Bay are monitored closely due to existing water quality concerns in the great watershed area, including invasive species and algae blooms that create shellfish consumption advisories (LARWQCB 2011). Concentrations of pollutants that have been observed in plankton, invertebrates, and shellfish species increase as sample locations approach the Palos Verdes Shelf (Schiff et al 2000). Storms disrupt predominant conditions, and create highly variable flow in the marine environment. During storms and precipitation events that create high flow of coastal runoff, there are suspensions on shellfish and seaweed harvesting, along with other objectives under Section 101(a)(2) of CWA (LARWQCB 2011). In order to maintain product viability, aquaculture projects sited in an AOA in Santa Monica Bay would likely need to monitor water quality conditions associated with storms and discharge plumes closely. This may require more logistics relative to Alternative 2 due to coordination with Federal, State, and local agencies. Variable water quality conditions and extra coordination may lead to extra vessel traffic, noise, and human activity at a project site, which could affect protected species. It would also be important that any accidental spills, other pollutant exposures, or marine debris from an aquaculture facility be prevented due to the state of the baseline conditions. BMPs for preventing marine debris and other spills are included under mitigation in Chapter 3, Section B.iv. (Water Quality). Shellfish aquaculture has the potential to have a beneficial impact on the water quality conditions in Santa Monica Bay, which could impact protected species indirectly, on an ecological level.

b) All Types of Commercial Aquaculture

Rates of interspecific interactions could increase due to wildlife aggregations at aquaculture sites within an AOA, and may be especially-pronounced in Alternative 3 based on existing associations observed in the area. Observations of resident dolphin species indicate that different species partition habitat, except in areas where prey is aggregated (Bearzi 2005). Sea lions are observed frequently in association with cetaceans, and cetaceans form mixed-species aggregations in the Bay (Bearzi 2005, Bearzi et al. 2008). As noted under Alternative 2, killer whales have historically preyed on other marine mammals in the CCE, and one pod has been targeting sea lions and dolphins between Long Beach and San Diego more recently (Fudge 2023, Sternfield 2024). These interactions could increase the risk of injury to both predator and prey if the interactions occur in concentrated areas, close to operations or associated vessels.

Elevated concentrations of several contaminants (including PCBs and DDTs) in fishes have been found in Santa Monica Bay (Schiff et al. 2000, LARWQCB 2011). During storms and precipitation events that create high flow of coastal runoff, there are suspensions on fishing, along with other objectives under Section 101(a)(2) of CWA (LARWQCB 2011). As described under sub-alternative a., an indirect impact on protected species from variable water quality conditions and coordination with Federal, State, and local agencies may be extra vessel traffic, noise, and human activity at a project site. It would also be important that any accidental spills, other pollutant exposures, or marine debris from a facility be prevented due to the state of the baseline conditions that may cause protected species in the area to be especially-susceptible to additional stressors. BMPs for preventing marine debris and other spills are included under mitigation in Chapter 3, Section B.iv. (Water Quality).

Scenarios related to IMTA aquaculture are the same for Alternative 3 as discussed under Alternative 2, and not repeated here.

Alternative 4: Combination of Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. The geographic scope of a protected species is considered over a significant portion of its range. Using this as an evaluator of risk, in combination with existing regulatory restrictions and requirements, could inform decisions on whether impacts may occur at a population-level. Multiple projects spread across Alternative areas may be more likely to have population-level implications based on species-specific life history and population size, and due to an assumed larger geographic scale of habitat disruption. If aquaculture increased in scale, so would the risk. Identifying AOAs across a larger geographic area may increase the risk of interactions more because the impacts are dispersed over a higher range of protected species stocks. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.

Temporary increase in vessel traffic and noise associated with one aquaculture facility, or even up to an area of 2,000 acres (the maximum size of one AOA in the scope of this analysis), is unlikely to result in significant adverse impacts; however, the cumulative impact from several AOAs (a potential area up to 15,000 acres) in close proximity to one another could change that assessment. If multiple AOAs were identified in Santa Barbara Channel, it would increase the total potential acreage of 2,000 acres (809 ha) (Alternative 2) to 15,000 acres (6070 ha). The total amount of habitat overlap that could occur would be about 1.2% of the total habitat in Federal waters of the SCB, and less than one-tenth of a percent of the total area of the SCB, as shown in Table 2. If multiple AOAs were identified in Santa Monica Bay, the total potential acreage would still be under 2,000 acres.

Benthic species are not as mobile as pelagic species, and would not be able to disperse as easily away from stressors, though both species of protected abalone are considered to be unlikely in any of the AOA options. For example, abalone may be more susceptible to adverse impacts, due to a larger seafloor footprint as a result of more aquaculture in one area.

If multiple AOAs were identified across both geographic areas, the total potential acreage would be 16,500 acres (6,677 ha) across approximately 14.8 km (8 nm) of the SCB. The impact on migratory species if aquaculture is sited may increase in scale with more and larger AOAs, and a greater amount of habitat potentially altered across the region. Any exclusion of individuals from important habitats could have broader and longer-lasting repercussions on the population. Large whales would likely be most susceptible to this risk under Alternative 4. Exclusion from optimal migratory or foraging grounds could vary seasonally and inter-annually; but even one year of exclusion could reduce fitness and reproductive success for species with low fecundity. In the SCB, large baleen whales would be at greatest risk of potential adverse impacts from high aquaculture density across the geographic scope of Alternative 4.

Changes in fine-scale abundance and distribution patterns of protected species between Santa Barbara Channel and Santa Monica Bay may occur, especially in resident species as a result of new or increased aggregations around a predictable food source and habitat. This could potentially benefit populations with new opportunities for breeding and introduced genetic diversity. Alternatively, the spread of disease may also be amplified across the SCB. Long-term risks to species that usually stay close to breeding or other foraging could occur if multiple AOAs sited across the SCB result in longer foraging time and decreased fitness. However, this long-term impact would likely be minor or negligible, given the baseline conditions of the highly-variable, boom/bust ecosystem in which prey abundance changes drastically on a seasonal, annual, and decadal basis.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

ii. Wild Fish Stocks

Affected Environment

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) establishes management authority over all living resources within the U.S. EEZ (3 to 200 nm from shore). The Pacific Fishery Management Council (PFMC) is one of eight Regional Fishery Management Councils established by MSA. PFMC is responsible for managing fisheries that primarily occur within Federal waters, 3-200 nm offshore. PFMC is required to achieve optimum yield for public trust marine fishery resources, which requires sustainably managing these resources, their habitats, and the fishing communities that rely on their harvest. PFMC may comment on actions that may affect a fishery resource under its authority in Section 305(b)(3)(A) of MSA. In addition, California is a member of the Pacific States Marine Fisheries Commission (PSMFC), an interstate agency that participates in PFMC as a non-voting member. The PSMFC has no regulatory or management authority; but it coordinates research, fisheries monitoring, and maintains the essential databases used in accordance with MSA, by PFMC and other Federal and State agencies for resource management. Databases managed by PSMFC include PacFIN, RecFIN, the passive integrated transponder (PIT) tag programs, Regional Mark Information System (RMIS), the aquatic habitat data project (StreamNet), an aquatic invasive species prevention program, and the Pacific ballast water group (PFMC 2013). The Northwest Fisheries Science Center (NWFSC) of NMFS manages groundfish observer data and the West Coast economics data program.

To help conserve and minimize any adverse effects on essential fish habitat (EFH), Section 305(b)(2) of the MSA requires Federal agencies to consult with NMFS on any action that may adversely affect designated EFH. PFMC may also comment on and make recommendations for actions that may affect the habitat, including EFH, of a fishery resource under its authority per Section 305(b)(3) of the MSA. EFH for species on the West Coast is designated under four FMPs (Pacific Coast Groundfish, Pacific Coast Salmon, Highly Migratory Species, and Coastal Pelagic Species). The Pacific Coast Groundfish FMP additionally describes EFH Conservation Areas, which are spatially discrete areas of particularly sensitive or productive benthic habitats where fishing with some or all types of bottom-contact fishing gear is prohibited. The MSA authorizes PFMC to designate habitat areas of particular concern (HAPC), a subset of EFH, and therefore subject to consultation under the MSA. HAPC designations for Pacific Coast Groundfish include rocky reefs, canopy kelp, seagrass, estuaries, and areas of interest such as seamounts and canyons (PFMC 2013). HAPC designations for Pacific salmon include estuaries, spawning habitat, marine and estuarine submerged aquatic vegetation, complex channels and floodplain habitats, and thermal refugia. Pacific Coast Salmon EFH off California is north of Point Conception. Many other important habitat features are included in the overall descriptions of EFH, including methane seeps, sand, mud, and coral/sponge habitats. The following information related to EFH from of Morris et al. (2021):

- Methods to incorporate EFH and HAPCs into the spatial modeling for Atlas are provided on p. 28 of the Methods section.
- EFH and associated FMPs that overlap with the alternative areas are provided in Table 3.22 on p. 195 of the Results section.
- Mapped hard bottom, rocky reef, other EFH, and deep sea coral observations and mapped hard bottom habitat relative to Alternative 2 are shown in Figure 3.48 on p. 116 and Figure 3.66 on p. 143 of the Results section.
- Mapped hard bottom, rocky reef, other EFH, and deep sea coral observations and mapped hard bottom habitat relative to Alternative 3 are shown in Figure 3.86 on p. 175 of the Results section.

Fish assemblages in the SCB vary by habitat, water temperature, and depth. Fish groups are distinct for bay, rocky bottom, and soft-bottom assemblages (Allen, 1985). Seasonal and inter-annual migrations of temperate and subtropical fishes into the SCB coincide with periods of increased and decreased upwelling, ENSO, and PDO (Dailey et al. 1993, Lluch-Belda et al. 2003, Horn et al. 2006, and Allen 2006). Warm cycles may favor subtropical fishes, and cooler cycles may favor more temperate fishes to occur in and around the alternative areas. Fish species preferring soft-bottom are most likely to occur in the AOA options, as this type of bottom habitat predominates. Species associated with nearby or unmapped rocky bottom habitat may also occur in the alternative areas. The N1-C and N1-D AOA options in Alternative 2 are within 5 km (2.7 nm) of mapped hard bottom habitat (Morris et al. 2021). Both AOA options within Alternative 3 are within 0.3 km (0.16 nm) from mapped hard bottom habitat (Morris et al. 2021). Fish assemblages around the alternative areas may include benthic, demersal, or pelagic species. Based on 1992 through 2002 data gathered from RecFIN, SCCWRP trawl surveys, NMFS GSP trawl surveys, and PISCO visual surveys, Alternative 2 shows higher diversity in the marine fish assemblages than Alternative 3 (NCCOS 2005). This data includes an El Niño event in 1998 where SST were higher than normal.

Pelagic species are associated with natural fish aggregating devices (FADs) in the open ocean, such as logs or seaweed. FAD is a common term in fisheries, sometimes intended to mean devices that intentionally attract fish for capture. However, in this DPEIS we mean any natural or artificial bottom-fixed, midwater, and surface structures that influence fish assemblages. Major fixed structures include natural reefs, artificial reefs, oil and gas platforms, and aquaculture facilities; other existing FADs in the SCB include kelp beds, drift kelp, and other floating objects (Kramer et al. 2015). A map of FADs is shown in Figure 1 on p. 12 of Kramer et al. (2015). The depth and fish assemblage characteristics of each FAD is provided in Table 2 on pp. 12 through 15 in Kramer et al. (2015). The nearest existing man-made FADs to Alternative 2 are oil platforms (about 2.6 km [1.4 nm] from N1-A and N2-C) and submarine pipelines (about 0.8 km (0.4 nm) from N1-C) (Morris et al. 2021). The nearest existing man-made FADs to Alternative 3 is an oil platform within 1.9 km (1.0 nm) from CN1-A, and submarine pipelines within 0.8 km (0.4 nm) of both CN1-A and CN1-B (Morris et al. 2021). A literature review of the fish assemblages around oil and gas platforms in the SCB is provided in Section 3.1.2.3 on pp. 18 and 19 of Kramer et al. (2015). There are three mapped and monitored kelp beds within 5 km (2.7 nm) of Alternative 2, with the nearest occurring about 0.07 km (0.04 nm) from N2-E (Protected Seas 2022). There is one mapped and monitored kelp bed within 0.5 km (0.27 nm) from both AOA options within Alternative 3 (Protected Seas 2022). An estimated 30% of the total documented species and 40% of fish families in the SCB depend on kelp habitat (McGinnis 2006). Kelp beds are especially important to juvenile fishes, as they provide nursery grounds.

There are over 500 documented fish species in the SCB (McGinnis 2006, Huff et al. 2013). In addition to the Federal ESA protected species included in Table 5, there are special-status species protected under State laws and protected from overfishing that may occur in the alternative areas. Habitat suitability models for four State-managed fish species thought to be representative of significant commercial, ecological, and recreational value in the SCB are provided in Section 4.1 of the NCCOS Biogeographic Assessment (BGA) of the Channel Islands National Marine Sanctuary (NCCOS 2005).

Wild fish stocks that are harvested in Federal waters, commercially and recreationally, are managed through Federal fisheries regulations in Fisheries Management Plans (FMPs) in accordance with MSA (16 U.S.C. § 1852). Federal FMPs that may occur in Federal waters of the SCB are provided in Table 7. The fisheries groups' potential to occur in Table 7 is analyzed for each alternative area considered in this DPEIS for the FMP, collectively. The specific species and target fisheries included under each FMP are provided for informational purposes. Site- and project-specific NEPA analyses may need to consider potential to occur with more detail, including State coordination for potential impacts to resources that may occur in both State and Federal waters (e.g. water quality and movement of living resources). Some stocks managed under Federal FMPs are harvested in State waters. Wild fish stocks that are harvested in State waters, commercially and recreationally, are also managed through State-level FMPs in accordance with California's MLMA (FGC § 7070-7072). NOAA Fisheries, USCG, CDFW, and other law enforcement partners enforce Federal and/or State laws and FMP compliance throughout the EEZ. See Chapter 3, Section D.i. (Commercial Fishing) and Section D.ii. (Recreational Fishing) for more information related to the community and socioeconomic aspects of FMPs.

Cartilaginous fishes (class Chondrichthyes) include sharks, rays, skates, and chimaeras. Slow growth rates and relatively late reproductive maturity in some species makes this class especially susceptible to overfishing (NMFS 2001). Giant manta rays (*Manta birostris)*, scalloped hammerhead shark (*Sphyrna lewini*), Pacific angel shark (*Squatina californica)*, and White sharks (*Carcharodon carcharias*) all occur in the SCB, while likelihood of occurring varies depending on typical range and habitat needs of the species. Giant manta ray movement, for example, is driven by multiple factors including foraging on zooplankton, current and tidal patterns, seasonal upwelling, seawater temperature, and possibly reproduction. The SCB is considered to be the northernmost range of the scalloped hammerhead shark (Morris et al. 2021). A literature review of studies from 1985 through 2020 describing potential nursery and juvenile white shark activity in the SCB is provided on p. 249 of Guana and Sternes (2024). An EFH consultation would focus on adverse effects on habitat for cartilaginous fishes identified in the HMS or Pacific Coast Groundfish FMPs; and an ESA consultation would focus on adverse effects on Federal ESA-listed species.

The U.S. National Plan of Action for the Conservation and Management of Sharks (2001), in accordance with the FAO's International Plan of Action for the Conservation and Management of Sharks (2000), provides objectives for the conservation of shark populations and management of long-term sustainable fisheries. Incorporated as an amendment into MSA, the Shark Finning Prohibition Act (2000) and the Shark Conservation Act (2010) provide domestic provisions that allow for sustainable shark fisheries while eliminating shark finning practices. While there is no Federal regulation that bans that sale of shark fins, California's Shark Fin Prohibition bans the possession, sale, trade, and distribution of sharks and detached shark fins within the EEZ (FGC § 2021 - 2021.5, FGC § 7704, Bonham 2014). These initiatives apply to domestic and international concerns on targeted shark fisheries, shark bycatch, and shark habitat. A proactive measure included in domestic management is to protect juvenile, sub-adult, and early reproductive stages in sharks, as well as the habitat for those life stages, in order to rebuild shark stocks (NMFS 2001).

The U.S. asserts exclusive jurisdiction over all highly migratory species of fish (HMS) within the EEZ. The U.S. is also a member of regional-international organizations to effectively manage HMS throughout their range including the high seas within the Convention Areas of the Regional Fisheries Management Organizations (RFMOs). The range of many species that occur in Federal waters extends throughout the west coast, CCE, and across national boundaries (CDFG 2010, PFMC 2013, PFMC n.d., IATTC 2024, and ISC 2024). International organizations in which the U.S. participates that include eastern Pacific Ocean waters include the Inter-American Tropical Tuna Commission, and the Agreement on the International Dolphin Conservation Program (U.S. Commission on Ocean Policy 2004a, NMFS 2023f). In addition, the U.S. participated in the Western and Central Pacific Fisheries Convention, which establishes conservation and management measures for all countries and vessels operating in the region under the U.N. Fish Stocks Agreement, and the Western and Central Pacific Fisheries Convention (WCPFC) (U.S. Commission on Ocean Policy 2004a, NMFS 2023f). The WCPFC Convention Area includes the western and central Pacific Ocean, and not the Southern California Bight, but HMS vessels such as longline, purse seine, and albacore troll often fish in both the eastern Pacific and western Pacific Ocean. Biomass and recruitment estimates for many HMS stocks that occupy the CCE are available from stock assessments conducted by collaborators under the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean or the Inter-American Tropical Tuna Commission (Harvey et al. 2023, PFMC n.d.). HMS that may occur in the SCB are included in Table 7, based on FMP information. HMS species under the HMS FMP could occur in that area; but the prevalence may vary depending on ocean conditions, seasons, and inter-annual variations. The following HMS are actively managed under the HMS FMP offshore of Southern California:

- North Pacific albacore (*Thunnus alalunga*);
- yellowfin tuna (*Thunnus albacares*);
- bigeye tuna (*Thunnus obesus*);
- skipjack tuna (Katsuwonus pelamis);
- Pacific bluefin tuna (*Thunnus orientali*s);
- common thresher shark (*Alopias vulpinus*);
- shortfin mako or bonito shark (*Isurus oxyrinchus*);
- blue shark (Prionace glauca);
- striped marlin (*Tetrapturus audax*);
- swordfish (*Xiphias gladius*); and
- dorado or dolphinfish (*Coryphaena hippuru*s).

Forage species, including small fishes and invertebrates (e.g. krill) are an important foundation for the marine food web that feed large pelagic fishes (including salmon), sharks, marine mammals, seabirds, and turtles. Changes to forage species populations can have dramatic effects on other populations in the CCE (Enticknap et al.2011, CDFW 2016b, and PFMC 2016). Forage species are targeted by humans globally to provide fish for aquaculture feed, livestock and poultry feed, and human consumption (OIMB 2011, Enticknap et al. 2011). Tourism and recreational fishing that rely on healthy forage species brought in over $23 billion in GDP to the west coast California, Oregon, and Washington combined in 2004 alone (Enticknap et al. 2011). Forage data for the Southern CCE come from springtime CalCOFI larval fish surveys, along with various NMFS surveys, which can be used to identify regional shifts in forage composition in fish assemblage data (Harvey et al. 2023). Some forage species are considered Shared Ecosystem Components as Amendment 15 to the Coastal Pelagic Species (CPS) FMP, Amendment 25 to the Pacific Coast Groundfish FMP, Amendment 3 to the Highly Migratory Species (HMS) FMP, and Amendment 19 to the Pacific Coast Salmon FMP (PFMC 2016). The PFMC implements protections for forage fish species under ecosystem-based management policies. California has conformed State commercial fishing regulations to achieve optimum yield while avoiding conflict with Federal regulations (14 C.C.R. § 111, pursuant to FGC § 7652) (CDFW 2016b). A list of forage species that occur in the CCE is included on pp. 32 and 33 of Enticknap et al. (2011).

California Cooperative Oceanic Fisheries Investigations (CalCOFI) surveys show that spatial and temporal patterns in life stage can play an important role in considering impacts to wild populations. For example, both alternative areas show low habitat suitability probability (HSP) for adult bocaccio (*Sebastes paucispinis)*; but areas around Alternative 3 show moderate to high HSP for juvenile bocaccio (NCCOS 2005). Both alternative areas show high potential for all life stages, including spawning grounds, for Pacific sardine *(Sardinops sagax)* and northern anchovy *(Engraulis mordax)* (NCCOS 2005). Spawning grounds and larval distribution are influenced by SST and surface currents (Washburn et al. 2002, NCCOS 2005). The majority of the central subpopulation of northern anchovy occurs in the SCB, and most juveniles are found within waters less than 90 m (295 ft) deep (Methot 1989, Smith 1985, NCCOS 2005, Dorval et al. 2018, Stierhoff et al. 2019, and Kuriyama et al. 2020). Some juvenile rockfish survival to adult dispersal has been associated with the presence of offshore oil platforms that can be used as nursery habitat (Vetter et al. 2003, Nishimoto et al. 2019). In the Santa Barbara Basin, the persistent counterclockwise gyre and bathymetric features restrict oxygen and larval distribution. Most larval survival and fishes occur in waters less than 300 m (984 ft) deep (Vetter et al. 2003). Larvae are retained towards the northwest side of the Santa Barbara Basin (Nishimoto et al. 2019). Movements of eggs and larvae around Santa Monica-San Pedro Basin, are contained in eddies within the waters of the SCC entering the SCB from the south, except during upwelling relaxation in fall and spring transitions (Vetter et al. 2003, Logerwell and Smith 2001, and Nishimoto et al. 2019). Connectivity in particle disbursement between the two basins associated with alternative areas is seasonal.

Fisheries-harvested landings and squid were incorporated into the Atlas, and are included as part of the affected socioeconomic environment in Chapter 3, Section D.i. (Commercial Fishing) and D.ii. (Recreational Fishing). For additional species and habitat information see:

- Habitat suitability models for eight Federally-managed fish species thought to be representative of significant commercial, ecological, and recreational value in the SCB are provided in Section 4.1 of the CINMS BGA (NCCOS 2005).
- A detailed species description and habitat suitability analysis for market squid (*Loligo opalescens*) is provided in Section 3.1 of the CINMS BGA (NCCOS 2005).
- Figures 2 through 12 of Relano and Pauly (2022) show the migratory routes, larval distribution, and spawning grounds for HMS species in the Pacific Ocean, with associated literature reviews per species and geographic area.
- Page 359 of Caselle et al. (2010) summarizes the fish species and species groups that characterize the “central” Santa Barbara Channel, which includes the alternative areas.
- Pages 536 through 539 of Nishimoto et al. (2019) provides a detailed literature review about fish and invertebrate assemblages and larval distributions associated with offshore oil platforms in the SCB, as well as Table 1.

Stressors

Existing conservation concerns for wild fish stocks in the SCB include targeted fishery pressure, fisheries bycatch, ocean acidification and other factors associated with climate change, habitat degradation, predation, and pollution. See Chapter 4, Section A.i. for predicted population trends associated with climate change. For larger, long-lived predatory fish, life history characteristics may act as a stressor when combined with any environmental changes and make them more vulnerable to human impacts. Smaller, forage species populations are more closely reliant on oceanographic conditions and primary productivity (discussed in more detail in Chapter 3, Section B.i. (Oceanography and Climate)). The existing fluctuations of the SCB ecosystem determine reproductive potential and survival of many fish species. The variation in forage species density and abundance is often thought to be a factor in mass mortality or unusual mortality events for seabirds and marine mammals. It can also change the distribution of predators like salmon that are commercial target species.

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- fixed gear and other equipment placement in the water column and surface;
- artificial light and underwater noise generated by systems, equipment, activities;
- risk of marine debris;
- human interactions;
- new areas for wildlife aggregations;
- effluents;
- risk of escapes;
- risk of parasites, viruses, bacteria, and vector transmission; and
- risk of the introduction of nonnative species.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

This section covers potential impacts on wild fish stocks as part of the biological environment and ecology of the SCB. See Chapter 3, Section D.i. (Commercial Fishing) and Section D.ii. (Recreational Fishing) for more information related to socioeconomic aspects of targeted fisheries in the SCB.

Habitat Characteristics and Habitat Use

While the action of identifying AOAs may not have impacts, offshore aquaculture activities during site assessments, construction, operations, and decommissioning have the potential to impact habitat characteristics and habitat use. Chapter 15 of Kiffney et al. (2022) analyzes the impacts of aquaculture on EFH. Impacts could range from temporary and long-term depending on the activity and the type of EFH. The temporal scale may be short term for migratory or transient species, or long term for the lifetime of the project for resident species (Clement 2013). Operational procedures and the timing of operations also influence the degree of impacts (Young 2015). It is not likely that all projects sited in an AOA would have the same or similar lifespans, therefore, the temporal scope of impacts would likely extend past what would be considered for an individual project. Short term impacts e.g., water column disturbance or wildlife aggregations, are more likely to occur to an individual, whereas populations may be more likely to be impacted by long term or permanent changes associated with habitat. The spatial scale of any impacts on habitat use would likely be amplified by siting multiple projects in an AOA.

Temporary disturbance to benthic habitat (e.g. from vessel anchors) would not likely have significant impacts on wild fish stocks if considerations from the Atlas, this DPEIS, and site-specific characterization surveys were conducted for siting and permitting decisions that avoid, minimize, mitigate, or otherwise offset adverse effects on EFH and other sensitive fish habitat. More long-term activities associated with aquaculture that could adversely affect fish habitat include fill and excavations necessary for site surveys or placement of moored structures. Potential changes to pelagic habitat that may impact wild fish stocks include water diversions, shading or artificial light, noise, exposure to chemicals or hazardous materials, and exposure to increased competition, predation, or disease via wildlife aggregations.

EFH and sensitive habitat were incorporated into the site suitability analysis in the Atlas used to develop the AOA options (Morris et al. 2021). However, it is possible that currently-unmapped habitat conditions may be discovered during site-specific baseline environmental surveys within an AOA. MSA's requirements for EFH at 50 CFR 600.920(a)(1) regard the potential impact of human activities on EFH functionality. During any permitting decisions for aquaculture facilities sited in an AOA, the permitting agencies would be required to consult with NMFS regarding any proposed actions that may adversely affect EFH that occurs within or near to the proposed area. Any aquaculture project would likely be required to undergo an EFH consultation to avoid, minimize, mitigate, or otherwise offset adverse effects (Morris et al. 2021, NMFS 2023e). More information on the proximity of the alternative areas to sensitive habitat is included under each alternative, below.

Changes to habitat use may include exclusion, avoidance, or attraction. Individual fish attraction and habituation could range from no impact, beneficial (e.g. increased foraging success), or adverse impacts (e.g. increased predation, risk of entanglement), depending on intra- and inter-specific interactions around a facility. Exclusion and avoidance may range from no impact on individuals, or adverse impacts if individuals are influenced to occur in less desirable habitat and/or areas of increased fishing pressure. Populations may be impacted if individuals experience long-term foraging, navigation, or communication obstacles that may lead to decreased reproductive success. Wild fish stocks are known to be attracted to structures in the water, which could lead to beneficial or adverse impacts.

Wildlife Aggregations

Fish assemblages in the SCB already show connectivity between existing offshore oil platforms, kelp beds, and offshore rocky reefs. A map of existing FADs in the SCB is shown in Figure 1 on p. 12 of Kramer et al. (2015). Based on the literature review in Rhodes et al. (2023a), wild fish aggregate around aquaculture facilities globally, regardless of cultivated species. Aquaculture structures in an AOA, regardless of cultivated species, would possibly increase potential for fish aggregations, and increase the connectivity between man-made structures in the offshore environment. This connectivity could create new dispersal pathways for native and nonnative invertebrates and fishes (Diana 2009, Adams et al. 2014). Biomass and fish species density may increase around structures, but effects are species-specific (Mercader et al. 2017). Additional effects may be minor and positive, such as opportunistic feeding for large, predatory fishes, sharks, and rays that may occur around an AOA-sited aquaculture facility. Opportunistic feeding around FADs would also increase the risk of entanglement, an adverse impact. For additional literature reviews describing how aquaculture facilities, or proxy offshore structures, create habitat and act as FADs see:

- pp. 167 and 168 of the NMFS Pacific Islands Region Aquaculture Management Program DPEIS (NMFS 2021a);
- Section 2.1.1 of Clavelle et al. (2019);
- Section 3.1.3 of Kramer et al. (2015), including Table 3 which predicts occurrence of special status fish species in the SCB near bottom, midwater, and surface structures; and
- pp. 536 through 539 of Nishimoto et al. (2019) provides a detailed literature review about fishes and invertebrate assemblages and larval distributions associated with offshore oil platforms in the SCB.

Habitat modifications that affect the abundance and diversity of marine organisms (e.g. biofouling invertebrates, algae, and surrounding fishes) can have both beneficial and adverse impact on fishes. Based on the literature review in Kramer et al. (2015) on ecological interactions of renewable energy structures, total number of bottom structures (e.g. anchors and foundations), vertical relief and complexity of bottom structures, and distance to the nearest natural reef or other hard structure would be important considerations to assess impacts on fish assemblages and ecological interactions. Benefits depend on the complexity of the modification that provides food opportunity and shelter from predators (Mercader et al. 2019). The availability of prey species is considered a component of EFH, similar to temperature, water quality, or sediment type. (PFMC 2013). Gear footprints may also create site-specific eddy effects that may impact egg and larval retention around gear. Increased fish abundance and diversity from FADs could also benefit wild fish stocks by increasing reproductive output in populations. Beneficial population-level effects due to facilitated recruitment and new nursery habitat may benefit any species in the SCB, while population-level effects resulting from fishing exclusion would likely benefit species most heavily targeted by commercial operations, and more residential species (Boehlert et al. 2013, Wilhelmsson and Langhamer 2014, and Kramer et al. 2015).

Examples of fish groups that may be influenced by new fixed gear and structural habitat are provided under each sub-alternative, below. In contrast, mesopelagic fishes are mostly found between 200 m (656 ft) and 1,000 m (3,281 ft) deep along the continental slope, beyond the area of analysis. While some studies show mesopelagic fishes may undertake spawning and feeding migrations of up to 1,000 km (540 nm) (Nafpaktitis et al. 1977 as cited in PFMC 2016, Brodeur and Yamamura 2005), large-scale population shifts would not be likely with the siting of projects in an AOA. Squid habitat varies per species, but is generally linked to salinity, temperature, and prey availability. It is not likely that mesopelagic population shifts would occur due to FADs around an AOA.

FADs increase the risk of entanglement, predation, targeted fishing (more likely from recreational or small-scale vessels without expansive gear considerations), and exposure to other risks. Large sharks and rays, or large HMS species may be at risk of entanglement and entrapment in aquaculture gear of any type. Incidents of manta rays entangled in mooring and boat anchor lines have been documented (Deakos et al. 2011). Shark entanglement would likely be due to the attraction to cultivated fish, and is discussed more under sub-alternative b. Smaller fishes may be subject to increased predation if large predatory fishes, seabirds, or marine mammals are present in wildlife aggregations around any aquaculture gear.

Marine Debris

Accidentally-discarded or lost gear or other supplies from an aquaculture facility could result in marine debris interacting with wild fish stocks. Potential adverse effects of marine debris on EFH is described on pp. 187 through 189 of Kiffney et al. (2022), incorporated by reference. These interactions may not be adverse, but exposes individuals to risks of adverse impacts including entanglement, suffocation, starvation if ingested, smothering/covering, or alteration of the benthic invertebrate community (EPA 2011a, CalOPC 2018, ONMS 2019, Bath et al. 2023, Katsanevakis et al. 2007, Gregory 2009, and Kuhn et al. 2015). When tangled, animals are more susceptible to other threats including injury, predation, and infections (ONMS 2019). When ingested, marine debris can increase tissue contamination, cellular damage (e.g. tissue erosion or tumors), and reproductive issues, an existing conservation concern for fishes in the SCB (Schiff et al. 2000, USFWS 2005, Komoroske et al. 2011, LARWQCB 2011, and Spyrka 2017). Longer-living species are at higher risk to exposure to pollutants due to bioaccumulation of hard metals and tissue contamination over time and through the food web. The existing trend in this baseline condition, however, is that contaminant levels detected in the tissues of fishes and benthic species are going down (Schiff et al. 2000, LARWQCB 2011, and McLaughlin et al. 2021). However, pressures from marine debris are increasing, with its own array of persistent organic pollutants that are harmful to wildlife (Spykra 2017). The spatial relationships on contamination are not clear, especially for highly-mobile predators, but the magnitude of bioaccumulation is generally consistent with the magnitude of sediment contamination, and observed in higher levels in animals that live or forage at the seafloor (Schiff et al. 2000, Deheyn and Latz 2006).

A summary of fishes observed around marine debris in the SCB is provided in Sections 3.1.2.6 and 3.1.2.7 of Kramer et al. (2015). These observations may be used as a proxy for what may occur around any accidentally-discarded marine debris from an offshore aquaculture facilities sited in an AOA. See Chapter 3, Section B.iv. (Water Quality) and Chapter 3, Section D.v.iii. (Public Health and Safety) for other concerns associated with marine debris. It is not likely that the type of aquaculture would affect the risk of marine debris; therefore, it is not discussed further under each sub-alternative.

Noise and Light Pollution

Sound is important for fishes to navigate and interpret their environment. Variations in sensory capabilities result in different reactions to sounds. Many fishes and benthic invertebrates produce low frequency sounds (Mooney et al. 2020). Figure 9 shows the overlap of general hearing ranges with common anthropogenic noise in the marine environment. Fish may be exposed to underwater noise with no impact, startle and avoid, habituate to the sound over time, or injury or death. The risk of injury to marine life from anthropogenic noise depends on the specific activity and the hearing capability of the species present, the distance from the sound source, and the timespan of the disturbance (Clement 2013, Hawkins et al. 2014, Beta 2017, NMFS 2018, SEER 2021, and NMFS 2021a). For example, schooling pelagic fishes show similar startle response to temporary anthropogenic noise as a predator response, which has a metabolic cost; and if repeated over time, the fitness of the population could be reduced (Hawkins et al. 2014, Cox et al. 2018, and Weilgart 2018). Prolonged stress from noise may impact fitness via body malformations, increased stress hormones, higher egg mortality, developmental delays, and slower growth rates (Cox et al. 2018, Weilgart 2018). Disruptions to the baseline acoustic environment can impact populations' community structure and biodiversity (Weilgart 2018, Mooney et al. 2020, and NMFS 2021a).

Underwater noise has the potential to occur at all stages of an aquaculture project. Any required seafloor mapping or geophysical surveys during site-specific characterization may impact the underwater acoustic environment. Project-specific factors that may affect sound production during construction, operation, and decommissioning include the number of lines, pens, anchors, and vessels associated with an activity (Bath et al. 2023). Noise from construction and operations may be impulsive (e.g. pile driving) or continuous (e.g. mechanical operations, engines), and generated by vessel and human activity, fixed-bottom foundations, and floating structures. Vessel sounds associated with aquaculture operations would likely be in similar frequency and intensity ranges as those of commercial fishing and transport operations (Olesiuk et al. 2012). Background noise in the open ocean is lower frequency and not as intense as in coastal areas (Olesiuk et al. 2012). The offshore environment, due to deeper waters and more open space, may help mitigate some adverse impacts from noise associated with aquaculture. A comparison of how sound travels and refracts in shallow versus deep ocean water is described in Section 2.2.5 on pp. 9 and 10 of Olesiuk et al. (2012).

Regulatory mechanisms to monitor and mitigate adverse impacts from underwater and overwater noise are discussed in Chapter 3, Section B.vi. (Acoustic Environment). There are also many established mitigation methods required for marine industries under ESA, MMPA, and MBTA that would be incorporated into Section 7 consultations and other permitting decisions. Impacts from noise on wild fish populations would also impact cultivated finfish. Shellfish species also show increased metabolic stress due to noise (Weilgart 2018). In addition to regulatory mechanisms to limit noise pollution, it is likely that aquaculture operations would take precautions to limit stress on cultivated species during operations, regardless of aquaculture type. Therefore, noise is not discussed further under the sub-alternatives.

Artificial light could impact pelagic fishes at any stage of an aquaculture project. It is not likely that benthic species would be impacted by lighting systems. Impacts could range from no impact to disturbance or injury, or an increase in predation activity (Nash et al. 2005, Clement 2013). Artificial light under barges, around oil and gas platforms, and other structures in the water can influence the behavior and community structure of plankton, nektonic invertebrates, and fishes (Nightingale et al. 2006, Ono et al. 2010, Barker 2016, Bassi et al. 2022, Simons et al. 2021, Marangoni et al. 2022, and Oyabu et al. 2024). A review of the impacts of artificially-lit coastal infrastructure on movements of juvenile salmonids is summarized in Table 1 on pp. 9 and 10 of Ono et al. (2010). Impacts observed in the marine coastal environment may be similar to what could occur in the offshore environment of the SCB. Predatory fishes that may occur in the alternative areas may be drawn towards lighting systems, which could increase foraging opportunities. Indirect impacts from light attraction or disorientation include being more susceptible to predation, changes in foraging success and fitness.

The cumulative impacts from the noise and light of multiple aquaculture facilities in proximity to one another within an AOA would be an important consideration during permitting decisions. The cumulative dynamic range of sound levels and acoustic variation to measure species present in an area would also be important to monitor before, during, and after an aquaculture project to measure impacts to pelagic and benthic communities (Mooney et al. 2020).

Water Quality Pollution

Activities that introduce chemical pollutants, sewage, changes in water temperature, salinity, dissolved oxygen, and suspended sediment into the marine environment pose a risk to any surrounding fish species. Demersal, soft-bottom fish assemblages are susceptible to pollution impacts; the species are relatively sedentary and respond to environmental stressors in sediments (Schiff et al. 2000). SCB fish communities have shown historic shifts in abundance, biomass, diversity, and species composition in response to wastewater discharges, attributed to functional food web relationships to benthic communities and the toxicity in sediments (Schiff et al. 2000, 2016). More on the impacts of changes to water quality are described in Chapter 3, Section B.iv. (Water Quality), and under each alternative below.

Escapes

Escaped organisms and/or reproductive material from any type of aquaculture could cause impacts related to the introduction of new individuals and new genes to wild populations. Impacts to marine communities more generally are discussed in Section C.iii.

The risk of adverse impacts on wild populations from escapes depends on the way in which the escape occurs. Escapes may occur due to human error, weather conditions, or gear failure. In the event of an accidental release, many of the fish may be recovered, but it is likely that a small portion of fish would escape into the natural environment. Types of escapes may include:

- release of reproductive material or larvae during grow-out;
- breakage or detachment of macroalgae during grow-out;
- leakage escape during normal operational activities including cleaning, maintenance, inventory, net transfers, or harvest; or due to normal wear and tear such as small tears in a net (~release of 10s to 100s);
- episodic escape due to small- to medium-scale loss of infrastructure and episodic failures of gear, during events like a breach by a predator, collapse of one net pen, grow-out container failure or loss, cage malfunction, bag tearing, damage to mooring lines, vessel collisions, or the impact of waves and currents at the farm site (~release 1,000s to 10,000s); and
- large-scale escape and catastrophic escape due to a total system or gear failure across a facility, loss of a substantial portion of a farm system or even the entire farm, (~release of 10,000s to 100,000s).

The environmental consequences of escaped organisms include potential genetic impacts and/or ecological impacts. Genetic impacts may include the introduction of maladaptive genes and reduced fitness into the wild populations, and/or the loss of genetic diversity within or between populations (McGinnity et al. 2003, Waples et al. 2016, and Purcell et al. 2023 (draft)). Cultured populations of shellfish and finfish often show reduced genetic diversity compared to wild populations because broodstock represents a small subset of individuals, a fraction of potential wild diversity and due to selective breeding processes used in aquaculture. Genetic diversity provides long-term resilience to wild populations from new and future stressors (e.g. temperature stress associated with climate change) (Waples et al. 2012, Purcell et al. 2023 (draft)). Loss of genetic diversity in a population could result in the inability to respond to new selective pressure (e.g., environmental changes and pathogens). However, the extent of diversity loss, and the ability of wild populations to withstand or recover from a loss of diversity is difficult to quantify and varies greatly.

Potential adverse ecological impacts from interactions with wild populations include increased competition with wild populations for food and space, predation, and the transmission of disease (Fleming et al. 2000, Green et al. 2012, Rhodes et al. 2023a,b, and OMEGAs). The extent of the impact varies depending on the number of cultured organisms escaping, the life stage when they may escape, the frequency of escape events, cultured population husbandry and genetic management (e.g. reproductive capabilities), the proximity to wild habitat, and the size and health of wild populations (Lorenzen et al. 2012, Atalah and Sanchez-Jerez 2020, Rust et al. 2014, and Purcell et al. 2023 (draft)). Ecological interactions may have immediate impacts similar to wildlife aggregations, acting on temporally co-occurring populations. Escapees quickly become prey to other predators, lessening their potential for food and habitat competition (NMFS 2022d). As soon as reproductive potential is factored into interactions, the potential impacts become additional genetic considerations. The spawning success of escaped/dispersed organisms could vary from them entirely sterile to being capable of more successful contribution to the next generation compared to wild fish (Purcell et al. 2023 (draft)).

Data from other countries on the dispersal abilities of cultivated finfish (e.g., tagged and recovered Atlantic salmon, farmed cod, Gilthead Sea Bream, and European seabass) show that escaped fish are highly capable of traveling great distances to find their way to wild populations of the same species, however, domesticated fishes have a low probability of surviving in the wild (Purcell et al. 2023 (draft)). Studies also show that both male and female domesticated fishes have much lower reproductive success than wild counterparts, although most of the data is limited to Atlantic salmon (Purcell et al. 2023 (draft)). If escaped fish survive long enough to interbreed with wild populations, reproductive capabilities would depend on genetic fitness and the biological characteristics of both the escaped fish and the wild fish stocks with which they interact.

Due to the potential for negative ecological and genetic impacts from escapement, NOAA Fisheries has aided in the development of a scientific decision-support tool called the Offshore Mariculture Escapes Genetics Assessment (OMEGA) model to better understand these effects. OMEGA is a mathematical model with inputs that include the size and growth characteristics of the cultured species, the frequency and magnitude of escape events, survival rates of escapees in the wild, probability of escapees encountering wild counterparts and interbreeding, and the dynamics of the wild population. Outputs from OMEGA describe the influence these aquaculture escapees may have on the survival and fitness of the mixed population over time and are described below for the different types of aquacultures. The OMEGA reports describe the types of escape and interactions that occur, potential competitive and genetic effects on wild species, and mitigation measures to minimize adverse effects from escapes.

Escape risks can be managed through strategic siting, engineering design, and nursery practices. However, any aquaculture operation must account for the potential risk of unintentional releases due to factors such as storm events, wave action, vessel collisions, handling mistakes, predator attraction, and gear malfunctions. Potential mitigation measures include broodstock management, genetic diversity monitoring, seeding time, siting, harvest before maturity, and sterilization. Escaped/dispersed organisms and reproductive material are considered biological material and a pollutant that must be considered in the NPDES permitting process.

Disease

Aggregations, as well as the baseline proximity and geographic overlap of species habitat creates a potential risk for increased spread of pathogens and disease. Infectious diseases require a pathogen and host; the spread requires a third factor: a favorable environment, which makes a pathogen capable of infecting (e.g. temperature) and a host susceptible (e.g. poor nutrition) (Rhodes et al. 2023a). These three factors influence and may help identify the likelihood of disease and to identify mitigation. Many disease-causing agents routinely occur on a host or in the environment naturally, without causing disease. The focus in this DPEIS is on those that do infect and cause disease, including compromised immune systems and other health issues, damage tissues, or death. The increased likelihood of aggregations of forage fish, such as anchovy, may also result in thiamine deficiency. More on the diseases and associated regulatory frameworks that may be considered in macroalgae, shellfish, and finfish aquaculture are included under Chapter 3, Section C.iv. (Potentially-Farmed Species). Potential impacts to wild fish stocks are included under sub-alternative (b) in this section.

Introduction of Nonnative Species

If aquaculture gear within an AOA creates new habitat connectivity and pathways for nonnative species already existing in the SCB, minor benefits to wild fish stocks may include the availability of a new source of food from biofouling organisms for those fish that eat such species. Ecological, indirect impacts could be adverse or beneficial, contributing to predator-prey and other interspecific interactions for resources. NOAA Marine Aquaculture Policy (2011) supports the use of only native or naturalized species in federal waters unless best available science demonstrates use of non-native or other species in federal waters would not cause undue harm to wild species, habitats, or ecosystems in the event of an escape (NOAA 2011).This DPEIS assumes no non-native species would be grown in an AOA, thereby eliminating the risk of introducing non-native species to the environment, other than via contaminated broodstock. Regulatory frameworks that prevent contaminated broodstock are discussed under Section C.iv. (Potentially-Farmed Species); however, broodstock sourcing is outside the scope of the DPEIS.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The amount of pelagic habitat overlap that could occur for each AOA option in Alternative 2 is shown in Table 2. The largest option at 2,000 acres (8.09 km^2) is less than one percent of comparable habitat in Federal waters of the Santa Barbara Channel, and about one-hundredth of a percent of surrounding habitat in the SCB. If all AOA options in Alternative 2 were identified as AOAs, the maximum of 15,000 acres (60.7 km^2) would overlap with 1.2% of the pelagic habitat of the Channel. Habitat overlap may not have as much of an affect on mobile, pelagic species. Site-specific surveys to characterize bottom habitat would be necessary to analyze potential impacts on benthic species.

The results of Nishimoto et al. (2019) show that larval disbursement and recruitment has high connectivity between three offshore oil platforms, one north and one south of Alternative 2.

a) Shellfish and Macroalgae

While the action of identifying AOAs may not have impact, macroalgae aquaculture facilities that are sited could have beneficial and adverse impacts on wild fish stocks, depending on the cultivated species, wild fish species, and scale of operations. Potential impacts on EFH species or complexes for an 86 acre (35 ha) kelp facility in the SCB are described in Section 11.2.3 on pp. 32 through 34 of USACE (2021), and could be used as an example for potential site-specific NEPA analyses in the future incorporated by reference. An estimated 30% of the total documented species and 40% of fish families in the SCB depend on kelp habitat (McGinnis 2006). The trade-off changes in ecosystem patterns for wild fish stocks and seaweed aquaculture are summarized in Table 5 on p. 202 of Preat et al. (2018), and could be used as an example for potential site-specific NEPA analyses in the future, incorporated by reference. In general, macroalgae aquaculture would create new FADs, habitat connectivity, shading, nursery habitat for juveniles, and predator protection. Artificial FADs near the Channel Islands show high influence on jack mackerel (*Trachurus symmetricus*) and juvenile rockfish (Kramer et al. 2015). Another potential population interaction could occur with silversides (family *Atherinopsidae*), which are rarely found offshore. The baseline habitat range would therefore be out of the area of analysis; but they are associated closely with kelp and other structures in the water column, especially to lay eggs (PFMC 2016). Macroalgae facilities could provide novel offshore spawning habitat for this and other species groups that usually associate with kelp beds closer to shore. However, fishes may be left more susceptible to predation upon harvest of the macroalgae.

Caselle et al. (2010) found that in the SCB, there is a large-scale adverse relationship between oceanographic conditions that favor kelp survival and abundance and conditions that concentrate and distribute fish larvae. In addition, Preat et al. (2018) showed that large-scale seaweed production may decrease fish biota in a local ecosystem due to cultivated seaweed biomass replacing phytoplankton biomass in the food web. A study of existing biomass subsidies and nutrient exchange between kelp forests on the west coast of North America and pelagic ecosystems is detailed in Zuercher and Galloway (2019), that notes the importance to juvenile rockfish, herring eggs, and community-level consequences.

The restorative potential for habitat would likely be net-positive for fish population; but the timing and amount of project-specific harvests may need to be considered along with spawning seasons to better analyze if impacts would be beneficial or adverse.

There are three mapped and monitored kelp beds within 5 km (2.7 nm) of Alternative 2, with the nearest occurring about 0.07 km (0.04 nm) from N2-E (Protected Seas 2022). Based on time series satellite data from 1984 through 2023 on KelpWatch.org, the total emergent kelp area in the Santa Barbara Channel was estimated roughly at about 1,600 acres (648 ha) from Point Conception south to Point Dume, and including the eastern side of the Northern Channel Islands (Bell et al. 2023, 2024). Using only data from the most recent season, 2022 to 2023, the estimated emergent kelp in the Channel was estimated at about 600 acres (243 ha). There is no way to predict what projects in an AOA would decide to grow and the size of production, but the potential to increase the amount of kelp habitat is pronounced, in acreage options ranging from 1,500 to 15,000 acres (607 to 6,070 ha) that could potentially be sited for macroalgae aquaculture. For example, Giant seabass (*Stereolepis gigas*), California sheephead (*Semicossyphus pulcher*), or California halibut (*Paralichthys californica*) are normally associated with nearshore kelp beds and could be drawn to macroalgal aquaculture, further offshore than what may be considered normal habitat in baseline conditions (Morris et al. 2021). An example of how EFH was considered for an offshore kelp facility in the Santa Barbara Channel is provided in Section 11.2.3 on pp. 32 through 33 of USACE (2021), and could be used as an example for potential site-specific NEPA analyses in the future and is incorporated by reference.

Shellfish and seaweed aquaculture would both increase structural complexity and productivity of the pelagic environment. Shellfish operations would likely improve water quality by removing particulates and excess nutrients from the water column (Clavelle et al. 2019). Underwood and Jeffs (2023) found that both mussel and seaweed aquaculture facilities in New Zealand increased settling and recruitment of fish populations, similar to a rocky reef habitat. Still, shellfish aquaculture may not have the same effect on spawning and early life stages of fishes, relative to those species that associate with macroalgae aquaculture. Studies in the SCB on pelagic fishes show an existing spatial association, but low functional, ecological relationships with structure-forming invertebrates (Tissot et al. 2006, Bright 2007, Bianchi 2011, and Hourigan et al. 2017).

The planktonic stages of many fish species last several months (Vetter et al. 2003). Therefore, seasonality of operations (e.g. harvest) and maintenance (e.g. eliminating biofouling organisms) would also be important to consider for potential impacts of macroalgae and shellfish aquaculture on the larval stages of wild fish stocks.

Wild fish populations may experience changes in habitat function as a result of escaped genetic material from macroalgae and shellfish aquaculture. For instance, proliferation of nonnative macroalgae (e.g., *Sargassum horneri*) and shellfish (*Crassostrea gigas*) have already been observed in the SCB.

b) All Types of Commercial Aquaculture

Habitat Use and FADs

Research and reports globally show net pens in marine aquaculture act as FADs. Reports and studies reviewed in Price and Morris (2013) from finfish aquaculture in the Aegean Sea and Greece concluded an overall benefit to wild fish community structure, factoring in wild fish abundance, length, and weight. Additional reports from the Aegean Sea imply fish abundance may be influenced up to 3 mi from a finfish facility (Callier et al. 2018). Excess feed, waste, and biofouling may provide a new food source for wild fish stocks, and net pens provide shading and shelter from predators (Price and Morris 2013, Kramer et al. 2015, Mercader et al. 2019, Fujita et al. 2023, and Rhodes et al. 2023a). During finfish grow outs, studies from Israel, Spain, and Australia reviewed in Price and Morris (2013) found that up to 80% of sedimented nutrients from fish aquaculture may be consumed by wild fish surrounding cages.

Studies have found much higher fish abundance, density and diversity below existing net pens in the region, compared to 500 m (1,640 ft) away and distant reefs in the SCB, and some of the structures (Oakes and Pondella, 2009). Prior to harvest, wild fish abundance was about 50 times greater at cages than at control sites, and even after harvests, wild fish abundance was double control levels (Oakes and Pondella 2009). Most fish associations at the net pens in northern Baja occur in late spring through fall, when water temperatures were higher (Kramer et al. 2015).

In a pelagic ecosystem, fixed gear and FADs would create beneficial feeding opportunities including any algal and invertebrate growth on cages, feed pellets falling through the cage, and shelter and foraging habitat for fishes in a pelagic ecosystem primarily devoid of both (Vita et al. 2004; Helsley 2007; Sudirman et al. 2009; and Price and Morris 2013). Nutrient enrichment, and related increases in primary productivity in the waters surrounding a finfish facility may create a new, reliable food source for planktivorous fishes and rays. For example, Pacific Herring populations (suborder Clupeoidei) are found typically closer to shore in the SCB, but can occur in depths up to 200 m (656 ft). This species could alter normal distribution patterns to take advantage of new productive habitat within the pelagic environment further offshore. At a finfish operation located in northern Baja, California, Mexico, large schools of forage species including anchovy and sardines have been documented around net pens, whether or not the cages were stocked (Kramer et al. 2015). Accounts from Hawaii also state that baitfish species distributions were especially-influenced by the presence of finfish cages (NMFS 2022e). Fishes that feed on output particulate organic matter, such as large benthic chondrichthyid rays and *Pagellus* spp. would likely shift with operation activities, but studies reviewed in Price and Morris (2013) show herbivores and mid-sized benthic carnivorous fishes remain after harvests of cultivated species.

Understanding species distributions can help narrow the list of species (wild and cultured) evaluated for disease transfer and the potential for genetic impacts if escaped aquaculture animals take part in hybridization or introgression with wild organisms (Parrish and Karp 2024). Rhodes et al. (2023a) analyzed the geographic overlap of the alternative areas with commercially and recreationally valuable species in the SCB. While the presence or absence of certain species in an area can vary greatly from year to year in the SCB, the analysis does provide a baseline for potential wild species interactions that should be considered in site specific NEPA analyses. In catch-per-unit-effort data from the annual U.S. West Coast Groundfish Bottom Trawl Survey analyzed from 2003 through 2023, 8 out of 14 evaluated fish species show distributions that overlap with AOA options included in Alternative 2, as shown in Appendix D2 on p. 104 of Rhodes et al. (2023a). Building upon Rhodes et al. (2023a), Parrish and Karp (2024) conducted a spatial analysis on wild fish biomass that are of conservation and/or commercial value in the SCB, and physiologically similar or the same species as those likely to be cultivated in an AOA. Alternative 2 has occurrence of bocaccio (*Sebastes paucispinis*), California halibut (*Paralichthys californicus*), Dover sole (*Microstomus pacificus*), English sole (*Parophrys vetulus*), lingcod (*Ophiodon elongatus*), Pacific pompano (*Peprilus simillimus*), California market squid, northern anchovy, and eulachon (*Thaleichthys pacificus*) (Parrish and Karp 2024). The amount of the SCB covered by areas of extremely low, low, moderate, and high biomass areas of each highlighted species is shown in Figure 5 on p. 17 of Parrish and Karp (2024). These analyses can serve as a baseline against which future analysis can be compared upon the establishment of aquaculture infrastructure, and may provide a framework for site specific NEPA analyses to inform permitting decisions. The potential socioeconomic impacts on commercial and recreational fisheries if these wild populations were impacted are included in Chapter 3, Sections D.i. and D.ii.

Net pens are also attractive to predatory fishes and sharks because of the food availability not just in facility outputs, but from the FADs themselves. Literature and reports from the west coast, Puerto Rico, Bahamas, Hawaii, Indian Ocean, southern Atlantic Ocean, and Australia all show that sharks are attracted to fish cages (NMFS 2021a, Fujita et al. 2023, and Bath et al. 2023). In Hawaii, it has been hypothesized that finfish facilities may even serve as navigational landmarks for sharks as they move throughout the islands (Papastimatiou et al. 2010). Shark attraction would increase potential predation on other fishes, and may increase the risk of shark entanglement in aquaculture gear (Mori and Riley 2021, NMFS 2021a). In Australia and South Africa, many white sharks (a species with conservation status in the SCB) have been killed annually at finfish facilities due to entanglement and predation concerns, which has led to public outcries and the shutdown of projects (Price and Morris 2013). A more detailed literature review of shark interactions with aquaculture gear is provided in Section 3.4 on pp. 19 through 21 of Bath et al. (2023).

An additional potential impact from finfish aquaculture on wild fish stocks may occur from the use of predator deterrents. The use of acoustic deterrents and small-charge explosive deterrents are used in the SCB already for other offshore industries, especially in areas where market squid are targeted in the purse-seine fishery (Krumpel et al. 2021). The potential effects of marine mammal deterrents on finfish around salmonid aquaculture in Canada is reviewed in section 2.4 o of Olesiuk et al. (2012).

Escapes

Fish escapes are inevitable in aquaculture and have been reported in almost every country where aquaculture occurs (Jackson et al. 2015, Glover et al. 2017, McIntosh et al. 2022, and Purcell et al. 2023 (draft)). Although diligence through technology and management help mitigate escapes, it is nearly impossible to guarantee that cultivated fish and organic material from macroalgae and shellfish aquaculture would not ever be released from facilities. The OMEGA model was used for three case studies of candidate aquaculture finfish species in Southern California. These scenarios are the best available science, in the absence of specific project designs that would contain project size and production scales. The results suggest:

- for California yellowtail (*Seriola dorsalis*): no significant impact on wild population fitness or genetic diversity;
- for white seabass (*Atractoscion nobilis*): slight loss in wild population fitness that would likely increase over time across multiple generations of fish, leading to long-term or cumulative impacts rather than short-term impacts, but no significant loss in genetic diversity; and
- for striped bass (*Morone saxatilis*): moderate impacts to wild populations, although there are many unknowns. The probability of smaller, localized populations in the SCB suggest a high potential for escaped cultured fish to affect fitness and genetic diversity.

The risk of wild population genetic change is species-dependent. Variation in risk is attributed to biological life history characteristics of a wild population, such as abundance relative to production scales, lifespan, and spawning behaviors. The timing of grow-out and harvest would also contribute to the effect, depending on the age and sexual maturity of escaped fish.

Overall, the likelihood of escapes is high. However, the likelihood of escapees contributing significant genetic change to wild populations is species-dependent and variable, but generally not high. The ability for domesticated fishes to survive, and compete with wild fish stocks for food or habitat is low.

Disease

Most offshore aquaculture systems would likely have free seawater interchange with few barriers to flow between the culture system and the open ocean. Infectious diseases caused by viruses, bacteria, fungi, and sporozoans (spore-forming protozoan pathogens) are a risk for wild fish stocks surrounding aquaculture facilities. The spread of disease may occur from wild populations to cultured, or vice versa. It may also spread within wild populations due to intra- and inter-specific proximity in wildlife aggregations around an aquaculture operation. Transmission methods include:

- waterborne transmission by release from an infected host into water and uptake directly from water by a susceptible host;
    - direct or physical contact between infected and susceptible individuals, including predation, ingestion of shed material such as feces or mucus, and feeds;

- association with organisms that can carry pathogens, either as reservoirs or as intermediate hosts;
- association with contaminated inanimate materials (fomites) such as substrates and structures (e.g., equipment, sediments) contaminated with a pathogen; and
- active pathogen movement from infected host to susceptible host (e.g., motile stages of parasitic copepods).

More detailed descriptions of each transmission method are provided on pp. 5 through 7 of Rhodes et al. (2023a).

Disease can affect individuals, populations, and habitat quality. Some pathogens have the ability to infect hosts of different species (Rhodes et al. 2023a). Sea lice, which have the potential to infect salmonids as well as other fishes, are a high-priority pathogen to control for fish health (Costello 2009, Thorstad et al. 2015, Guragain et al. 2021, Mordecai et al. 2021, and Rhodes et al. 2023a,b). Fishes, sea turtles, and marine mammals in wildlife aggregations are all considered a risk to spread bacterial infections to other species, including cultivated or wild fish, as well as to humans (Warwick et al. 2013, Mashkour et al. 2020, Ebani 2023, and Rhodes et al. 2023a). HABs (discussed in more detail under Chapter 3, Section B.iv. (Water Quality)), can also sicken and kill marine organisms at all trophic levels.

The effect of disease as well as therapeutic drugs are expected to be lower in the offshore environment than would be used in nearshore, shallow waters or in closed systems over land due to higher flushing rates, distance between facilities, and other natural factors of the offshore environment, such as those described in Chapter 3, Section B.i. (Oceanography and Climate), that would mitigate the risk and spread of disease (Price and Morris 2013, Rust et al. 2014, and Fujita et al. 2023). Still, the proximity and geographic overlap of potentially cultured species with wild populations increases the risk of disease. Disease interactions between wild and cultured fishes is described on p. 172 of the Pacific Islands Aquaculture Management Program DPEIS (NMFS 2021a). Most of the research on disease and pathogens in finfish aquaculture comes from salmonids, which would not likely be grown in the SCB due to industry interest and policy directives from the State. However, it is the best information available on the methods of transfer, and on mitigation strategies, that may be used as a proxy to analyze the risks in other types of finfish aquaculture. A list of pathogens and diseases that have been identified by the World Organization for Animal Health with host type is provided in Appendix A of Rhodes et al. (2023a). General descriptions of diseases and current management tactics for them are provided in Appendix B of Rhodes et al (2023a).

Pressure on Forage Species

Globally, wild juvenile fishes may be used to stock finfish aquaculture, and wild forage fish species may be used as feed inputs. Formulated feeds are dependent on inclusion of fish meal and oil to provide the protein and nutrients necessary for proper growth of cultured carnivorous fish, varying depending on the species being raised. The primary fish species used for feed in the U.S. are the Gulf and Atlantic menhaden, followed by Atlantic herrings and Californian pilchards (NMFS 2021a). The reliance of finfish aquaculture on wild fish stocks is an existing conservation concern that requires both managing fisheries sustainably and fostering an innovative aquaculture industry (Duarte et al. 2009; Naylor et al. 2000, 2009, and Clavelle et al. 2019). However, turning whole fish into fish meal in California is currently illegal. In addition, FGC for potential finfish marine aquaculture that could occur in state waters requires the use of fish meal and fish oil be minimized in feed (FGC §15400(b)(3)). If projects sited in federal waters were to consider and operate consistently with this requirement in state waters, impacts may be minimized (CDFW 2019). Existing regulatory measures in SCB fisheries would not likely allow harvest of forage species above sustainable levels, and currently-caught fish could be used without increasing fishery pressure.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The amount of pelagic habitat overlap that could occur for each AOA option in Alternative 3 is shown in Table 3.The larger option at 1,000 acres (4.05 km^2) is under one-hundredth of a percent of comparable habitat in Federal waters of Santa Monica Bay, and even less of surrounding habitat in the SCB. Habitat overlap may not have as much of an effect on mobile, pelagic species. If aquaculture facilities are sites in this area, site-specific surveys to characterize bottom habitat would be necessary to analyze potential impacts on benthic species.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section. Two differences to note are the proximity to mapped kelp beds, and the relationship of historic water quality concerns to harvests of marine life in Santa Monica Bay.

There is one mapped and monitored kelp bed within 0.5 km (0.27 nm) from both AOA options within Alternative 3 (Protected Seas 2022). Based on time series satellite data from 1984 through 2023 on KelpWatch.org, the total emergent kelp area in Santa Monica Bay was estimated roughly at about 67 acres (27 ha) from the Ventura-Los Angeles County line south to Griffith park, extending to the shelf (Bell et al. 2023, 2024). Using only data from the most recent season, 2022 to 2023, the estimated emergent kelp in the Bay was estimated at about 119 acres (48 ha). The increase in emergent kelp appears to be concentrated near Palos Verdes Estates. There is no way to predict what projects in an AOA would decide to grow and the size of production, but the potential to increase the amount of kelp habitat is pronounced in acreage options ranging from 500 to 1,500 acres (202 to 607 ha) that could potentially be sited for macroalgae aquaculture. This would likely be a net-benefit for wild fish populations, again depending on sustainable methods, amounts, and seasonality of harvests. The example of how EFH was considered for an offshore kelp facility in the Santa Barbara Channel provided in Section 11.2.3 on pp. 32 through 33 of USACE (2021), is the nearest proximal location to Alternative 3 and is incorporated by reference.

Shellfish aquaculture has the potential to have a beneficial impact on the water quality conditions in Santa Monica Bay, which could impact wild fish stocks on an ecological level. Areas exhibiting large shellfish populations in Santa Monica Bay are monitored closely due to existing water quality concerns in the great watershed area, including invasive species and algae blooms that create shellfish consumption advisories (LARWQCB 2011). Concentrations of pollutants that have been observed in plankton, invertebrates, and shellfish species increase as sample locations approach the Palos Verdes Shelf (Schiff et al 2000). Storms disrupt predominant conditions, and create highly variable flow in the marine environment. During storms and precipitation events that create high flow of coastal runoff, there are suspensions on shellfish and seaweed harvesting, along with other objectives under Section 101(a)(2) of CWA (LARWQCB 2011). Aquaculture facilities sited in an AOA in Santa Monica Bay would likely need to monitor storms and discharge plumes closely for product viability, which may require special coordination with Federal, State, and local agencies. An indirect impact on wild fish stocks from these variable water quality conditions and coordination may be extra vessel traffic, noise, and human activity at a project site, compared to Alternative 2. It would also be important that any accidental spills, other pollutant exposures, or marine debris from a facility be prevented due to the state of the baseline conditions. Example BMPs for preventing marine debris and other spills are provided in Appendix 1.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section. There are a few differences in species that may be highlighted in Santa Monica Bay for potential interactions with cultivated finfish populations, and the relationship of historic water quality concerns to harvests of marine life in Santa Monica Bay.

Rhodes et al. (2023a) analyzed the geographic overlap of the alternative areas with commercially and recreationally valuable species in the SCB. In Catch-per-unit-effort data from the annual U.S. West Coast Groundfish Bottom Trawl Survey analyzed from 2003 through 2023, 5 out of 14 finfish species evaluated overlap with AOA options included in Alternative 3, as shown in Appendix D2 on p. 104 of Rhodes et al. (2023a). While the presence or absence of certain species in an area can vary greatly from year to year in the SCB, the analysis does provide a baseline for wild species interactions that should be considered in site specific NEPA analyses. Building upon Rhodes et al. (2023a), Parrish and Karp (2024) conducted a spatial analysis on wild fish biomass that are of conservation and/or commercial value in the SCB, and physiologically similar or the same species as those likely to be cultivated in an AOA. Alternative 3 has occurrences of Dover sole, English sole, lingcod, Pacific pompano, and sablefish (Parrish and Karp 2024). These analyses can serve as a baseline against which future analysis can be compared upon the establishment of aquaculture infrastructure, and may provide a framework for site specific NEPA analyses to inform permitting decisions. The potential socioeconomic impacts on commercial and recreational fisheries if these wild populations were impacted are included in Chapter 3, Sections D.i. and D.ii.

The potential impacts of finfish and IMTA aquaculture may impact the water column via effluents, which could exacerbate baseline stressors for wild fish in Santa Monica Bay. The offshore environment is thought to mitigate many of the adverse impacts to water quality in comparison to nearshore, more shallow and enclosed waters (Price and Morris 2013). However, some of the baseline conditions may amplify any risk of water quality changes. Elevated concentrations of several contaminants (including PCBs and DDTs) in fishes have been found in Santa Monica Bay (Schiff et al. 2000, LARWQCB 2011). According to the State Office of Environmental Health Hazard Assessment (OEHHA) of potential risks to humans associated with consumption of seafood species taken from the Bay, white croaker (*Genyonemus lineatus*) is considered to be the most contaminated fish, along with California corbina (*Menticirrhus undulatus*), queenfish (*Seriphus politus*), surfperches, and California scorpionfish (*Scorpaena guttata*) (CRWQCB, 1997).

Due to the existing water quality and sediment stressors in Santa Monica Bay, wild fish stocks may be especially-susceptible to human activities and impacts from an aquaculture project. As with shellfish and macroalgae aquaculture, finfish or IMTA projects sited in an AOA in Santa Monica Bay would likely need to monitor storms and discharge plumes closely for product viability, which may require special coordination with Federal, State, and local agencies as well as extra vessel traffic, noise, and human activity at a project site, compared to Alternative 2. It would also be important that any accidental spills, other pollutant exposures, or marine debris from a facility be prevented due to the state of the baseline conditions. Site Specific NEPA analyses would likely need to incorporate fine scale, site-specific data on species presence, hydrology, sedimentation and nutrient patterns to predict the risk of adverse impacts to wild fish stocks. Resources that would provide the most up to date science on contaminants from ongoing monitoring and research in the SCB are provided under Ongoing Monitoring and Coordination in Chapter 3, Sections B.iv. (Water Quality) and D.viii. (Public Health and Safety).

A few scenarios related to protected species that could occur as an indirect impact of IMTA are as follows:

- Growing seaweed adjacent to finfish could slow flow rates, amplifying any decreased oxygen in the surrounding water column; however, if grown at an appropriate distance down-current, it may help assimilate nutrients into the food web (Rensel and Forster 2007).
- Growing crustaceans with finfish can alleviate some of the pressures of parasitic organisms that could infect wild populations (Rensel and Forster 2007).
- Growing any combination of trophic levels may encourage an increase of local biodiversity and species abundance, enhancing the local food web (Rensel and Forster 2007).
- Including cohabiting predatory fishes can remove weak, diseased, or invasive fishes from net pens or ranches (Akiona et al. 2022).

Alternative 4: Combination of Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.

The spatial scale of any impacts on habitat use would likely be amplified by identifying multiple AOAs across a larger geographic scale, assuming more aquaculture would be sited across 14.8 km (8 nm) of the SCB. The greater the geographic range, the greater the scale of impacts may occur – for both beneficial (e.g. kelp habitat and habitat connectivity among FADs) and adverse impacts (e.g. fish escapes, effluents).

Any cumulative impacts of aquaculture sited close to one another could be mitigated by a broader geographic context (Gentry et al. 2017, Fujita et al. 2023). Identifying AOAs in both geographic areas could speak to this effect, with the assumption that projects would be encouraged to use spatial distribution as impact mitigation and management. A few examples include compounding effects of noise, light, and glare from facilities sited close to one another; wild fish populations may maintain distribution patterns more similar to baseline conditions with facilities spaced farther apart across the SCB; spacing facilities further apart from one another and away from other concentrations of wild populations would reduce the transmission rates of disease; and if water quality concerns arise to limit operations in one area, they may be maintained elsewhere.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

iii. Ecologically-Important Marine Communities

Affected Environment

Ecological communities are important to consider in programmatic evaluations of proposed activities that may cover a large area or region, especially in the marine environment. Due to the large geographic scope of some of the marine resources covered in this DPEIS, and without knowing site-specific presence-absence information within each alternative, describing potential interactions at a community level may be necessary to assess impacts from future activities. The information provided in this section builds upon the habitat modeling and suitability analysis of the Atlas, which analyzes over 200 large-scale datasets in the SCB (Morris et al. 2021). The information provided in this section also builds upon more targeted sections of the DPEIS that focus on specific species and other natural resources protected by Federal regulations. This section provides information generally and qualitatively on lower trophic levels, as well as benthic and pelagic resources, as a comprehensive approach to support ecological management of marine resources.

Interactions between California state and Federal regulations are discussed in Chapter 3, Section A.ii. (Federal and State Regulatory Frameworks). Incorporating the State and Federal species into aquaculture permitting discussions would support ecosystem-level management, which improves the likelihood of recovery of protected species and habitats and helps prevent future endangered species act listings by improving conditions for all native species (Mount et al. 2019).

It is the policy of the U.S. to prevent the introduction, establishment, and spread of invasive species, as well as to eradicate and control populations of invasive species that are established. Invasive species may be plants, animals, or other organisms, and can occur in any type of habitat within the ocean. The National Invasive Species Council (NISC), established under E.O. 13112, describes invasive species as non-native species whose introduction does, or is likely to cause, economic or environmental harm or harm to human, animal, or plant health; and further, that do not provide an equivalent or greater benefit to society (ISAC 2006). Although some invasive species are considered harmful, (e.g. resource competition) others may consider them beneficial (e.g. new food source). The Department of the Interior's most recent National Invasive Species Management Plan (NISC 2016) and Invasive Species Strategic Plan (DOI 2021) provides further policy guidance and notes that many established nonnative species are non-invasive and support human livelihoods or a preferred quality of life. Various nonnative species have been approved for cultivation and importation into California, through registrations, permits, and lease conditions that are subject to ongoing adaptive management over time (CDFW 2020a). Those specific cases related to aquaculture are discussed in Chapter 3, Section C.iv. (Potentially Farmed Species).

The United States Coast Guard (USCG) has established standards for allowable concentrations of living organisms that may occur in ballast water discharged in waters of the U.S., with the intent of preventing and controlling invasions of aquatic invasive species (77 FR 17254). Maritime vessel masters, owners, operators, and persons-in-charge are integral to training crews to properly maintain and achieve compliance in management systems (USCG 2018). The EPA built on the USCG ballast water regulations and standards with general vessel permits for vessel discharges, limiting pollutant discharge in U.S. waters (PFMC 2013). Management controls are discussed in this section under recommended mitigation, below.

Benthic refers to anything occurring at or in the bottom of a body of water. Infauna are benthic organisms that live in the sediments (e.g. polychaetes, flatworms, and small crustaceans); and epifauna are benthic organisms that are found on or attached to the seafloor (e.g. corals, sponges, barnacles, echinoderms, and sponges) (Schiff et al. 2000, Walag 2022). There are over 5,000 documented benthic invertebrates in the SCB (Huff et al. 2013, PFMC 2016). Polychaetous annelids dominate in most unimpacted regions (Schiffet et al. 2000). According to Schiffet et al. (2000), areas of altered benthos due to environmental stress were estimated to occupy a very small area (less than 10%) of the mainland shelf of the SCB. Those areas that showed changes in community composition included reduced benthic diversity in approximately 2% of the region, with many of these areas located near river discharges.

Benthic habitat may be soft-bottom or hard-bottom in the action alternative areas. Soft-bottom species include generally bottom-dwelling invertebrates and fishes. Sandy benthic habitat in the SCB generally extends to water depths of approximately 91 m (300 ft); and muddy sediment bottoms are typically found in water depths greater than 91 m (300 ft) along the shelf but also occur in estuaries and lagoons (CDFW 2022). Structure-forming invertebrate taxa support the function of benthic habitat, and may support nursery habitat for higher trophic levels, although the science is divided on whether aggregations of adult fishes species are associated directly with structure-forming benthic invertebrates (Tissot et al. 2006, Whitmire and Clarke 2007, PFMC 2013, and Poti et al. 2020). Benthic structure-forming invertebrates, in particular corals and sponges, is considered by NMFS and PFMC in EFH designations and other conservation areas, especially within the Groundfish EFH review (PFMC 2013). Water depth, nutrient availability, geology (e.g. sediment type and grain size), and geography (e.g. bathymetry) influence the characteristics of benthic communities (Schiff et al. 2000, NCCOS 2005, and CDFW 2022). See Chapter 3, Section B.iii. (Seafloor Characteristics) for more information. Benthic life zones, by depth, in the SCB are shown in Figure 1.3.2 on p. 8 of the CINMS BGA (NCCOS 2005).

The geographic distribution of benthic habitats and biological communities of the SCB are classified by substrate type and depth. As described in NCCOS 2005, those include:

- the top 30 m (98 ft), light penetrates surface waters (known as the photic zone), supporting a highly productive nearshore community;
- soft bottom or rocky reefs at depths between 30-100 m (98-328 ft) (known as the upper continental shelf), that support kelp forests and associated biological communities, as well as flatfish and molluscs occupying soft substrates;
- soft bottom or rocky reefs at depths of 100-200 m (328-656 ft), that support commercially-valuable fisheries species such as rockfish and prawns; and
- continental slope soft substrates at depths greater than 200 m (656 ft) (beyond any alternative area in this DPEIS).

Section 3.1 of the CINMS BGA provides habitat suitability models for 13 benthic and pelagic invertebrates (NCCOS 2005). The results of the analysis showed high suitability can occur over hard and soft substrate types in waters between 0-60 m (0-197 ft). Habitats between 60-90 m (197-295 ft) were classified as moderately suitable, and depths between 90-140 m (295-459 ft) were considered low suitability. Many organisms, including phytoplankton, zooplankton, euphausiids, crustaceans, mollusks, fishes, marine mammals, and piscivorous birds may occupy the pelagic habitat of the SCB. The CPS FMP prohibits harvest of all species of euphausiids (krill) that occur within the U.S. West Coast EEZ to help maintain important predator-prey relationships and the long-term health and productivity of the West Coast ecosystem (PFMC 2013). Fish assemblages are described in Chapter 3, Section C.ii. (Wild Fish Stocks), and Federally-protected species of all other taxonomic groups are included in Section C.i. (Federally-protected Species and Habitat).

Primary productivity is the base of the food web for most marine life. Primary production is considered under CWA management decisions (79 FR 22188). Corals protected under ESA depend on primary productivity and symbiotic algae to survive; and coral density in the SCB is associated with chlA persistence, especially in shallower depths (Huff et al. 2013). All marine life protected under ESA, MMPA, and other Federal regulations depend on plankton biomass to maintain complex habitat and food resources, especially in upwelling areas (PFMC 2013, PFMC 2016, and Harvey et al. 2023). These needs relate to human wellbeing for seafood and recreation. Primary productivity has been shown to be the limiting factor on fisheries economic performance, which relates management decisions on these lower trophic levels to MSA regulations (Marshak and Link 2021). The direct link of primary production and fisheries economic performance supports the need for continued implementation of ecosystem-based fisheries management and developing a greater understanding of ecosystem overfishing along with its economic consequences. Monitoring primary production and its impacts on regional ocean economies is vital for understanding how the ocean is responding to shifts in production due to climate change, fishing pressure, and other stressors.

Both Alternative 2, in the Santa Barbara-Ventura Basin, and Alternative 3, in the Santa Monica-San Pedro Basin, reflect higher than average chlorophyll-a (chlA) densities within and surrounding the areas of analysis (NCCOS 2005). Seasonal trends in chlA concentrations in Alternative 2 are shown in Figure 3.56 on p. 124 and Figure 3.74 on p. 151 of the Results section of the Atlas (Morris et al. 2021). Seasonal trends in light attenuation in Alternative 2 are shown in Figure 3.57 on p. 125 and Figure 3.75 on p. 152 of the Results section of the Atlas (Morris et al. 2021). Seasonal trends in chlA concentrations in Alternative 3 are shown in Figure 3.94 on p. 183 of the Results section of the Atlas (Morris et al. 2021). Seasonal trends in light attenuation in Alternative 3 are shown in Figure 3.95 on p. 184 of the Results section of the Atlas (Morris et al. 2021). Nutrient enrichment from coastal river and creek flows contribute to especially-high concentrations of chlA within Santa Monica Bay (NCCOS 2005). Waters adjacent to the Santa Monica-San Pedro Basin (west and further offshore of Alternative 3) exhibit chlA densities lower than average, due to influence from the SCC (described under Chapter 3, Section B.i. (Oceanography and Climate)).

Major phytoplankton classes within the CCE include diatoms, dinoflagellates, small eukaryotes, and cyanobacteria (PFMC 2016). Diatoms and dinoflagellates can have large productive blooms in upwelling regions in winter to early spring, which provide an important food source but can also cause harmful algal blooms (HABs). HABs occur on the west coast in a progression from south to north, and can vary in timing from year to year (Lynn et al. 2003, Holt and Mantua 2009, and PFMC 2013). Phytoplankton biomass in the SCB increases in spring and summer, and seasonal surface currents push the biomass offshore (Airame et al. 2003, NCCOS 2005). Eukaryotes and cyanobacteria productivity rates may be high in offshore regions (Sherr et al. 2005, PFMC 2013). Other phytoplankton blooms tend to occur largely after the main spring transition. In particular, some dinoflagellates and other types of blooms occur after spring and into fall, as waters stratify (PFMC 2013).

Marine vegetation is an important component of California's marine ecosystems that offer vertical and horizontal substrate for a variety of marine organisms, and account for a large portion of the primary productivity in nearshore ecological communities, and feeds pelagic and benthic organisms. The natural extent of the kelp canopy in the SCB in the 1990s was estimated to be 88 km^2 (34 mi^2), less than 0.1% of the SCB area, yet still provided an estimated 6% of the total energy input into the SCB (Hood, 1993). Kelp beds provide habitat for more than 800 species of fishes and invertebrates, and are important for sport fishing, and recreational diving (CRWQCB, 1997). Species of polychaetes, amphipods, decapods, gastropods, and ophiuroids are common among kelp holdfasts (NCCOS 2005). In the SCB, kelp forests provide shelter for both juvenile and adult species of fishes, and historically provided important nursery habitat for Southern Sea Otters (*Enhydra lutris nereis*). Piscivorous birds feed among kelp beds, and marine mammals have been observed seeking shelter, grooming, or playing (see Chapter 3, Section B.i. (Federally-protected Species and Habitat).

Algal beds in the SCB include 87 species of macroalgae (MESC 2015). There are two primary canopy-forming kelp species: Giant Kelp (*Macrocystis pyrifera*) and Bull Kelp (*Nereocystis luetkeana*) (CDFW 2022). Genetic studies have identified three population clusters in the SCB: the Channel Islands, mainland central California, and mainland Southern/Baja California, suggesting isolation due to ocean currents between these regions despite close geographic proximity between populations (Johansson et al. 2015). Several other canopy-forming species are found in lesser abundance in the offshore environment and around the Channel Islands including *Macrocystis integrefolia*, the elk kelp—Pelagophycus, Cystoseira, and Sargassum (PFMC 2013). In California, kelp is managed through a system of Administrative Kelp Beds, and harvest limitations are administered by CDFW. Kelp restoration projects have been done for several decades in southern California, which contribute to management efforts (CDFW 2021). Kelp forests grow along rocky coastlines and are usually found attached to the seafloor or nearshore in the intertidal zone. It is common for these species to become dislodged and form floating rafts, which could occur in the offshore environment. Bull kelp occurs in water as deep as 23 m (75 ft), while giant kelp forests can occupy reefs at 37 m (120 ft) in areas with excellent water clarity (PFMC 2013). In the SCB, kelp beds can also occur on sandy surfaces, where they attach to worm tube reefs (NCCOS 2005, and PFMC 2013). Kelp distribution, productivity, growth, and persistence is dependent on a variety of environmental factors related to water quality, geology, and grazer abundance (e.g. sea urchins).

Monitoring indicates significant declines in Bull Kelp within certain parts of their range. A petition was submitted in 2022 for the listing of bull kelp under ESA, but the listing was rejected in July 2023 (88 FR 40782). While generally abundant, factors like eutrophication and environmental contaminants have also been associated with population stress and declining abundance in Fucus species (Whitaker et al. 2017, Meichssner et al. 2021, and Knoop et al. 2022). All kelp beds are sensitive to both natural and anthropogenic impacts. They die off in the SCB seasonally due to fluctuations in water temperature, nutrient availability, and wave energy, as well as with periods of low nutrients (such as El Niño events). Seasonal effects are often more localized, and more large-scale, low-frequency episodic changes in nutrient availability seem to result in the most significant changes due to cascading community effects (NCCOS 2005, PFMC 2013). Anthropogenic impacts have been attributed to increased turbidity that reduces light penetration, nutrient inputs, and pollutants. Overgrazing by urchins on kelp have also resulted in major losses of whole kelp forests or the creation of "urchin barrens" (Pearse and Hines 1979, Tegner and Dayton 2000). Urchin grazing can destroy kelp forests at a rate of 9 m (30 ft) per year (PFMC 2013).

Stressors

Existing conservation concerns at the community level in the SCB include targeted fishery pressure, fisheries bycatch, ocean acidification and other factors associated with climate change, HABs, habitat degradation and pollution. See Chapter 4, Section A.i. for predicted population trends associated with climate change. Existing physical and chemical oceanographic fluctuations of the SCB ecosystem determine primary productivity and the reproductive potential and survival of many organisms.

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- increased vessel traffic and fixed gear in the water;
- risk of effluents and marine debris;
- localized changes to the physical and chemical characteristics of the water column (e.g. increased or decreased temperature, dissolved oxygen, and nutrient levels, depending on the type of aquaculture pursued);
- localized changes to habitat characteristics and quality;
- potential escape of biological and genetic material; and
- FADs and associated animal and human interactions with FADs.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Potential community-level impacts that may occur as a result of human activities and environmental shifts include biophysical composition of habitat, species abundance, and organism diversity. Without adopting ecologically-sound management practices, an expanded aquaculture industry could make the world's food supply less resilient by posing a threat to ocean fisheries (Naylor et al. 2000, Clavelle et al. 2019). Changes in habitat can lead to exclusion and competition for space, food, mates, and other resources. Changes in standing biomass can lead to changes in food web interactions such as predator-prey and competition. Community species assemblages may be impacted, and also the assemblages of age and sex within species groups (PFMC 2013). Disturbance of benthic and pelagic organisms may occur at any stage of an aquaculture project due to vessel traffic, construction and maintenance activities, noise and light, and turbidity. Abundance and diversity of benthic and pelagic organisms may change during operations of an aquaculture project as a result of fixed gear in the water, the organisms being cultivated in the gear, and FADs around the gear.

Benthic community structure impacts would be expected to be dependent on sediment characteristics, and tied to any impacts to sediments (discussed in Chapter 3, Section B.iii. (Seafloor Characteristics). At Pt Conception, Hardin et al. (1994) examined the spatial distribution of epifaunal assemblages in relation to suspended sediment flux. In the SCB a negative correlation has been shown between sediment flux within 2 m (6.6 ft) of the seafloor and the coverage of filter-feeding organisms, including stony corals – *Lophelia pertusa* and *Desmophyllum dianthus* (Whitmire and Clarke 2007). Changes to the characteristics of benthic habitats could occur due to disturbance from vessel anchors, certain survey methods, other gear disturbance and gear anchoring systems. The placement of anchors may also result in a reduction in available benthic habitat for foraging (Mori and Riley 2021). Alternatively, anchors may be utilized as habitat by marine invertebrates such as tunicates, sponges, corals, and bryozoans. These species may or may not provide additional foraging opportunities. Examples from the installation of anchors and energy transmission cables in the SCB imply the potential for altered hydrodynamic flow and redistribution of sediments, which likely alter biological species and abundance near the area (Poti et al. 2020). For example, deployment or operational aspects of BOEM's marine projects are considered for impacts to the seafloor (Boehlert et al. 2013, Hourigan et al. 2017). While the effects of pollutants in nearshore habitats are documented, the effects to deeper, offshore benthic communities is uncertain or not thought to be likely to cause changes at a community-level (Whitmire and Clarke 2007, Price and Morris 2013, and NMFS 2021a). Additionally, impacts to water quality and benthic habitat could occur during transportation and mooring of aquaculture support vessels, from accidental spills of oil and other hazardous material, or from scouring of benthic habitat from vessel anchors (Neira et al. 2014, PFMC 2022a).

In general, the effects of pelagic habitat modification from floating aquaculture gear may include the loss or creation of habitat, depending on the species. For most existing lease sites, the size of the lease area in relation to the actual gear footprint (which is typically much smaller) has ensured sufficient suitable habitat remains for pelagic species to forage, migrate, or rest in a potential action area (Mori and Riley 2021). However, habitat modification may affect behaviors of higher taxonomic groups, discussed above and in other sections of this DPEIS. Human interactions with pelagic marine organisms may occur at any stage of an aquaculture project. Potential interactions with marine mammals, birds, and sharks are described in Chapter 3, Section C.i. (Federally-Protected Species and Habitat), C.ii. (Wild-Fish Stocks), D.v. (Tourism and Recreation), and D.viii. (Public Health and Safety). In addition, the illegal harvesting of wild fish in aquaculture FADs by employees of aquaculture facilities has been observed and recorded as a concern in the Mediterranean (Akyol and Ertosluk 2010, Bacher et al. 2012, Bacher and Gordoa 2016). If regulatory compliance mechanisms are put into place this impact should not occur; however, it is important to examine for ecological biomass considerations.

Pollution from noise and light has the potential to impact all marine life surrounding an aquaculture operation. In addition to impacts discussed for Federally-protected species and wild fish stocks, many species of pelagic plankton and invertebrates show similar reactions to noise pollution (Hawkins et al. 2014, Weilgart 2018). In the numerous studies reviewed in Weilgart (2018), there are evident behavioral responses in some species; however, some large invertebrates including squid, octopus, and cuttlefish that have been in controlled noise response experiments may not show a direct reaction to sounds, even over prolonged amount of time, but then do not eat or mate. Studies reviewed in Weilgart (2018) showed that biofouling organisms (e.g. bryozoans, tube worms, barnacles) settle faster in environments with noise than silence, and some species grow larger in noise-stimulated environments. The settling effect also impacts shellfish, including oysters and mussels, but species-specific size impacts may be beneficial or adverse.

Marine debris has various adverse effects on the marine environment. Plastics interfere with the health and functioning of marine ecosystems (UNEP 2009, Macfadyen et al. 2009, Mouat et al. 2010, EPA 2011a, Spykra 2017, Miller et al. 2018, CalOPC 2018, and Bennett et al. 2022). There is evidence that marine plastics may reduce atmospheric oxygen production by inhibiting the growth and functioning of marine photosynthetic microorganisms (Spykra 2017, Zeldovich, 2019). Debris can serve as transport vectors for invasive species and disease. Algae can coat the exterior of floating debris and create a new habitat substrate for native or nonnative biofouling organisms. Examples of biofouling organisms observed on marine debris include microbes, epibiont, barnacles, tube worms, foraminifera, coralline algae, hydroids, and bivalve mollusks (Spykra 2017). If debris aggregates due to eddies or other localized current conditions, it may provide habitat for larval and the juvenile stages of multiple marine organisms of different taxonomic groups. These floating islands have been observed worldwide, and can be described as a plastisphere, the idea of an ecological community that lives on plastics (Journal of College Science Teaching 2014). Although marine debris may provide suitable settling or foraging habitat for pelagic and benthic communities, which at first could increase abundance and biodiversity, it could also have adverse impacts on biodiversity due to the lack of permanence or potential hypoxia and anoxia. Hypoxic and anoxic zones can exist in pelagic aggregations, which could kill any biomass on the debris; and marine debris on the sea floor could also lead to anoxia and hypoxia zones induced by inhibition of gas exchange between pure water and seawater (Spykra 2017).

Biofouling would likely occur at any growout facility. Suspended culture sites may facilitate introduction or spread of biofouling organisms and/or invasive species. If cultured sites act as a 'stepping stone' for organisms, it could help transport around naturally-occurring biogeographic breaks (Mooney et al. 2020). The SCB is known to be a biogeographic break from the rest of the California and Baja coasts (NCCOS 2005). Gear would likely be cleaned in situ and may produce short-term increases in organic matter around or under the facilities that would be dispersed by ocean currents. Biofouling organisms could spread disease or tissue covered in antifouling agents into the surrounding marine environment when cleaned off of gear (Floerl et al. 2016). Biofouling organisms may also provide a new food source for surrounding organisms, which could be a benefit or have adverse food web effects if tissues covered in antifouling agents are eaten.

The cleaning of biofouling organisms from other artificial FADs that exist currently in the SCB is not thought to affect the population stocks of pelagic communities such as wild fish stocks, because most reef fish species in the SCB, including those that occur at the base and amid vertical structures of artificial FADs, utilize natural areas with rock substrate at depths shallower than 100 m (328 ft) for settlement, and newly recruited fishes are much less abundant at deeper depths (Nishimoto et al. 2019). It is not thought that biofouling organisms and the debris released during cleaning are significant sources of organic input to sediment beneath aquaculture facilities, even for net pens in the coastal environment (CDFG 2010).

Invasive species may establish and spread by being transported on vessels, materials, and organisms brought into an AOA, or by using fixed gear as new habitat. This impact could occur at any stage of an aquaculture project, but is most likely to occur during growout or harvesting phases of operation. Microbial, parasitic, or pathogenic invasives may spread among cultivated organisms, or between cultivated and wild populations. For a non-native organism to be considered an invasive species in the policy context, the adverse effects that the organism causes or is likely to cause are deemed to outweigh any beneficial effects (NISC 2016). Invasive species can lead to the displacement or even extinction of native plants and animals, decrease biodiversity, and permanently alter habitats. This can result in economic impacts and fundamental disruptions of aquatic ecosystems. Invasives may adversely affect native species due to interactions like predation, and competition for food, light, or habitat. Invasives can also spread disease to and between species. If disease-causing pathogens are also new to the ecosystem, this can cause native species to be more vulnerable to infection. See Chapter 3, Section C.i. (Federally-protected Species), C.ii. (Wild Fish Stocks), Section D.iv. (Potentially Farmed Species) for a discussion on the potential impacts of disease for cultivated organisms. Invasive species can sometimes establish and reproduce rapidly outside of their native range, which may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat (CNRA 2008). Impacts are often characterized by a cascade of impacts realized throughout the environment; and the severity of potential impacts of invasive species are often the result of the effects that invasive species have on a wide range of ecosystem services that underpin marine ecological cycles, human well-being, and economic stability or growth (NISC 2016).

Escaped organisms and/or reproductive material from any type of aquaculture could cause impacts on ecologically-important communities due to the introduction of new individuals and new genes to wild populations in the same ways as described above for wild fish stocks, see Chapter 3, Section B.ii.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Most of the benthic monitoring in southern California has examined the mainland shelf up to 100 m (328 ft) depth (Schiff et al. 2000). That majority of the AOA options within Alternative 2 are inclusive of 100 m depth. The mean depths of the AOA options within Alternative 2 range from 25.4 to 95.0 m (83.3 to 311.7 ft), so they may include benthic communities typical of the photic zone and upper continental shelf. Mapped hard bottom, rocky reef, other EFH, and deep sea coral observations and mapped hard bottom habitat relative to Alternative 2 are shown in Figure 3.48 on p. 116 and Figure 3.66 on p. 143 of the Results section of the Atlas (Morris et al. 2021). The rest of the alternative area is either unmapped, or is soft sediment. Using benthic communities that occur around existing oil platforms in Santa Barbara Channel as a proxy for what may occur around anchoring systems in an AOA, Gillett et al. (2020) describes them as "in a relatively good state, with reference-condition infauna, minimal levels of chemical exposure, and five instances (25% of samples) of low-level toxicity. Samples from around the oil platforms were in overall similar condition to the region, with slightly better condition infauna, nearly identical chemistry, and slightly worse toxicity." The pelagic habitat of the Santa Barbara Channel is surrounded by Federal NMSs and State MPAs, and the waterbody supports abundant populations of pelagic organisms of multiple trophic levels (CINMS 2010). There are 34 freshwater drainages that pass through agricultural and urban areas in Santa Barbara and Ventura Counties before draining into the ocean, which may affect plankton communities and water quality in the Santa Barbara Channel (CINMS 2010, pers. comm. FDA 2023). The following sections of NOAA's Water Quality Characterization of the Channel Island National Marine Sanctuary and Surrounding Waters (CINMS 2010) to characterize pelagic ecology and potential habitat effects:

- Section 4.1 addresses direct and in some cases point sources that originate offshore and in the Santa Barbara Channel;
- Section 4.2 addresses those direct point sources that originate on land, including sewage treatment and power plants; and
- Section 4.3 addresses indirect sources, including the large contributions of stormwater runoff.

a) Shellfish and Macroalgae

There are three mapped and monitored kelp beds within 5 km (2.7 nm) of Alternative 2, with the nearest occurring about 0.07 km (0.04 nm) from N2-E (Protected Seas 2022). Based on time series satellite data from 1984 through 2023 on KelpWatch.org, the total emergent kelp area in the Santa Barbara Channel was estimated roughly at about 1,600 acres (648 ha) from Point Conception south to Point Dume, and including the eastern side of the Northern Channel Islands (Bell et al. 2023, 2024). Using only data from the most recent season, 2022 to 2023, the estimated emergent kelp in the Channel was estimated at about 600 acres (243 ha), which could dramatically increase the amount of comparable habitat in Santa Barbara Channel, and change the majority of habitat from nearshore to offshore waters.

Kelp beds increase the complexity of the surrounding pelagic habitat, and provide a new source of shelter and food for invertebrates and fishes. Kelp growth rates have been measured up to 2 m (6.6 ft) per day; and can exert large effects in the SCB (Schiff et al. 2000). Seaweed monitored in correlation to phytoplankton productivity in coastal environments of France and Ireland show high seasonality, depending on localized carbon concentrations and regenerated nutrients from plankton blooms (Preat et al. 2018). Overall, aquacultured seaweed showed a lower net primary productivity than the phytoplankton (Preat et al. 2018). A study of existing biomass subsidies and nutrient exchange between kelp forests on the west coast of North America and pelagic ecosystems is detailed in Zuercher and Galloway (2019). A literature review for community-level impacts from cross-ecosystem attributes is summarized in Table 3 on p. 17 of Zuercher and Galloway (2019).

Extensive studies since the 1960s have been conducted on the west coast to address concerns regarding the impacts of harvesting giant kelp in nearshore ecosystems. Findings showed potential impacts may include displacement of adult or young-of-the-year fishes, predation on those young-of-the-year by larger fishes, increased growth of sub-canopy species, increased harvesting of fishes and invertebrates by anglers or divers when harvesters create pathways through the beds, and delayed regrowth (PFMC 2013). These predicted impacts may be expected in the offshore space as well; however, depending on the production size, macroalgae facilities could increase the amount of comparable habitat dramatically. There is no way to predict what projects in an AOA would decide to grow and the size of production, but the potential to increase the amount of kelp habitat is pronounced, in acreage options ranging from 1,500 to 15,000 acres (607 to 6,070 ha) that could potentially be sited for macroalgae aquaculture. Commercialization and scalability of seaweed aquaculture offers great environmental potentials; however, it also presents challenges such as oligotrophication and encroachment for existing ecosystems due to nutrient and spatial requirements (Bigelow Laboratory for Ocean Sciences 2024). Decreased light penetration and anchor placement that may occur from installation of facilities could adversely affect sensitive habitat and light-sensitive communities, by decreasing growth rates of light-dependent species or crushing benthic species (CDFW 2019).

Ecosystem services of seaweed aquaculture are well-described in the literature, particularly nutrient removal and habitat provisioning services (Alleway et al. 2019, Gentry et al. 2020, and Bigelow Laboratory for Ocean Sciences 2024). Kelp has been used historically in SCB monitoring programs for toxicity testing to protect ecosystem health (EPA, 1995).The potential ecosystem services from seaweed cultivation are shown in Figure 1 on p. 4 of Mooney-McAuley et al. (2016). The alignment of seaweed aquaculture with the United Nations Sustainable Development Goals are listed in Table 3 of the Bigelow Laboratory for Ocean Sciences Interagency Working Group for the Farming of Seaweeds and Seagrasses's Congressional Report (Bigelow Laboratory for Ocean Sciences 2024). Hard substrate of mooring systems and lines in seaweed aquaculture would provide novel habitat for fouling organisms; and during growout seasons vegetated lines may provide novel habitat for resident and transient fishes. Seaweeds and macroalgae grown in aquaculture facilities would mimic natural drift habitat, which supports fouling invertebrates, fishes, and marine mammals (CDFW 2010, MESC 2015). Torn pieces that drift from sites and potentially reach the bottom would add to natural pelagic and benthic food webs and carbon cycles (MESC 2015). The escape of genetic material is often considered as an adverse environmental impact; but in areas where restoration is warranted because of historic declines, spillover of stock from sites could support the maintenance of wild populations (Alleway et al. 2019). This could be an important case for the SCB and greater California coast, where kelp populations have seen severe declines (Schiff et al. 2000, MESC 2015, Purcell et al. 2023 (draft)), and Bigelow Laboratory for Ocean Sciences 2024). Seaweed aquaculture can also increase dissolved oxygen at surface waters and create localized reduced acidification and temperature buffers from surrounding waters (Gentry et al. 2020, Xiao et al. 2021).

Gene flow between cultivated and wild populations would also be an important potential impact. Although significant population decline has been observed in kelp forests along the California coast, there were low impacts to genetic diversity of kelp populations (Klingbeil et al. 2022). Persistent high genetic diversity within populations may be due to the oceanographic transport of dislodged living sporophytes from distant populations via rafts (Johansson et al. 2015). Kelp rafts can float alive for a long time, 74 to 88 days on average (CDFW 2021). Data from the U.S., China, and Norway all show that macroalgae blade erosion is common, which could release gametophytes into the water column (Buck and Buchholz 2005, Broch et al. 2022). According to global studies reviewed in Purcell et al. (2023 draft), dispersal ranges of varying cultivated macroalgae species have been observed to be limited to about 10 m (33 ft) from the parent plant, up to 16 km (8.6 nm) away from a facility. Petroleum has been shown to inhibit spore release in some macroalgae species (Klinkenberg 2020). Given the three populations identified in the Southern California region, there is more risk that facilities in particular locations may impact one or more of these populations, and selection of seed stock should take into account oceanographic patterns to determine which population(s) may be most impacted by dislodged material (Purcell et al. 2023 (draft)). More information is needed on the duration of reproductive capabilities, dispersal range, genetic population structures, and other biological factors of macroalgae species to assess the opportunities or limits of success for potential colonization of dispersed propagules or blade fragments. The cultivation method, whether through sexual spore production or asexual fragmentation, presents different risks to natural populations (Purcell et al. 2023 (draft)). Biological criteria for reproductive and colonization success include having sufficient male and female gametes for fertilization (although not relevant for spore dispersal), suitable substrate for settlement, low grazing pressure, appropriate temperature and light levels, ample nutrients, and the right current and wave exposure (Mooney et al. 2020).

Intra- or inter-specific impacts for space may occur, and could increase competition for space with wild populations, especially if GMO-cultivated species were developed for better settling in the high energy offshore environment. Settled or dislodged, floating macroalgae blades may also help the transport of biofouling organisms, as well as larval shellfish and fish species. See Chapter 3, Section C.ii. (Wild Fish Stocks for more of a discussion on fish-related impacts). The prevention of pest species for crop loss and the introduction of non-native species that settle or travel on macroalgae are the primary biosecurity concerns for macroalgae aquaculture (Rhodes et al. 2023a, b).

The release of genetic material from shellfish aquaculture is also possible, in the form of sperm or eggs from shellfish operations. The release of genetic material could occur during seeding and harvest, or if cultivated organisms break free and are carried in ocean currents from the system during grow-out. The release of genetic material from macroalgae or shellfish aquaculture could cause changes in community health, abundance, diversity, distribution, or dispersal. Maladaptive genes could reduce fitness and genetic diversity within a population (McGinnity et al. 2003, Waples et al. 2016). Individuals could compete for food and space, or introduce disease (Fleming et al. 2000, Green et al. 2012). Intra- and inter-specific competition for space may occur for space between cultivated and wild populations (CDFW 2010). This could have adverse ecological impacts to wildlife populations, or, it could lead to restoration and ecosystem services. For example, the fecundity of nursery-conditioned abalone has been shown to be much greater than that of abalone conditioned under natural conditions, which would be a benefit to natural populations facing significant reductions due to disease and overharvesting in the SCB (Gruenthal et al. 2014, Purcell et al. 2023 (draft)). Cultivation of declined shellfish species could serve a dual purpose by providing marketable products and contributing to the replenishment of wild stocks; but offshore cultivation of those species would carry a high risk of genetic impact since the natural populations are so low. If hatcheries employ strategies to maximize genetic diversity in cultured populations, offshore aquaculture might mitigate adverse effects of dispersed larvae and potentially benefit natural populations (Purcell et al. 2023 (draft)).

The OMEGA model was used to consider potential genetic risks to wild populations from dispersal of genetic material from candidate shellfish and macroalgae aquaculture species in the SCB. Overall, the likelihood of escapes is high. However, the likelihood of escaped/dispersed organisms contributing significant genetic change to wild populations is species-dependent and variable, but generally not high

(Purcell et al. 2023 (draft)). Escaped/dispersed organisms and reproductive material are considered biological material and a pollutant that must be considered in the NPDES permitting process.

Ecosystem services of shellfish aquaculture in coastal waters are well-described in the literature, particularly nutrient removal and habitat provisioning services (Alleway et al. 2019, Gentry et al. 2020, Stenton-Dozey and Broekhuizen 2019, Parker and Bricker 2020, and Von Thenen et al. 2021). Natural shellfish habitats provide important high-value ecosystem functions through filtration, denitrification, and the creation of habitat for associated species – all of which may be realized in the offshore environment around a shellfish facility as well. Shellfish aquaculture may even generate habitat for a higher volume of fish and invertebrates than natural shellfish reefs (TNC 2021). In a literature review of seaweed and bivalve aquaculture, wild fish abundance and diversity were higher and in association with aquaculture facilities than nearby reference sites (Theuerkauf et al. 2021). There is a potential trade-off with released larvae, as they could provide a new food source for certain species, but compete with others (Lloyd 2003). Other potential ecosystem services include protection of coastlines from storm surge and waves, reduction of shoreline erosion, and increased biodiversity.

There can be potential deposition of organic matter if shellfish are dislodged or crushed and break free from growout gear. Species diversity in crustaceans, echinoderms, and fishes are observed to be greater around shellfish aquaculture in coastal waters, compared to coastal areas adjacent to operations (see studies listed in Lloyd (2003). In the offshore environment, at depth, the influence may not be as measurable in benthic species, but may be similar for fishes. The offshore environment, with consistent water flow and deep waters, is thought to mitigate the potential impacts of nutrient enrichment on benthic sediments (Price and Morris 2013, Fujita et al. 2023). Species diversity and abundance for benthic species may show beneficial impacts due to the exclusion of trawl activities from under the gear (Inglis and Kross 2000, Whitmire and Clarke 2007, Clark et al. 2016, and Goode et al. 2020). The risk of habitat changes acting as a benefit or adverse impact would depend on the carrying capacity of the surrounding environment, the facility size, and rate of development (VPD 2018, CDFW 2019, and TNC 2021).

Disease transmission between cultured and wild macroalgae is poorly understood and requires significant additional research on the potential impacts of macroalgae culture on wild populations (Rhodes et al. 2023a). In the case of mussel aquaculture in New Zealand, although parasites of cultivated shellfish may be spread during transfer or growout, it is not thought that they are unrelated taxa; however, other pathogens could spread to wildlife surrounding a facility (Lloyd 2003).

b) All Types of Commercial Aquaculture

Ecosystem services from finfish aquaculture include habitat enhancement or support and potential maintenance of wild populations, depending on cultivated species. Hard substrate on mooring systems and net pens would provide novel habitat for fouling organisms. There are also some studies that show that establishment of aquaculture can have positive impacts on fisheries landings, both in the immediate vicinity and at a regional scale (Gentry et al. 2020). Net pens are well known to act as FADs, which can be beneficial in certain ways for wild marine life (discussed under Chapter 3, Sections C.i. (Federally Protected Species and Habitat) and C.ii. (Wild Fish Stocks)). More on population restocking potential is discussed in Section C.iv. (Potentially Farmed Species).

A global literature review of effects on benthic communities is provided in Table 8 on p. 83 of Price and Morris (2013). Of the studies summarized in Table 8, the majority found decreased abundance and species diversity generally, but an increase in opportunistic, generalist species.

An examination of the average depths for the AOA alternative areas indicate that most are deep enough to sustain low benthic impact from a facility (Rhodes et al. 2023a). Saba and Steinberg (2012) studied the rates of sinking fish pellets from wild fish populations in the Santa Barbara Channel, and described detailed estimates of vertical flux of particulate matter in the region. In observed salmon net pens in Puget Sound, benthic impacts, when present, were most intense under and immediately adjacent to the pens; and the distance of the impact zone varied from zero to more than 61 m (200 ft) (EPA 1991). As a worst-case temporal example, in the 1970s, degraded conditions and the loss of major benthic taxonomic groups were shown to extend more than 15 km (8.1 nm) away from a large outfall system operated by the County of Los Angeles; but by 1990, conditions had improved to the extent that the most severe effects were absent, strong impacts were restricted to an area within 5 km (2.7 nm) of the outfall, and communities typical of undisturbed areas were present within the monitoring zone (Schiff et al. 2000). Invertebrate community impacts were observed several years after finfish operations were removed up to 0.3 km (0.16 nm) from the area (Kraufvelin et al. 2001). FGC has a requirement for potential finfish marine aquaculture sited in state waters that applicants provide baseline benthic habitat and community assessments of a proposed lease site to the applicable RWQCB or SWRCB, and monitor the benthic community during operations (FGC §15400(b)(5)). Benthic community impacts have been considered to be minimized if sited consistently with this state requirement (CDFW 2019). Potential aquaculture facilities sited in Federal waters, with deeper depths, may follow similar predicted impacts.

Similarly, nutrient enrichment of the water column is generally not detectable beyond 100 m (328 ft) of a finfish facility (Clavelle et al. 2019). West coast examples of finfish feed include: typical salmon feed contains 40% protein, 30% to 35% lipids, and about 10% carbohydrates; the white seabass OREHP utilizes a marine fish food that contains 50% protein, 14% fat, and has Vitamin C and zinc incorporated into it (CDFG 2010). Lost feed from the OREHP facilities has been considered minimal and not thought to contribute significantly to surrounding organic matter (CDFG 2010). However, the scale of OREHP facilities are much smaller than what may be sited in an AOA. Even at larger scales, there is little evidence of a direct link between open-ocean finfish aquaculture and harmful algal blooms (Price et al. 2015). Pitta et al. (2009) demonstrated that grazing around in and around net pens plays a key role in regulating phytoplankton biomass, keeping chlorophyll-a at very low levels, and effectively transferring nutrients up the food web, in both cultivated and wild populations of fish. The effects of FADs on higher taxonomic groups are covered in Chapter 3, Sections C.i. (Federally-protected Species and Habitat) and C.ii. (Wild Fish Stocks). Genetic impacts and disease risks are also covered under those sections, as well as in Section C.iv. (Potentially Farmed Species).

Models can help predict environmental impacts and carrying capacity estimations. A large-scale example that covered a large area used for seaweed, shellfish, and finfish aquaculture is featured in Sun et al. (2020), which incorporates nitrogen and phosphorus into hydrodynamic and oceanographic models, and applied it to IMTA. Influences of different cultivated species on pelagic variables under different cultivated species-dependent scenarios are summarized in Section 3.3 on pp. 7 and 8 of Sun et al. (2020). Additional ecological scenarios that could occur as an indirect impact of IMTA are as follows:

- Growing seaweed with shellfish could slow flow rates, increasing the amount of planktonic and larval filtration from the water column.
- Growing seaweed adjacent to finfish could slow flow rates, amplifying any decreased oxygen in the surrounding water column; however, if grown at an appropriate distance down-current, it may help assimilate nutrients into the food web (Rensel and Forster 2007).
- Nutrient input from finfish could stimulate seaweed growth; but if it reaches an amount that causes a plankton bloom that decreases light penetration, it could have adverse effects on vegetation, invertebrate, and fish communities.
- Growing shellfish with finfish may mitigate nutrient enrichment impacts to the surrounding pelagic and benthic habitat.
- Growing crustaceans with finfish can alleviate some of the pressures of parasitic organisms that could infect wild populations (Rensel and Forster 2007).
- Growing any combination of trophic levels may encourage an increase of local biodiversity and species abundance, enhancing the local food web (Rensel and Forster 2007).

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Most of the benthic monitoring in southern California has examined the mainland shelf up to 100 m (328 ft) depth (Schiff et al. 2000). The majority of the AOA options within Alternative 3 are inclusive of 100 m depth, but the maximum depth of CN1-A reaches 145.6 m (478 ft). The mean depths of the AOA options within Alternative 2 range from 66.6 to 98.9 m (218.5 to 324.5 ft), so they may include benthic communities typical of the upper continental shelf. Mapped hard bottom, rocky reef, other EFH, and deep sea coral observations and mapped hard bottom habitat relative to Alternative 3 are shown in Figure 3.86 on p. 175 of the Results section of the Atlas (Morris et al. 2021). The remaining areas are either unmapped, or soft-bottom. Soft-bottom habitats in Santa Monica Bay and San Pedro Bays are monitored due to historic pollutants that were dumped in the region, run-off, and busy harbor activities near Los Angeles and Long Beach (CINMS 2010, LARWQCB 2011). Most of the soft bottom habitat is considered in fair to excellent condition because it supports healthy benthic infaunal communities similar to those present within reference areas (except for in the sediments around the JWPCP outfall on the Palos Verdes Shelf) (LARWQCB 2011). The Palos Verdes Shelf is located south of Alternative 3 and is effectively separated biogeographically by a submarine canyon and prevailing currents. The pelagic habitat is considered fair to good based on algal blooms, phytoplankton and zooplankton, fish and mammal assemblage and population, contaminant burdens, and commercial and sportfish catch efforts. Offshore areas appear in better shape than nearshore areas due to distance from human activities (LARWQCB 2011).

a) Shellfish and Macroalgae

Kelp beds in Santa Monica Bay are often found in hard bottom areas at depths of 6 to 21 m (20 to 70 ft), west of Malibu and around the Palos Verdes Peninsula (LARWQCB 2011). Extensive kelp beds near Palos Verdes were dramatically reduced since the 1950s (Schiff et al. 2000). The recovery of kelp canopy has been considerable but its current extent is still less than 25% of the highs recorded one hundred years ago (LARWQCB 2011). There is one mapped and monitored kelp bed within 0.5 km (0.27 nm) from both AOA options within Alternative 3 (Protected Seas 2022). Based on time series satellite data from 1984 through 2023 on KelpWatch.org, the total emergent kelp area in Santa Monica Bay was estimated roughly at about 67 acres (27 ha) from the Ventura-Los Angeles County line south to Griffith park, extending to the shelf (Bell et al. 2023, 2024). Using only data from the most recent season, 2022 to 2023, the estimated emergent kelp in the Bay was estimated at about 119 acres (48 ha). The increase in emergent kelp appears to be concentrated near Palos Verdes Estates. There is no way to predict what projects in an AOA would decide to grow and the size of production, but the potential to increase the amount of kelp habitat is pronounced in acreage options ranging from 500 to 1,500 acres (202 to 607 ha) that could potentially be sited for macroalgae aquaculture, which could dramatically increase the amount of comparable habitat in Santa Monica Bay, and change the majority of habitat from nearshore to offshore waters.

The remaining information used to discuss ecosystem services and ecological impacts of macroalgae and shellfish aquaculture in Alternative 2 is also the best available information to predict and describe potential impacts in Alternative 3. However, a higher risk of water quality concerns exist related to seafood harvest in Santa Monica Bay (see Chapter 3, Sections B.iv. (Water Quality), C.iv. (Potentially Farmed Species), and D.viii. (Public Health and Safety). Alternative 3 may be an area to highlight opportunities for user-environment-beneficiary interactions in planning decisions (TNC 2021, Von Thenen et al. 2021). These interactions may be especially-relevant in Alternative 3, where ecosystem services related to water quality, water transparency, and nutrient extraction could still be realized during those time periods if and when potential runoff plumes or HABs limited seafood harvesting. There are commercial applications for fertilizer, biofuels, and restoration that could be taken advantage of instead of food products.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section. A higher risk of water quality concerns exist related to seafood harvest in Santa Monica Bay (see Chapter 3, Sections B.iv. (Water Quality), C.iv. Potentially-Farmed Species, and D.viii. (Public Health and Safety).

The remaining information used to discuss ecosystem services and ecological impacts of finfish aquaculture in Alternative 2 is also the best available information for Alternative 3, and is not repeated here. In order to realize some of the potential ecosystem services from aquaculture, the surrounding waterbody should be able to benefit from improvement or increased resilience in ways that can be provided by the species being grown. For example, the culture of these species would not be considered restorative for water quality if the water body could not benefit from water quality improvements and/or the resilience or productivity of the water body could not be increased (TNC 2021). IMTA may have the potential to provide more benefits in Santa Monica Bay than in Santa Barbara Channel, where historic contamination from pollutants is not as pronounced, and current run-off concerns are not as much of a concern in the watersheds that drain into Santa Barbara Channel as the highly urbanized greater Los Angeles area's watersheds which drain into Santa Monica Bay.

Alternative 4: Combination of Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified. Generally, the potential impacts to benthic and pelagic biological communities and habitat of future offshore aquaculture may be greater in Alternative 4 than in Alternative 2 or 3, assumed as a result of more identified AOAs. Benthic environmental health effects from finfish aquaculture are thought to be relatively consistent across the entire SCB. The potential adverse impact to benthic communities have been estimated to increase linearly with each additional finfish facility sited in the region (Lester et al. 2018b). However, if Alternative 4 provided multiple discrete areas for finfish facilities to be sited further from one another across Alternative areas the linear growth associated with potential adverse impacts to benthic communities could be mitigated. Although good management and modern operating conditions are thought to largely eliminate the potential impacts of aquaculture on surrounding water quality in deep offshore waters, and on benthic and pelagic communities, the additive impacts of multiple projects sited near one another or across a whole region may change observed impacts and associated risks.

An indirect potential community-level benefit of siting multiple AOAs would be additional ocean spaces that may functionally exclude and restrict bottom trawl activities. Trawl components that contact the seafloor have the potential to snare, undercut or topple emergent structures, and are considered more harmful to the physical and biological components to bottom habitat than longline and pot/traps (Morgan and Chuenpagdee 2003, PFMC 2019, and Whitmire and Clarke 2007). While it is acknowledged that the structure and materials of fisheries gear and aquaculture gear differ, the shape and footprint of aquaculture gear may be compared to longline and pot gear in this prediction. Benthic disturbance per fishing gear type summarized in Table 3.3 of Whitmire and Clarke (2007). This potential ecological benefit to benthic communities would create a trade-off, at the cost of potentially-excluding more commercial fishing activities.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

iv. Potentially-Farmed Species

Affected Environment

The U.S. Department of Agriculture's Animal and Plant Health Inspection Service (USDA-APHIS) and veterinary services is the lead federal agency for animal and plant health. USDA APHIS, authorized under Animal Health Protection Act (AHPA, also known as the Animal Welfare Act), oversees the prevention, detection, control, and eradication of animal diseases in aquaculture (7 U.S.C. § 8322 and 10401). AHPA also regulates the treatment of animals in research, teaching, testing, exhibition, transport, and by dealers (USDA 2023). Additional laws that provide a framework for protecting animal health domestically and internationally are described on USDA's APHIS website, available online at https://www.aphis.usda.gov/laws-regs (USDA 2024). USDA APHIS also collects data for reportable diseases nationwide for submission to the World Organization for Animal Health (WOAH). Other federal agencies involved in aquatic animal health are the U.S. Food and Drug Administration (FDA) Center for Veterinary Medicine, NOAA, USFWS, and delegated authorities to the State. There are reciprocal agency evaluations and oversight, depending on enforcement authorities and expertise (pers. comm. FDA and NOAA 2021). The U.S. states in which facilities are located or to which organisms are transported also have health authority, defined by each state's legislative codes, regulations, and policies (Rhodes et al. 2023a). This section of the DPEIS focuses on the animal health aspects of aquaculture. For human aspects related to seafood safety, see Chapter 3 Section D.viii (Public Health and Safety).

Among the major growing areas for shellfish in California, the Santa Barbara Channel ranks fifth for oysters, second for mussels, in annual production value by weight (CDFW 2020a). California is also home to seven native abalone species; but the green and pink abalone, with more southern distributions, are particularly suitable for aquaculture in Southern California due to their tolerance for higher water temperatures (McBride and Conte 1996, Purcell et al. 2023 (draft)).

Southern California is considered an ideal region for rearing marine fish in the U.S. because of its mild climate and ocean conditions, and high value species that are native or established (CDFW 2010). Yellowtail and white seabass are expected to benefit from warmer temperatures of 72 to 77°F (22 to 25°C) that would be more typical off Mexico; Cabezon are coastal groundfish that perform best in cooler waters of 53 to 58°F (12 to 14°C); California halibut, and striped bass are found in brackish water as juveniles and, therefore, are generally tolerant of changing temperature and salinity (CDFW 2010).

Market interest, economic and biological viability, and regional policies influence the likelihood of which species are thought to be pursued by future offshore aquaculture. Seafood product diversity in the future is not thought to come necessarily from the next new species market; rather, market expansion is predicted to come from the same species with a new preparation, sauce, product form, or image (Rubino (ed.) 2008). In preparation for this DPEIS, NOAA does not have the authority to authorize specific species, or combination of species, that future aquaculture projects may choose to grow in an AOA, if identified. However, using the best information available on industry interest, the following native or naturalized species are thought to be potentially-suitable in an AOA in the SCB (USDA and NCCOS 2021, Dealy et al. 2024).

- Macroalgae/ seaweed: Sugar kelp (Saccharina latissimi); Ribbon kelp (Alaria marginata), Giant Kelp (Macrocystis pyrifera), Bull Kelp (Nereocystis luetkeana), Bladderwrack (Fucus distichus), Kombu (Laminaria setchelli), Sea Palm (Postelsia palmaeformis), Sea Cabbage or sweet kombu (Hedophyllum sessile (formerly Saccharina sessilis)), Nori (Pyropia spp.), Sea spaghetti (Gracilaria andersonii), Turkish Washcloth (Mastocarpus papillatus).
- Shellfish: Olympia oyster (*Ostrea lurida*), Pacific oyster (*Magallana gigas*), Purple-hinged rock scallop (*Crassadoma gigantean*), Manila clam (*Venerupis philippinarum*, *Tapes* spp.), Pismo clam (*Tivela stultorum*), California mussel (*Mytilus californianus*), Mediterranean mussel (*Mytilus galloprovincialis*), Abalone (*Haliotis* spp.).
- Finfish: California yellowtail (*Seriola lalandi*), Longfin yellowtail (*Seriola rivoliana*), white seabass (*Atractoscion nobilis*), Striped Bass (*Morone saxatilis*), Sablefish (*Anoplopoma fimbria*), California Halibut (*Paralichthys californicus*), Olive flounder (*Paralichthys olivaceus*).

Purcell et al. (2023 draft) provides species descriptions, cultivation methods, range and other life history descriptions of fish, shellfish, and macroalgae, respectively. The species of shellfish, seaweed, and macroalgae that are currently cultivated in California as of 2019 are summarized in Table 2-3 on p. 12 of the CDFW report, The Status of Commercial Marine Aquaculture in California (CDFW 2020a).

Stressors

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- the use of native versus naturalized species;
- the use of genetically-modified stock in cultivated organisms;
- the use of antibiotics and/or other husbandry materials;
- exposure to, and interactions with, existing pollutants or harmful algal blooms that may occur in the SCB;
- the translation and adoption of surveillance and eradication programs, biosecurity guidance, import controls, and emergency response and planning from land-based and coastal systems to the offshore space; and
- increased biomass and related topics for animal welfare in artificial containments.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Aquaculture operations in an AOA could increase logistical demands on permit compliance and enforcement. Animal health measures are already well established in the U.S. and in California for wild-harvested species, international aquaculture imports, and domestic nearshore aquaculture products. The biosecurity measures described in this DPEIS are existing regulatory mechanisms that establish strategic and integrated approaches into U.S. policy and regulatory frameworks aimed at analyzing and managing risks relevant to human, animal and plant life and health, including associated environmental risks. Any aquaculture projects sited in an AOA would need to coordinate with state and local agencies for appropriate transport, testing, and other established regulatory requirements. The new amount of product from large-scale, offshore operations would likely be much greater than the current small operations in the region and WCR. Initially, this could cause bottlenecks in transport, testing, or other stages of regulatory systems for seafood safety. Bottlenecks in regulatory processing may impact product viability, and business costs. However, overtime, increased demand for biosecurity logistics in the U.S., as well as potential increased demand for products produced under U.S. biosecurity controls could stimulate increased market supply and private investments to support efficient production.

Section 312 of the Clean Water Act (CWA) prohibits vessel discharge of pollutants, including sewage, in areas designated as “no discharge zones” (NDZ) (33 U.S.C. § 1322, EPA 2023). These policies and regulations are jointly enforced by the EPA and USCG (40 C.F.R. § 140, 33 C.F.R. § 159). If an offshore aquaculture facility is not positioned in an NDZ, animals could potentially be exposed to pollutant discharges from vessels (Rhodes et al. 2023a).

Non-infectious diseases, infectious diseases, and parasites are all risks to organisms being grown in an aquaculture facility. See Chapter 3, Section C.i. (Federally-protected Species) and C.ii. (Wild Fish Stocks) for a discussion on the potential impacts of disease to wild populations. This section of the DPEIS focuses on the cultivated populations. Pathogens may be associated with growing species, interstate transport, or with potential invasive species already found in the marine environment (pers. comm. FDA and NOAA 2021). Disease transfer principles between cultivated and wild populations are summarized in Table 1 of Rhodes et al. (2023a). Disease risk at an individual facility would vary based on ambient water temperature and salinity fluctuations, seasonal changes to algae concentrations, and worker activity at the site (Rhodes et al. 2023a). Organisms that are more stressed due to culture density, predation patterns, handling or other movement such as inclement weather conditions may also make them more susceptible to disease (Rhodes et al. 2023a). Disease transmission between facilities would be concentrated in areas where ocean currents generate high levels of connectivity among potential aquaculture sites (Lester et al. 2018b). Organism stress and death may be direct impacts; disease may also have broader indirect impacts on surrounding ecosystems, public perceptions, demands for cultured products, and policy decisions (USDA 2020). Potential mitigation measures to reduce occurrence of disease, including best management husbandry practices, are discussed in Appendix 1.

Biofouling would likely occur at any growout facility. Suspended culture sites may facilitate introduction or spread of biofouling organisms and/or invasive species. Biofouling can contribute to stress and disease occurrence in cultivated organisms by reducing water flow and survival, while increasing crowding and potentially harboring pathogens. The composition of fouling communities vary spatially and temporally, based on availability of light and water flow or the depth and orientation of a settling surface; and their effects on cultivated organisms is largely dictated by the properties of the fouling surface, the protection and management of those surfaces, and seasonal variations in the physiology of cultivated species (Fitridge et al. 2012, Purcell et al. 2023 (draft)). Husbandry techniques are used to manage biofouling, which carry their own potential impacts.

Shellfish, and finfish all may bioaccumulate antibiotic residuals, heavy metals, or other pollutants that may be found in the water column as a result of antibiotics, antimicrobials, antiparasitics medications, vaccines, other medical preventatives, and other husbandry materials. Antibiotic residuals have been shown to occur around marine aquaculture, which can induce changes to water quality and have the potential to be toxic to marine life (Zhang et al. 2023). Disease control for each type of aquaculture is included under the appropriate sub-alternative, below. More of a discussion for human-related topics may be found under Chapter 3, Section D.viii. (Public Health and Safety)).

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

a) Shellfish and Macroalgae

This section considers potential impacts on cultured animal health, therefore impacts on macroalgae are not discussed.

If the identification of an AOA facilitates and increases the growth of shellfish aquaculture, the current needs of the industry would likely increase. Industry members have expressed the need for research that individual facility producers may not be able to execute on their own, including heat tolerance and disease resistance (USDA 2020). For any emerging molluscan species (those that are not being commercially-grown already), there would be critical research needs to optimize production in all stages, from hatchery through nursery and grow-out (Sea Grant 2016). A growth in grower demand, especially within a defined geographic area of an AOA, could potentially-help generate interest and coordinate partnerships for these necessary research topics.

California mussels can be harvested year-round, except for times when a quarantine is in effect because of hazardous levels of biotoxins present in mussels, generally between May and October (CDFW 2020a). Spawning in the California mussel occurs throughout the year at a very low level, with peaks in July and December but reproductive output can be up to eightfold greater for sites south of Point Conception relative to more northerly sites (CDFW 2010). In the case of oysters, there is seasonal elevation of oyster herpesvirus and bioaccumulation of other toxins during warmer months (CDFW 2010, Petton et al. 2021, Rhodes et al. 2023a). Summer mortality of Pacific oysters was first reported in California in the 1960s, and have historically reached mortality levels as high as 65% in adult Pacific oysters (CDFW 2010). Dinoflagellate blooms are also associated with warmer water events, and have impacted abalone aquaculture in State waters by causing gill damage and by also lowering the amount of dissolved oxygen in the seawater (CDFW 2010). Industry members have also cited pest control as an impediment for growth in the coastal environment (USDA 2020, Fujita et al. 2023). Growing shellfish further offshore in AOA may reduce the risk of some of the biotoxin and disease concerns that are typical in nearshore aquaculture.

Water biosecurity cannot be controlled in open-ocean culture structures, and this free exchange of seawater provides the main disease transmission route to cultivated shellfish. Shellfish diseases are an existing major concern to State resource agencies and the oyster industry; and regulations are established through cooperative agreements between agencies (described under Environment, above). Disease factors and pathogens of concern during invertebrate grow-out vary depending on culture method and life-history biology. Viral diseases that are represented in shellfish aquaculture, globally, are listed in Table A-1 on pp. 83 of Rhodes et al. (2023a). Bacterial diseases represented in shellfish aquaculture, globally, are listed in Table A-2 on pp. 84 of Rhodes et al. (2023a). Common parasitic diseases represented in shellfish aquaculture, globally, are listed in Table A-3 on pp. 85 of Rhodes et al. (2023a).

In shellfish aquaculture, biofouling impacts may include physical damage to the cultivated species, biological and space competition, and environmental modification. Examples of biofouling organisms that may occur on shellfish species, globally, with associated literature are listed in Table 1 on p. 650 of Fitridge et al. (2012). Potential biofouling organisms that were analyzed for shellfish offshore of Ventura are described in Dudek (2019). The likelihood of cultivated shellfish to harbor or help spread invasive species depends, in part, on the surrounding substrate (the closer hard bottom habitat occurs to a specific facility location could facilitate spread) (VPD 2018). However, within the cultivated population, competition for space and crowding can cause instability of shellfish masses and could cause biomass loss when coupled with high current speeds or turbulent waters (Ramsay et al. 2008, CDFW 2010). Biofouling may also facilitate introduction or spread of disease and invasive species (Lloyd 2003, McKindsey et al. 2011, Rhodes et al. 2023a, and Purcell et al. 2023 (draft)).

Stress can impact shellfish and other invertebrates' susceptibility to infection. Water temperatures and salinities have predictable effects for some diseases (Rhodes et al. 2023a). Oysters started in a hatchery may be stressed and susceptible to infection (CDFW 2010). Studies reviewed in Weilgart (2018) showed that biofouling organisms (e.g. bryozoans, tube worms, barnacles) settle faster in environments with noise than silence, and some species grow larger in noise-stimulated environments. The settling effect also impacts shellfish, including oysters and mussels, but species-specific size impacts may be beneficial or adverse. Biomass density affects oxygen demands, which may put cultivated shellfish at risk of destabilization or hypoxia.

Risk to shellfish also include contamination from fecal coliform bacteria from pinnipeds, which is a documented issue in nearshore operations in British Columbia and Washington from harbor seals (Moore and Wieting 1999). The impact is more due to habitat overlap than pinnipeds being drawn to a shellfish facility (Price et al. 2017). This impact is thought to be mitigated by siting aquaculture in offshore waters where aquaculture would be further from rookeries and haulouts, but may be more effective for sea lions than seals (Moore and Wieting 1999, Wursig and Gailey 2002, Price et al. 2017, and Bath et al. 2023). Bacteria related to the invertebrate disease Withering Syndrome has also been an existing issue for abalone aquaculture on the west coast, and the herpes virus is common in oysters but may affect abalone as well (Purcell et al. 2023 (draft)).

Disease prevention in shellfish include probiotics, prebiotics, synbiotics, and biofloc technology; but the best way to minimize potential for infection is to maintain proper density management and avoidance of any acute changes in environmental conditions (e.g. temperature, salinity) (Fitridge et al. 2012, de Souza Valente and Wan 2021, and Rhodes et al. 2023a). Because invertebrates lack the adaptive immunity found in vertebrates, traditional vaccination is not possible (Rhodes et al. 2023a).

In New Zealand, in the past, mussel aquaculture was thought to accelerate the spread of harmful algal blooms, by harboring the phytoplankton and also stimulated by increased release of ammonium and other micronutrients (Lloyd 2003). A related example observed in the SCB includes a dinoflagellate that impacts abalone aquaculture by causing gill damage and by also lowering the amount of dissolved oxygen in the seawater (CDFW 2010). The Federal Waters Shellfish Biotoxin Advisory Board (FWSBAB) serves as a technical advisory group to support the National Shellfish Sanitation Program (NSSP) regarding marine biotoxins and bivalve molluscan shellfish in federal waters. The FWSBAB is led by the Food and Drug Administration (FDA) and is comprised of representatives from the FDA, National Oceanographic and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA), and the Centers for Disease Control and Prevention (CDC). The group was established to assist in gathering marine biotoxin data in coastal and ocean waters that may impact shellfish in federal waters, including:

- identifying the presence of toxic algae/toxins in Federal waters and in any molluscan shellfish grown in Federal waters;
- establishing criteria for determining which geographic areas within Federal waters require a marine biotoxin management plan;
- reviewing marine biotoxin management and contingency plans when submitted;
- providing technical assistance related to selection of marine biotoxin management strategies;
- developing data requirements (including quality assurance/quality control) per marine biotoxin management strategy; and
- review of federal waters marine biotoxin data generated under marine biotoxin management and contingency plan requirements (pers. comm. FDA 2023).

b) All Types of Commercial Aquaculture

Finfish

Finfish for which rearing techniques have been suitably developed for California marine aquaculture include white seabass (*Atractoscion nobilis*), California yellowtail (*Seriola lalandi*), California sheephead (*Semicossyphus pulcher*), cabezon (*Scorpaenichthys marmoratus*), and striped bass (*Morone saxatilis*).

Most species reared in net pens undergo a hatchery biosecurity phase at a land-based facility before stocking on marine-sited facilities. That is considered out of scope for this DPEIS. Therefore, the focus of pathogens, disease, and biosecurity focuses on juvenile and adult introduction pathways that may occur in the offshore environment. Those include: biosecurity failure during transfer of animals to and from net pens (e.g., fish escapes, discharge of contaminated materials) and the free exchange of ocean water through structures (Rhodes et al. 2023a). Risk factors associated with the transport and grow out phases of finfish aquaculture are summarized on pp. 17 through 19 in Rhodes et al. (2023a). Viral diseases that are represented in finfish aquaculture, globally, are listed in Table A-1 on pp. 83 of Rhodes et al. (2023a). Bacterial diseases represented in finfish aquaculture, globally, are listed in Table A-2 on pp. 84 of Rhodes et al. (2023a). Common parasitic diseases represented in finfish aquaculture, globally, are listed in Table A-3 on pp. 85 of Rhodes et al. (2023a). A list of observed disease organisms among several cultured species of finfish in California are provided in Table 22-1 on p. 22-6 of the CDFW Status of the Fisheries Report 2008 (CDFW 2010). Infectious diseases caused by viruses, bacteria, fungi, and sporozoans (spore-forming protozoan pathogens), as well as parasites that are monitored in the State's OREHP for finfish are further described biologically with historic context associated with the OREHP or other monitoring efforts in central and southern California in Chapter 7 of the white seabass enhancement plan (CDFG 2010).

Biofouling growth on fish cages and infrastructure may restrict water flow, increase risk of disease, and impact the gear infrastructure. If cultivated fish are populated in net pens at high density, flushing may also be reduced which could lead to lowered dissolved oxygen levels (Fitridge et al. 2012). Examples of biofouling organisms found globally associated with marine finfish aquaculture are listed in Table 2 on p. 652 of Fitridge et al. (2012). Nets and raceways are usually cleaned in situ and may produce short-term increases in organic matter under the facilities (CDFG 2010).

Disease prevention and response for finfish may include vaccination, probiotics, immunostimulatory molecules, antimicrobial peptides, or antibiotics. Some common chemical pollution sources in marine finfish related to therapeutics are listed in Table 2 of Carballeria Brana et al. (2021). Antibiotics may be used in finfish aquaculture as a response therapeutic to disease, depending on the system and approved use. There are currently none approved for use in the U.S. A literature review, including examples of the use of antibiotics in finfish aquaculture in other countries, is provided in Section 5.6.2 on pp. 11 and 12 of Fujita et al. (2023). Adults may be injected with therapeutic drugs, and juvenile fish may be fed therapeutants at early feeding (Rhodes et al. 2023a). However, the use of antibiotics in finfish aquaculture is not high, and is expected to be even lower in the offshore environment due to improved water quality, fewer interactions with host fish, and less biofouling (Rensel and Forster 2007, Hjeltnes et al. 2019). OREHP facilities in coastal State waters do not utilize any insecticides, fungicides, or rodenticides, nor does it use any regulated antifoulants (CDFG 2010).

Many countries have strong regulation for antimicrobial use, and some have phased out or banned the practice due to concerns about human health impacts of antimicrobial resistance (Cabello et al. 2013, Sneeringer 2015, and Rhodes et al. 2023a). In the U.S., FDA established Veterinary Feed Directives (VFDs) to ensure antibiotics are applied under the supervision of a licensed veterinarian. Under the Animal Medicinal Drug Use Clarification Act, veterinarians may administer approved therapeutic drugs beyond approved uses (known as "extra-label use") under strict conditions (21 U.S.C. § 530). Administration of antimicrobials and prescription/veterinary feed directive drugs in the U.S. requires a valid veterinarian–client–patient relationship. Although there have been successful efforts to gain approval of drugs for aquaculture, these have been primarily focused on freshwater aquaculture species to date (Rhodes et al. 2023a).

Vaccines have shown to be a highly useful and cost effective measure against diseases in finfish, and can greatly-reduce the use of antibiotics (Ma et al. 2019, Barnes et al. 2022, and Rhodes et al. 2023a). In this way, vaccines contribute to environmental, social, and economic sustainability in global aquaculture (Ma et al. 2019). The vaccines that are licensed for finfish aquaculture use, globally, are listed in Table 1 on p. 3 of Ma et al. (2019). Vaccines are predicted to be used in the offshore environment at the same rate or less as are used in hatcheries (Fujita et al. 2023). Vaccines also carry public concerns for public health and may affect consumer choices.

Non-medical disease may include culling or segregation of diseased fish, site rotation, and fallowing (Fujita et al. 2023, Rhodes et al. 2023a). The State of Maine requires site rotation and fallowing in all nearshore aquaculture leases; but on the west coast in Washington and British Columbia, antiparasitic use to respond to sea lice are the biggest pathogen concern (Fujita et al. 2023). A review of prevention and treatment methods are provided on p. 16 in Rhodes et al. (2023a). Sea lice infections off the coast of Canada showed seasonal increases from April through June, and in higher salinity waters (Foreman et al. 2015). Tuna parasite loads have been shown to be reduced in offshore locations, compared to nearshore counterparts (Kirchhoff et al. 2011). Minimizing stress in finfish is the best preventative measure against infection. (Rhodes et al. 2023a). The presence and active hunting by seabirds and marine mammals could worsen a disease outbreak in fish species by increasing stress levels.

In addition to environmental or biomass stress, finfish may experience other types of stress, related to impacts on animal welfare. Fish handling is defined and described on p. 2-13 of the CDFW Coastal Marine Aquaculture Program Draft PEIR (CDFW 2019). The regulations and conditions in CDFW (2019) apply to public net pens under research permits in State waters, and are therefore different from what may occur in commercial operations in Federal waters. However, it is the best available information of circumstances when fish would be handled through transport and growout phases. The very act of constraining an animal within an enclosure may be seen as contrary to an individual's ethics and animal rights (Asche et al. 2001). Similar to shellfish, the risk of hypoxia, destabilization, or death would depend on biomass density and oxygen demands. Crowding stress reduces fertility, increases susceptibility to disease, and increases ammonia excreted by cultivated fish which is toxic to animals, especially at high pH levels (Aguilar-Manjarrez et al. 2017, Carballeria Brana et al. 2021). Noise at finfish facilities may affect growth rates and disease resistance (Bart et al. 2001, Wysocki et al. 2007, and Zhang et al. 2023). In the Pacific Northwest salmon industry, fish losses due to direct predation, fish injury, or escapement have been estimated to account for losses of up to 10% of cultivated fish populations, and can relate to worker or recreational safety associated with human-animal interactions (Nash et al. 2005, CDFG 2010, and Price and Morris 2013). Finfish facilities throughout the Mediterranean, where dolphin interactions are common, report that the animals negatively impact their businesses because of depredation on cultured fish, as well as inducing stress on those fish (Bath et al. 2023). Cannibalism can also occur among younger life stages of marine fish before size grading (moving among pens) is practical (CDFW 2010).

Integrated Multi-Trophic Aquaculture (IMTA)

IMTA would propagate multiple aquatic species from different trophic levels in complementary facilities sited near each other. The potential benefits of IMTA include operation efficiencies, reduced waste, and ecosystem services. The increased dissolved oxygen, reduced acidification, and temperature buffers created by seaweed aquaculture may be beneficial as effective habitat refugia within a region for calcifying organisms (Xiao et al. 2021, TNC 2021). In this way, growing seaweeds alongside shellfish species may enhance shellfish production. Literature reviewed in Gentry et al. (2020) concluded that seaweed and bivalves can remove nutrients from the water, and some studies show evidence that seabass and other invertebrates can provide the same ecosystem service. Growing an extractive species alongside finfish could counteract any localized adverse impacts within the project footprint to reduce localized impacts. Wastes can be exploited as another profitable output or as feed for a second species, which may result in less environmental contamination and higher economic profits (Carballeria Brana et al. 2021). These benefits could be scaled up if aquaculture facilities of different types were sited near one another within an AOA.

The potential impacts of IMTA specific to the cultivated populations include disease transmission, attraction of wild species, biofouling, mechanical or chemical control, and other impacts associated with more common ocean aquaculture operations (PFMC 2022a). There may be trade-offs in IMTA that may not occur in single-species cultivation (Buck et al. 2018, Fong et al. 2023). For example, heavy metals accumulated in seaweeds are higher when grown in association with finfish – this may be an ecosystem service, but could limit the viability of any seaweed products for human food consumption from an IMTA operation (Ratcliff et al. 2016). Antifouling products that may be necessary to use in finfish aquaculture are associated with increased copper levels, which are toxic to marine invertebrates, especially molluscs (Fitridge et al. 2012). In land-based examples from the U.S. and China, rice grown in association with crustaceans have to reduce yields in order to optimize production of both foods (Fong et al. 2023). These potential impacts may be realized within a single facility, or within the geographic bounds of an AOA if projects of different types were sited near one another. The potential impacts, and the degree of impacts, from IMTA would depend on specific project designs and the potential interactions among projects sited in an AOA.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section. Higher risk of water quality concerns exist related to seafood harvest in Santa Monica Bay (see Sections B.iv. (Water Quality), D.viii. (Public Health and Safety)

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section. A higher risk of water quality concerns exist related to seafood harvest in Santa Monica Bay (see Sections B.iv. (Water Quality), D.viii. (Public Health and Safety) Elevated concentrations of several contaminants (including PCBs and DDTs) in fishes have been found in Santa Monica Bay (Schiff et al. 2000, LARWQCB 2011). According to the California Office of Environmental Health Hazard Assessment (OEHHA), a department within the California EPA, potential risks to humans associated with consumption of seafood species taken from the Bay, white croaker is considered to be the most contaminated fish, along with California corbina, queenfish, surfperches, and California scorpionfish (LARWQCB 2011). The higher contamination is assumed to be due to lipid content, and should also be a consideration for choosing potential finfish species for an aquaculture project sited in Alternative 3.

Alternative 4: Combination of Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified. It may be assumed that if multiple AOAs were identified, then more aquaculture may develop in the identified areas. Siting aquaculture projects across the region may increase any potential impacts (beneficial or adverse) from a local scale to a regional scale. Most of the potential impacts to cultivated populations would likely depend on techniques and technologies within individual facilities, and would not likely change depending on if AOAs were identified in more than one Alternative area.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

D. Socioeconomic Environment and Potential Impacts

The ocean is a major component to sustain the human socioeconomic environment. Ocean-related socioeconomic matters are defined in E.O. 13840. Coastal areas account for less than 10% of the U.S., and accounts for about 40% of the U.S. population (NOAA 2024b). In 2020, the overall U.S. marine economy contributed $361 billion to GDP, generated $610 billion in sales, and supported 2.2 million jobs. By 2030, global marine economy growth is projected to reach $3 trillion (NOAA 2022a). The CCE is integral to the economy, culture, and well-being of the U.S. west coast. The coastal and offshore waters of the SCB provide recreational and tourism activities, commercial fishing, critical routes commerce, and homeland security for millions of Americans.

i. Commercial Fishing

<u>Affected Environment</u>

NOAA Fisheries manages four FMPs along the west coast, pursuant to MSA. Viable commercial fisheries require not only healthy marine resources and habitat, but also people and businesses to support fishing activities that support the economy. A fishing community is defined under the MSA at 50 C.F.R. § 600.345(b)(3). Areas that may be considered fishing communities in California are listed on p. 365 of the NMFS Community Profiles for West Coast and North Pacific Fisheries (Norman et al. 2007). Components of the MSA, descriptions of wild fish stocks, and potential impacts related to the biological environment are described in Chapter 3, Section C.ii. of this DPEIS. This section describes the socioeconomic environment and potential impacts related to the commercial fishing activity in the SCB. Federal FMPs that may apply to Federal waters of the SCB are provided in Table 7. The potential for fisheries groups to occur in the Alternative areas are included in Table 7; and are considered in this DPEIS for the FMP, collectively. The specific species and target fisheries included under each FMP are provided for informational purposes. Site- and project-specific NEPA analyses may need to consider potential to occur with more detail, including State coordination for potential impacts to resources that may occur in both State and Federal waters.

The management of commercial fisheries in the SCB varies between State and Federal authorities for a given fishery depending on species, location, timing, and gear type. An example (based on 2013 regulations) is provided on Sea Grant's commercial fishing website (Sea Grant 2024b). California limits participation in commercial fisheries through permits, monitored use of gear, trip limits, and seasonal closures (PFMC 2013). The status of all stocks under PFMC jurisdiction are listed on pp. 7 through 9 of Table A. of the NOAA Fisheries 2022 Status of the Stocks Report (NMFS 2023g). Harvest rates are limited based on fish population status and environmental variables including fishing pressure, habitat degradation, pollution, climate change, and disease.

In 2021, commercial fishermen harvested nationally over 8.5 billion pounds of seafood, valued at $6.3 billion (NMFS 2023h). Compared to 2019, these numbers represent a notable decrease for commercial fisheries, attributed to safety measures put in place for the COVID-19 pandemic. Despite the pandemic, the commercial fishing and seafood industry in California generated the largest employment impacts in the Pacific Region with 129,938 full- and part-time jobs (NMFS 2023h). According to census data from

2000, fishing occupations accounted for 1.7% of the west coast population (Norman et al. 2007). California also generated the largest sales impacts ($26.2 billion), value-added impacts ($9.3 billion), and income impacts ($5.6 billion) despite having the lowest landings revenues of the west coast states (NMFS 2023h). Total commercial supply of marine finfish in the U.S. in 2019, divided by species, is presented in Table 8 on p. 12 of Engle et al. (2022). The following historic landings and revenues of west coast and/or California commercial fisheries:

- West coast commercial fishing described by species groups and landings in Section 3.3.1 and 3.3.2 on pp. 45 through 52 of the NMFS Community Profiles for West Coast and North Pacific Fisheries (Norman et al. 2007).
- Landings and revenues for all west coast states through 2019 are summarized in Section 3.4.2 on pp. 44 through 59 of the PFMC Pacific Coast Fishery Ecosystem Plan (PFMC 2022b).
- Landings and revenues for all west coast states through 2020 are summarized on pp. 38 and 39, and detailed per species groups on p. 44 of the NOAA Fisheries Economics of the U.S. 2020 Report (NMFS 2023h).
- Commercial landings for the state of California from 1916 through 2020 are reviewed in Free et al. (2022).
- Details on the economic contribution to the California seafood industry from commercial fisheries and key species groups are provided on p. 48 of the NOAA Fisheries Economics of the U.S. 2020 Report (NMFS 2023h).
- Trends in California commercial fisheries landings are summarized in data through 2023 in Figure P.3 on p. S-75 of Appendix P in Harvey et al. (2023).
- Trends in California commercial fisheries revenues are summarized in data through 2023 in Figure P.4 on p. S-76 of Appendix P in Harvey et al. (2023).

Alternative 2 is within the Santa Barbara Channel commercial fishing region, which is considered as State and Federal waters offshore from Point Conception to Point Dume, including the Northern Channel Islands (Sea Grant 2024b). In data analyzed through 2019, the Channel Islands contribute some of the top consistent commercial fisheries by volume to the state (CDFW 2020b). The four primary port-based fishing communities within the region are Santa Barbara, Ventura, Oxnard, and Port Hueneme. Ventura and Santa Barbara are the closest to Alternative 2, between 8.5 and 20.7 km (4.6 and 11.2 nm) (Morris et al. 2021). Port Hueneme and Ventura support relatively larger fisheries, including coastal pelagic species and market squid; Santa Barbara and Channel Islands (Oxnard) harbors primarily serve smaller dive, trap and trawl operations including lobster and sea urchin (Sea Grant 2024b). The mix of fisheries and level of activity in each port varies due to factors that change seasonally and annually, including species distribution, market demand, regulations, available infrastructure, and buyers. An example of the seasonality of commercial fish landings in the region is provided on Sea Grant's commercial fishing website (Sea Grant 2024b). Fishing communities and other coastal communities along the shoreline of the Santa Barbara Channel region are included under Chapter 3, Section D.iii. (Ports and Working Waterfronts). Historic and cultural ties to the fishing industry are included in Chapter 3, Section E.

Alternative 3 is at the northern end of the South Coast commercial fishing region, considered as the State and Federal waters offshore from Point Dume to the San-Diego-Mexico border (Sea Grant 2024b). The South Coast region is supported by 11 port-based fishing communities across Los Angeles, Orange, and San Diego Counties (Sea Grant 2024b). Marina del Rey is the closest to Alternative 3, between 9.8 and 11.3 km (5.3 and 6.1 nm) (Morris et al. 2021). Other ports along the shore of Santa Monica Bay include King Harbor at Redondo Beach and Santa Monica. The leading fisheries by value are coastal pelagic species including market squid, anchovy, and sardine, as well as spiny lobster (*Panulirus interruptus*) and red sea urchin (*Mesocentrotus franciscanus*) (Sea Grant 2024b). The tuna fishery and other HMS species are one of the primary fisheries for the region by weight, and are an important fishery to the region historically and culturally. Fishing communities and other coastal communities along the shoreline of the

South Coast region are included under Chapter 3, Section D.iii. (Ports and Working Waterfronts). Historic and cultural ties to the fishing industry are included in Chapter 3, Section E.

Commercial landings and fishing activity data were incorporated into the spatial analysis in the Atlas. The following figures from the Results Section of the Atlas (Morris et al. 2021):

- Figure 3.7 on p. 66 features navigation activity for fishing vessels carrying (Automated Identification Systems) AIS transponders.
- Figures 3.16 through 3.18 on pp. 78 through 79, and Figures 3.21 through 3.35 on pp. 83 through 97 show aggregated Vessel monitoring system (VMS) data for 15 target fisheries, as well as data with gear not listed, haul out, and long-term departure.
- Figure 3.36 on p. 98 is the site suitability model for all fishing data for each study area analyzed in the Atlas.

There are limitations in using VMS and AIS data to estimate fishing activity in an area. VMS is used in some fisheries for management and enforcement as a way to track patterns of fishing transits and intensity via satellite data; but is limited by the frequency of transmission and access is restricted for confidentiality (Russo et al. 2016, Shepperson et al. 2018, and Oceana 2021). AIS data is higher resolution and able to be accessed publicly; but it covers less fishing activity due to existing regulations (Russo et al. 2016, Shepperson et al. 2018). USCG regulations require AIS on commercial fishing vessels 65 feet or more in length (33 CFR §164.46). Whereas VMS is limited by ease of access, AIS data may underestimate the amount of fishing industry vessel traffic in the alternative areas, based on the size of commercial and recreational vessels that are used in the area (Morris et al. 2021, PFMC 2022a). The combination of VMS and AIS data analyzed in the Atlas was the best source of information available for the preparation of this DPEIS. Potential resources are included under Ongoing Monitoring and Coordination, below. A gear calendar for all FMP fisheries that may occur in the SCB is provided in Table 6.

Stressors

Baseline stressors for the commercial fishing sector include other offshore industries, fishing regulations, marine conservation efforts that exclude fishing activity, variations in fish availability, area closures due to HABs, oil spills or other pollutants, weather, markets, and competition with imports (Russel et al. 2016, Rizman et al. 2018, Moore et al. 2020, and Vizak et al. 2020). Interactions with other offshore industries and marine conservation efforts are included in Chapter 4, Section A. Ecosystem variations (included in Chapter 3, Section B.i. (Oceanography and Climate) relate to conservation concerns for wild fish stocks in the SCB (included in Chapter 3, Section Ci.ii.). In 2020, the COVID-19 pandemic caused commercial fishing landings revenue to decline 15% in 2020 (down 19% accounting for inflation) and seafood exports declined 23% (NMFS 2023h). The decline was attributed to the proportion of seafood that goes to restaurants, which shifted to retail sales during the pandemic (Froehlich et al. 2020). These uncertainties may continue to impact the commercial fisheries in the SCB and CCE in the foreseeable future.

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- fixed gear and other equipment placement in the water column and surface;
- risk of marine debris; and
- new areas where wildlife aggregations may occur.

Potential market overlap between wild-harvested and aquaculture products is included in Chapter 3, Section D.iii.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

A summary of socioeconomic and ecological interactions between aquaculture and fisheries is provided in Table 2 on p. 377 of Clavelle et al. (2019). Some interactions are positive, negative, or a combination of both. Trade-offs would need to be considered in site specific NEPA analyses once project-specific sites and designs are known. These interactions – experienced or perceived -- have been observed as one of the greatest conflicts for marine aquaculture in Norway, New Zealand, Portugal, Ireland the Mediterranean, and parts of the U.S. (Hoagland et al. 2003, Mikkelsen 2007, Rubino (ed.) 2008, Akyol and Ertosluk 2010, Ramos et al. 2015, Aquarium of the Pacific 2016, Froehlich et al. 2017b, Clavelle et al. 2019, and Rubino 2022). The resources used to consider fishing grounds in the spatial analyses in the Atlas are provided on pp. 29 and 30, in Table 2.9 on p. 38 of the Methods section, as well as in Appendix A of the Atlas (Morris et al. 2021). The results are included under each alternative, below.

Potential geographic overlap of an AOA with fishing grounds may disrupt fishing access and fishing practices. The identification of an AOA would likely group aquaculture projects together within certain geographic boundaries, creating navigation obstacles. Commercial fishing groups may experience changes in fishing access due to safety, transit patterns, other fishing practices that contribute to fishing effort, and fishery productivity (Hoagland et al. 2003, Mikkelsen 2007, Clavelle et al. 2019, and PFMC 2022a). The identification of an AOA would not disqualify commercial fishing. However, safety buffers may be set up around project sites during survey operations, construction, maintenance, and decommissioning activities. An example from the oil and gas industry in the SCB precludes vessels from entering or remaining within established safety zones that extend 500 m (1,640 ft) from the outer edges of Platforms Elly, Ellen, and Eureka (BOEM 2018).

Simultaneous to navigating new fixed gear in the ocean space, the distribution of targeted species may change due to the presence of new FADs in the offshore space. Whether FADs act as a benefit (i.e. more fishing opportunity) or adverse impact (i.e. displacement), and the severity of impact on fishers, would depend on the specific vessel size and gear types. For example, a small hook and line operation could fish closer to a facility relative to a large trawl operation that may be excluded due to the clearance needed to operate effectively and safely. This may create an advantage for certain vessels over others, changing the existing trends in competition among fleets in the offshore space.

It is important to distinguish potential impacts to the fishery overall, the fleets, and individual vessels. Fish landings in the region may not change enough to show an impact to the fishery overall; but certain vessels could be excluded completely due to new operation costs (e.g. increased fuel consumption by vessels having to avoid facilities in an AOA and higher expenditures on fuel). More detailed analyses of impacts would occur when facilities are proposed in the future.

Seafloor disturbance during baseline surveys and construction would likely have a short-term adverse impact on benthic fish, urchin, and sea cucumber presence in the direct area; and that disturbance could benefit fishing effort in proximal areas to the disturbance, if targeted species are dispersed there. The wild-capture California halibut fishery, and landings of other benthic species, may experience some displacement and/or increased effort in other areas, as many flatfishes use the same soft-bottom habitat that would likely be developed for aquaculture (Lester et al. 2018b). Sea urchins settle on hard substrate associated with kelp beds and brown macroalgae, commonly in depths up to 100 m (328 ft) but as deep as 160 m (525 ft) (SiMoN 2024). Sea cucumbers also prefer hard substrate, and are found in depths up to 75 m (249 ft) (Sea Grant 2024c). All of the surveyed, measured or modeled depths within the AOA options of Alternative 2 are within the deepest range for red sea urchin; and all of the western AOA options within Alternative 2 (those labeled N2 in Figure 1) are within the depth range for sea cucumber (Morris et al. 2021). Anchoring systems would likely provide novel habitat for invertebrate species, which could be a benefit for the urchin fishery. In contrast, the trawl-based sea cucumber fishery would not be able to take advantage of any ecological benefit from anchoring systems due to incompatibility of trawl operations and fixed aquaculture gear.

A potential benefit to the commercial fleets in the SCB would be a diversification of labor and revenue by participating in offshore aquaculture operations. Diversification can take place in the form of targeting different fisheries, regions, or spreading effort throughout the year. Fishers with more diversified activities tend to have higher total revenue and less revenue variability (Harvey et al. 2023). Commercial fishers, in particular, might be well-suited for work involving transportation and vessel maintenance involved with offshore aquaculture, either as a new occupation or one that complements current fishing activities, as they would have detailed knowledge of local oceanic and weather conditions (Rubino 2007; Valderrama and Anderson 2008, and Rubino 2022). Operational synergies between aquaculture and fishing, including examples in California, are summarized on pp. 4 and 5 of Rubino (2022). Froehlich et al. (2020) points out the two sectors are managed separately, but would share geographic space and markets in feed and/or seed. Furthermore, the seafood supply chain could benefit from having a predictable, increased supply of products which would help maintain these new jobs (Rubino (ed.) 2008, Froehlich et al. 2020). Fisheries and seasonal diversification in commercial fishing activity in the CCE has been trending down in all west coast vessels since 2015, thought to be associated with the onset of marine heatwaves and then COVID-19 in 2020 (Harvey et al 2023). Offshore aquaculture could alter this baseline trend, with beneficial impacts to the commercial fleets.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The site suitability model of the Atlas combined over 15 types of available fisheries data for potential geographic overlap with commercial fisheries in the alternative areas, as incorporated in the Environment portion of this section, above. The available information for Federal waters in the Santa Barbara Channel as a whole (including Alternative 2 and additional areas throughout the Channel), are shown in the upper left corner of Figure 3.26 on p. 98 of the Results Section of the Atlas (Morris et al. 2021). The percent overlap of recorded activity for each fishing data set with Alternative 2 is shown in Table 3.5 on p. 75 of the Atlas (Morris et al. 2021). (Alternative 2 is represented as “N” (North Study Area) in Table 3.5). Alternative 2 overlaps CDFW catch blocks 665 and 666.

According to the spatial analysis in the Atlas, the highest-ranked fishing transits in and around Alternative 2 are sea cucumber and California halibut trawl, prawn and Dungeness crab pot/trap, and gillnet (Morris et al. 2021). According to PFMC estimates, Alternative 2 is located on grounds important to HMS fishers (although it was noted that tuna and swordfish harvesters based in the area would not likely be displaced from fishing grounds), as well as non-HMS fishers targeting ridgeback prawn, sea cucumber, California halibut and coastal pelagic species (PFMC 2022a). Before the decline of the salmon fishery, the Santa Barbara Channel region was important to salmon trollers (PFMC 2022a). These fisheries may be especially-important to analyze during permitting decisions under a site specific NEPA analysis for potential impacts due to geographic overlap.

According to data from 2010 through 2019, CDFW catch blocks 665 and 666 brought in an annual average of 964,450lb and 329,875lb of total landings, respectively (Morris et al. 2021). According to the most recent data from CDFW’s Fisheries Data Explorer (available online at oceanspaces.org), top fisheries by revenue in Santa Barbara County Ports are red sea urchin, rock crab, sablefish, lobster, and sea cucumber, supporting an estimated 261 fishers and contributing over $12M in gross revenue in 2014 (Ocean Spaces 2014 data). The Port of Santa Barbara takes roughly half of the total statewide volume in sea urchin, according to data analyzed from 1980 through 2022 (CDFW 2020b, USFWS 2022, and CDFW 2023). Ventura top fisheries were market squid, CPS, shrimp/prawn, and lobster, supporting an estimated 199 fishers and over $14M gross revenue in 2014 (Ocean Spaces 2014 data). Port Hueneme-

Oxnard top fisheries were market squid, red sea urchin, CPS, rock crab, and white seabass (Ocean Spaces 2014 data). These fisheries may be especially-important to analyze during permitting decisions for a site specific NEPA analysis for potential landings impacts related to geographic overlap or increased fishing effort.

The percent of each fleet that may be affected by geographic displacement, or exclusion due to fishing effort and practices may also be an indicator of how these offshore impacts relate to fishing communities on the coast. Project-specific NEPA analyses that may have more information on coexistence versus competitive impacts should further analyze disproportionate impacts to small, local, and independent businesses which could also lead to greater adverse impacts on fishing communities. More on working waterfronts, social indicators, potential community vulnerability, and community wellness are discussed in Chapter 3, Section D.iv. (Ports and Working Waterfronts) and Section E. (Cultural and Historic Environment).

a) Shellfish and Macroalgae

Much of the potential impacts to commercial fisheries from shellfish and macroalgae, specifically, would likely be associated with FADs. The potential impacts to wild fish stock habitat and habitat use, including FADs, are described under Chapter 3, Section C.ii. (Wild Fish Stocks), and not repeated here.

Macroalgae aquaculture may affect the amount of fish landings in an area. Preat et al. (2018) modeled potential impacts of large-scale seaweed aquaculture on fish landings in the North Sea, considering Sugar Kelp and European fish and seaweed markets in France and Ireland. Their findings show that while seaweed aquaculture at a large scale may impact fish landings adversely due to cultivated biomass replacing phytoplankton biomass in the food web, the amount was not significant enough to have any market impacts. In addition, the economic benefit added to the markets for seaweed production outweighed any adverse economic impacts to fisheries. It should be noted that an overall economic impact to the market may not reflect economic hardship to individual vessels or businesses that rely on certain species. Additionally, macroalgae has been shown to inhibit the growth of known Harmful Algal Blooms (HABs) species, potentially reducing the occurrence of HABs which is known to impact West Coast fishing communities (Tang et al. 2014).

In a recent EA for kelp aquaculture in the Santa Barbara Channel, the commercial fishing community was engaged prior to the analysis, in which the size of the facility was reduced from 133 to 86 acres (54 to 35 ha) to minimize impacts on squid and trawl fisheries (USACE 2021). In addition, it was recommended that construction time frames consider squid spawning and purse seine seasons to minimize impacts to the fishery (USACE 2021). On-site gear monitoring at a minimum of twice a month, with maintenance and recovery requirements, were included in the permitting decisions to avoid interactions with derelict gear and risks of marine debris (USACE 2021). Potential impacts to species managed under salmon, groundfish, CPSD, and HMS FMPs were considered in Section 4 on pp. 17 through 39 of the EFH analysis of the project (pp. 167 through 189 of the EA (USACE 2021)).

The nearest offshore aquaculture operation that could be used as a proximal example for analyzing fisheries displacement is a 100 acre (40 ha) shellfish facility (no longer in operation), near the San Pedro Shelf off the coast of Long Beach. In the EA, it was concluded that squid harvesters would not be impacted since the majority of the fishing effort for squid occurs within one mile from shore; hook and line capture species such as California halibut would not be impacted by longline cultivation methods; and surface fishing effort for swordfish and other HMS species would not be impacted since shellfish is cultivated about 9 m (30 ft) below the surface of the water (USACE 2012).

b) All Types of Commercial Aquaculture

Rhodes et al. (2023a) analyzed the geographic overlap of the alternative areas with commercially and recreationally valuable species in the SCB. While the presence or absence of certain species in an area can vary greatly from year to year in the SCB, the analysis does provide a baseline for potential wild species interactions that should be considered in a project specific NEPA analyses. In catch-per-unit-effort data from the annual U.S. West Coast Groundfish Bottom Trawl Survey analyzed from 2003 through 2023, 8 out of 14 evaluated fish species show distributions that overlap with AOA options included in Alternative 2, as shown in Appendix D2 on p. 104 of Rhodes et al. (2023a). Building upon Rhodes et al. (2023a), Parrish and Karp (2024) conducted a spatial analysis on wild fish biomass that are of conservation and/or commercial value in the SCB, and physiologically similar or the same species as those likely to be cultivated in an AOA. Alternative 2 has occurrences of bocaccio, California halibut, Dover sole, English sole, lingcod, Pacific pompano, market squid, northern anchovy, and eulachon (Parrish and Karp 2024).

Fishing activity around aquaculture facilities in an AOA may increase due to the FAD effect, depending on compatibility of gear types. A beneficial biomass effect may result at a local, and long-term temporal scale, which would benefit commercial fisheries (Arechavala-Lopez et al. 2011). All types of aquaculture facilities may act as FADs, though the effect may be amplified around finfish facilities due to additional factors of feed, waste, and predation opportunities. A survey of 21 finfish facilities around the Mediterranean found the positive FAD effects for fishing were far greater than other types of FADs in the ocean (e.g. oil rigs, artificial reefs) due to feeding practices (Akyol and Ertosluk 2010, Bacher et al. 2012, Bacher and Gordoa 2016). Accounts from Hawaii also state that finfish cages are more effective at drawing in fish than other FADs (NMFS 2022e). The potential impacts to wild fish stock habitat and habitat use, including FADs, are described under Chapter 3, Section C.ii. (Wild Fish Stocks), and not repeated here. It is likely that projects within an AOA would be sited with some distance between them; so commercial fishing vessels could take advantage of this effect. However, FADs within an AOA could also alter access to favorable fishing grounds. This change may impact the size of vessels and the types of gear that make more or less landings, which could create new competition among fishing vessels, especially between large-scale, industrial operations and smaller, artisanal fishers (Akyol and Ertosluk 2010, Price and Morris 2013, and Clavelle et al. 2019).

An ecological benefit associated with finfish aquaculture, globally, is that it may decrease pressure on wild fish stocks (Naylor et al. 2000, Rubino (ed.) 2008, and Clavelle et al. 2019). The most recent FAO State of World Fisheries and Aquaculture report (2022) showed the percentage of stocks within biologically sustainable levels decreased 1.2% between 2017 and 2019 globally, continuing a trend since 1974. More specifically, 13.8% to 14.3% of the assessed stocks in the eastern Pacific are considered unsustainable (FAO 2022). Based on 198 stock assessments in the U.S. as of 2022, an estimated 88 percent of the stocks most targeted by fishermen, have a known overfishing or overfished status (NMFS 2023g). Forty-eight stocks or stock complexes are currently in rebuilding plans, and of the 48, 41 are considered overfished (NMFS 2023g). Conservation hatchery production is an existing example on the west coast where aquaculture has helped wild fish populations; however, other hatchery programs have resulted in unsustainable predation levels on native fish species. Existing public hatcheries and private population restocking programs on the west coast exist currently for species such as salmon, trout, bass, and halibut (Rubino (ed.) 2008, CDFW 2010, and MacNamara et al. 2022). As an example of scale, there are almost 400 salmon hatcheries on the west coast that release about 1.7 billion juvenile salmon per year into the Pacific Ocean, with an estimated value of $60 million in data analyzed through 2005 (Rubino (ed.) 2008). These species support some commercial landings, as well as Tribal and recreational fisheries (discussed in Chapter 3, Section D.ii.).

If identifying an AOA resulted in increased finfish aquaculture in the SCB (e.g., as a result of this long-term planning and environmental review), there may be an increased demand for forage fish. The identification of an AOA could potentially contribute to the baseline trends for the forage species; however, it is beyond the scope of this DPIES to analyze if feed would be live, fish-based, from a wild or cultivated source, and the location where it would be sourced.

A trade-off analysis would likely be necessary for a site specific analysis if they pursued permits to cultivate a species currently targeted by commercial fisheries in the SCB. Sablefish, for example, are a species that could be considered under this effect. Though the species is not considered to be experiencing overfishing or considered overfished in the region, biomass trend has shown declines, and is thought to be susceptible to climate change (Hartley et al. 2020). In this case, the source of cultivated versus wild-harvested sablefish at existing receivers in Santa Barbara County and at Port Hueneme-Oxnard may impact commercial fishers ability to participate in the existing market. More on markets and regional food systems is discussed in Chapter 3, Section D.iii.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The site suitability model of the Atlas combined over 15 types of available fisheries data for potential geographic overlap with commercial fisheries in the alternative areas, as incorporated in the Environment portion of this section, above. The available information for Federal waters in Santa Monica Bay as a whole (including Alternative 3 and additional areas throughout the Bay), are shown in the upper right corner of Figure 3.26 on p. 98 of the Results Section of Morris et al. (2021). The percent overlap of fishing activity for each fishing data set within Alternative 3 is shown in Table 3.5 on p. 75 of the Atlas (Morris et al. 2021) (Alternative 3 is represented as "CN" (Central-North Study Area) in the Atlas). Alternative 3 overlaps with CDFW catch block 702 (Morris et al. 2021). As stated for Alternative 2, the percent of each fleet that may be affected by geographic displacement, or exclusion due to fishing effort and practices may be an indicator of how these offshore impacts relate to fishing communities on the coast.

Commercial fishing is not allowed in the Central North Study Area, with limited exceptions (Morris et al. 2021, PFMC 2022a). According to data from 2010 through 2019, CDFW catch block 702 brought in an average of 915,038 lb (Morris et al. 2021). This data makes it evident that commercial fishing does occur, despite restrictions. Any impacts to fishing activity in this catch block may have more pronounced impacts to the fleets, if fixed gear adds another barrier to access. Information on how important this catch block is to the vessels that fish there was not available in preparation of this DPEIS. Marina del Rey is the closest fishing port in proximity to Alternative 3; but no port group summary was available in the Fisheries Data Explorer. According to the most recent data from CDFW's Fisheries Data Explorer (available online at oceanspaces.org), the top fisheries by revenue in the Los Angeles-Long Beach Area are market squid, CPS and other pelagic species, and red sea urchin, supporting an estimated 215 fishers with over $19M gross revenue in 2014 (Ocean Spaces 2014 data).

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

b) All Types of Commercial Aquaculture

Rhodes et al. (2023a) analyzed the geographic overlap of the alternative areas with commercially and recreationally valuable species in the SCB. In Catch-per-unit-effort data from the annual U.S. West Coast Groundfish Bottom Trawl Survey analyzed from 2003 through 2023, 5 out of 14 finfish species evaluated overlap with AOA options included in Alternative 3, as shown in Appendix D2 on p. 104 of Rhodes et al. (2023a). While the presence or absence of certain species in an area can vary greatly from year to year in the SCB, the analysis does provide a baseline for wild species interactions that should be considered in site specific NEPA analyses. Building upon Rhodes et al. (2023a), Parrish and Karp (2024) conducted a spatial analysis on wild fish biomass that are of conservation and/or commercial value in the SCB, and physiologically similar or the same species as those likely to be cultivated in an AOA. Alternative 3 has occurrences of Dover sole, English sole, lingcod, Pacific pompano, and sablefish (Parrish and Karp 2024).

Additional information used to analyze potential impacts to commercial fishing from finfish aquaculture in Alternative 2 is also the best available information for Alternative 3, and is not repeated here.

Alternative 4: Combination of Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.

If multiple areas were identified as AOAs under Alternative 4, the potential impacts from geographic overlap may occur across a larger geographic scale. Geographic expansion would not necessarily mean a serial depletion of landings, though, due to the highly variable existing conditions of fisheries and the SCB ecosystem.

Siting aquaculture in multiple AOA options spread across Alternative areas could provide a trade-off scenario, where fishing grounds could be strategically avoided depending on the season and distribution of fish biomass from year to year. For example, Lester et al. (2018b) found that the most profitable sites for kelp and finfish aquaculture are concentrated away from the halibut fishery's most valuable areas in the SCB, and thus could be developed with no significant impact on the fishery. The scale of aquaculture practices and adjacent capture fisheries are important modifiers for nearly all ecological interactions between the two industries that influence the beneficial or adverse outcomes and severity of impacts (Clavelle et al. 2019). In order for this net benefit to be realized, cooperative management between aquaculture and fisheries would be necessary, discussed under potential mitigation, in Appendix 1.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

ii. Recreational Fishing

Affected Environment

Recreational fishing activity encompasses any fishing activity in which the fish is not sold for profit (CDFW 2016c, NMFS 2023g, and NMFS 2023h). It includes businesses of sportfishing, angling, charter fishing, commercial passenger fishing vessels (CPFV), as well as individual vessels that engage in fishing activity for subsistence or fun. These categories of fishing activity are described in Sections 3.3.3 and 3.3.4 on pp. 53 and 54 of the NMFS Community Profiles for West Coast and North Pacific Fisheries (Norman et al. 2007). Recreational fishing in Federal waters is regulated under the MSA (see Chapter 3, Section C.i., C.ii., and Section D.i. for statutory information).

The Modernizing Recreational Fisheries Management Act of 2018 (Modern Fish Act) pursues efforts to expand fishing opportunities for recreational fishers, and seeks to better understand the fishing public's vision for management by engaging recreational fisheries stakeholders in a more in-depth discussion of optimum yield and how it can be used to identify and prioritize management objectives that are better suited to the cultural, economic, and conservation goals of the angling community (NMFS 2021c, NMFS 2022e). A National Saltwater Recreational Fisheries Policy (2015, rev. 2023) also guides NOAA Fisheries activities to foster, support, and enhance a broadly accessible and diverse array of sustainable saltwater recreational and non-commercial fisheries for the benefit and enjoyment of the nation. Goals of the policy include promoting inclusive and sustainable saltwater recreational and non-commercial fishing for the social, cultural, and economic benefit of the nation, as well as enable enduring participation in, and enjoyment of, saltwater recreational fisheries through science-based conservation and management (NMFS 2023i).

Socioeconomics of recreational fishing activity is tracked by expenditures and profits generated by trip and durable good expenditures; by the number of fishing trips; and by the number of licenses in the state or region (NMFS 2023i). There are approximately 350 sportfishing vessels licensed in the state, with an estimated 108 operating in the south coast region, 41 in the south-central coast region (CARB 2021). Ticket prices average about $147.50 for a day trip, and about $335.11 per day for a 6-pack vessel and are projected to increase due to State regulatory requirements related to air resources and engine upgrades through 2034 (CARB 2021). The Pacific-wide regional average expenditure for guide fees (i.e. charter or party vessel tickets and surcharges, etc.) in 2022 was $330 (NMFS 2024d).

According to the Bureau of Economic Analysis, outdoor recreation accounts for approximately 1.9% of total U.S. gross domestic product (2020) with fishing and boating representing the largest conventional outdoor activity in the nation. It is essential to recognize the existence and significance of non-commercial fishing and acknowledge its role in the overall fishing landscape, shaped not only by markets, but also demographics of coastal communities and ecological shifts. According to the most recent NOAA Fisheries status of the stocks, saltwater angling nationally generated $138 billion in sales impacts, contributed $74.9 billion in value-added impacts, and supported 692,000 jobs as of 2020 (NMFS 2024d). Compared to 2021, these numbers represent an increase for recreational fisheries. Additional information about the economic contribution of recreational fisheries to the U.S. economy from the NOAA Fisheries Economics of the U.S. 2022 Report (NMFS 2024d):

- The overall economic impact and expenditures for the U.S. is provided on pp. 11 through 13.
- Details for recreational fisheries in all west coast states are provided on pp. 14, 15, and 17.

NMFS WCR, the NWFSC, the SWFSC, and PFMC work together to support West Coast recreational fishing communities, covering 317,690 mi^2 of the eastern Pacific Ocean, and more than 7,000 miles of tidal coastline (NMFS 2023h). In 2018, over 38,000 albacore tuna (*Thunnus alalunga*), 4,000 dorado (*Coryphaena hippurus*), and 4,000 yellowfin tuna (*Thunnus albacares*) were caught and landed by private boaters along the West Coast. In 2019, recreational fishermen took 4.3 million saltwater fishing trips on the West Coast supporting approximately 10,900 jobs and $1.5 billion in sales (NMFS 2023h). A more detailed report on the West Coast recreational fisheries is provided in Section 3.4.2.2 on pp. 53 through 57 of the PFMC Pacific Coast Fishery Ecosystem Plan (PFMC 2022b).

Recreational fishing contributes to the California economy and culture. Recreational fisheries have historically been a significant proportion of total catch throughout California, particularly concentrated on nearshore and shelf species in the SCB (Miller et al. 2014a). A detailed report on recreational fishing in California is provided in Section 3.4.2.2 on pp. 53 through 57 of the PFMC Pacific Coast Fishery Ecosystem Plan (PFMC 2022b). In California as of 2020, the recreational fishing industry was estimated to generate $718 million in sales, contributed $302 million to the U.S. economy, and supported 5,083 jobs (NMFS 2023h). Harvey et al. (2023) Appendix P, Section p.1: and Figure p.3 show annual CA landings 1983 through 2023.

Key recreational species found off the coast of California are Pacific and California halibut, salmon, rockfishes and other groundfish, seabasses, tunas and other HMS (PFMC 2013, NMFS 2023g). While unlikely to occur in offshore waters, the recreational harvest of some shellfish, crustaceans, and macroalgae for personal use is permitted in California (14 C.C.R., § 28.60, 29.05, 29.10, 29.80, 29.91, 30, and 30.10). The CPFV fleet operates year round, but has a peak HMS fishing season in spring and summer (NMFS 2024e). Bass species and rockfishes have generally been more important species targeted during the fall to winter season, whereas warm-water HMS migrants are important during the summer season (Schiff et al. 2000). Forage species also support recreational fishing activity in the SCB (Schiffet al. 2000, NMFS 2020a). Historic trends in catch rates by species in the SCB from 1980 through 2000 are summarized in Figure 4 on p. 173 of Jarvis et al. (2004). More recent recreational landings data (excluding salmon, Pacific halibut and HMS) in California were analyzed in Harvey et al. (2023), which showed landings had both a decreasing trend and below-average status over the past five years, associated with decreased landings of lingcod and vermilion rockfish in particular. Recreational salmon landings in California were within 1 standard deviation of the long-term average over the last 5 years; however, recreational ocean salmon fisheries were closed off California in 2023 (Harvey et al. 2023, NMFS 2023j).

Upwelling, bathymetric features and other geologic components of the marine environment influence popular recreational fishing spots. In historic recreational catch trends from 1980 through 2000, all species trends associated with upwelling were positive (Jarvis et al. 2004). According to a recreational fishing survey in an EA for offshore wind in the SCB, BOEM (2018) found that rockfish particularly are targeted by recreational fishers at the heads of submarine canyons in approximately 90 to 183 m (300 to 600 ft) of water in the SCB; and recreational users commonly access and transit over the offshore space to rocky areas around Santa Catalina Island. The overlap, or proximity of the alternative areas to some specific bathymetric features, existing FADs, and the Channel Islands to the alternative areas are discussed in Chapter 3, Section B.i. through B.iii. and Section C.ii.

Stressors

Baseline stressors for the recreational fishing sector include those listed for commercial fisheries and are not repeated here. The COVID-19 pandemic caused large-scale disruption to the U.S. economy. In 2020, the impacts to the for-hire fishing trips were immediate, more severe, and more long-lasting than those incurred in most other sectors of the economy (NMFS 2023h). Trip impacts in Southern California were some of the highest in the nation, at a 33% loss (NMFS 2023h). These uncertainties may continue to impact the recreational fisheries in the SCB and CCE in the foreseeable future.

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- fixed gear and other equipment placement in the water column and surface;
- risk of marine debris; and
- new areas where wildlife aggregations may occur.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

This growth of offshore aquaculture within an identified AOA may change recreational fishing activities in the SCB due to geographic and ecological interactions. The ecological interactions listed in Table 2 on p. 377 of Clavelle et al. (2019), for commercial fisheries, would also apply to recreational fishing activity. Socioeconomic interactions with recreational fishing are more likely to be associated with ports and working waterfronts, such as CPFV businesses, tackle shops, boatyards and marinas (Lovell et al. 2016). More on working waterfronts is discussed in Chapter 3, Section D.iv. There is a strong association with recreational fishers to maintain fishing opportunities (i.e., the experience) over catching certain amounts of target species (NMFS 2022e). Therefore, the impacts on individuals who participate in boat-based fishing may be more pronounced associated with socio-cultural interactions in addition to ecological interactions.

Fishing vessel groups may experience changes in fishing access due to safety, transit patterns, other fishing practices that contribute to fishing effort, and fishery productivity (Hoagland et al. 2003, Mikkelsen 2007, Clavelle et al. 2019, and PFMC 2022a). The chance of displacement and the severity of impact on fishers would depend on the compatibility of gear types resulting in coexistence or competition for space. Safety buffers may be set up around project sites during survey operations, construction, maintenance, and decommissioning activities. These impacts would likely only affect recreational fisheries temporarily, while work was underway. In the case with existing oil and gas platforms in the SCB, vessels under 30.5 m (100 ft) are allowed within the buffer (BOEM 2018). Most recreational vessels are likely small enough to operate within an AOA and very close to a facility; and most recreational fishers typically use hook-and-line (rod and reel or pole-and-line), which is a hand-held fishing rod with a manually or electrically operated reel attached, though some anglers successfully target HMS and other fisheries using spearfishing gear (NMFS 2024e).

Overall, having new reliable FAD locations could be a benefit to recreational fishing. However, certain vessels could be excluded completely due to new operation practices (e.g. increased fuel consumption by vessels having to avoid facilities in an AOA and higher expenditures on fuel).

Another potential source of new competition for boat-based fishing has been observed in the Mediterranean, the illegal harvesting of wild fish in FADs by employees of aquaculture facilities (Akyol and Ertosluk 2010, Bacher et al. 2012, Bacher and Gordoa 2016). If regulatory compliance mechanisms are put into place this impact should not occur; however, it may be an important ecological consideration. If illegal fishing activity occurs due to new wildlife aggregations, it would be a new source of competition for recreational fisheries and marine predators in the offshore space.

Seafloor disturbance during baseline surveys and construction would likely have a short-term adverse impact on benthic fish and invertebrates in the direct area. That disturbance could benefit fishing effort in proximal areas to the disturbance if targeted species are dispersed there. Anchoring systems would likely provide novel habitat for invertebrate species, which in turn, could attract demersal reef and pelagic fishes which would be a benefit for recreational fishers (Johnston et al. 2022).

A potential benefit to employees of CPFV and other guided fishing businesses in the SCB would be a diversification of labor and revenue by participating in offshore aquaculture operations. These fishers, in particular, might be well-suited for work involving transportation and vessel maintenance involved with offshore aquaculture, either as a new occupation or one that complements current fishing activities, as they would have detailed knowledge of local oceanic and weather conditions (Rubino 2007; Valderrama and Anderson 2008, and Rubino 2022). It is noted that this might apply to charter boats and guide services in California, but not necessarily to private anglers that comprise the bulk of the recreational fishery or the associated businesses that support them. While this may be a beneficial impact for the workforce, it would likely create a resource competition between aquaculture and boat-based recreation businesses. While this type of ocean-based, skilled employment competition likely already exists between commercial fisheries and recreational fisheries, aquaculture would introduce a new opportunity and diversification of labor for employees. A trade-off analysis, considering the available workforce, need for seasonal versus year round workers, skilled versus labor-based work may be analyzed in site specific NEPA analysis defined site-specific designs with associated waterfront auxiliary needs.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Spatial data for recreational fishing in the SCB from 2010 through 2019 was incorporated into the Atlas. The resources used are provided on pp. 29 through 31, as well as in Table 2.9 on p. 38 of the Methods section, as well as in Appendix A of the Atlas (Morris et al. 2021). Alternative 2 is located within the North Study Area in the top left corner of each of the following figures from the Results section of the Atlas (Morris et al. 2021):

- Figure 3.10 on p. 69 shows AIS passenger vessel transits;
- Figure 3.19 on p. 81 shows aggregated CPFV activity; and
- Figure 3.20 on p. 82 shows aggregated individual vessel recreational survey data.

Interactions with recreational fishers are likely in Alternative 2. A survey of recreational target species that compared habitat between oil and gas platforms in the Santa Barbara Channel and rocky substrates in Santa Monica Bay showed higher fish densities, but lower species diversity, near the FADs in the Channel than natural habitat in the Bay (Schroeder and Love 2002). In data analyzed from 2004 through 2011, the estimated recreational catch in the Ventura and Santa Barbara region fluctuated between 1,000 to 3,000 mt annually (PFMC 2013). These estimated catch rates were higher than the south coast. Potential conflicts with CPFV and private boat fishing operations may be pronounced in waters deeper than 100 m (328 ft); because these areas have become more accessible to anglers lately because of changes in regulations, in addition to improvements in fish finder and fishing gear technology (PFMC 2022a).

a) Shellfish and Macroalgae

The potential impacts on recreational fisheries from shellfish and macroalgae, specifically, would likely be associated with FADs. The potential impacts to wild fish stock habitat and habitat use, including FADs, are described under Chapter 3, Section C.ii. (Wild Fish Stocks), and not repeated here. California sheephead *(Semicossyphus pulcher)* provides an example of a species that is recreationally-targeted that could change distribution in association with macroalgae aquaculture. The species occurs nearshore along the California mainland from Point Conception to Palos Verdes Point, highly associated with kelp beds (NCCOS 2005). If the species is drawn to offshore macroalgae aquaculture, that may impact trends within the recreational fishery closer to shore. These facilities could also increase the overall amount of preferred habitat.

The potential impacts of shellfish and macroalgae aquaculture discussed for commercial fisheries (Section D.i.) would likely be similar for recreational fishing activity. The potential advantage recreational fishers may have over commercial operations near fixed gear would not likely be affected by the type of aquaculture. In a recent EA for kelp aquaculture in the Santa Barbara Channel, recreational fishing areas were not thought to be in conflict with the operations, as long as navigational hazards and notice to mariner requirements were followed (discussed in Chapter 3 Section D.vi.). On-site gear monitoring at a minimum of twice a month, with maintenance and recovery requirements, were included in the permitting decisions to avoid interactions with derelict gear and risks of marine debris (USACE 2021). More on navigational hazards and marine debris are discussed in Chapter 3, Section D.vi. (Transportation and Navigation) and D.viii. (Public Health and Safety).

The nearest offshore aquaculture operation that could be used as a proximal example for analyzing fisheries displacement is a 100 acre (40 ha) shellfish operation no longer in operation, near the San Pedro Shelf off the coast of Long Beach. In the EA, it was concluded that the facility would have a net benefit for fishing potential, especially recreational opportunities (USACE 2012). Hook and line capture species, such as California halibut, would not be impacted by longline cultivation methods; and surface fishing effort for swordfish and other HMS species would not be impacted since shellfish is cultivated about 9 m

(30 ft) below the surface of the water (USACE 2012). This operation was known to draw in pelagic game fish (e.g., California yellowtail (*Seriola dorsalis*)), along with the private boaters (hook and line and spearfishing) and CPFVs targeting them.

b) All Types of Commercial Aquaculture

Accounts from finfish aquaculture, globally, show FAD effects are more pronounced around finfish facilities than around other types of aquaculture (see Chapter 3, Section C.ii. (Wild Fish Stocks), sub-alternative b). Cultured fish that may escape have also been shown to be more susceptible to capture by anglers, according to reports reviewed in Purcell et al. (2023 draft). Long-term impacts from FADs around finfish aquaculture during operations would likely benefit recreational fishers. Similar considerations discussed for commercial fishing activity around finfish facilities (discussed in Section D.i.) would likely apply to recreational fishers. The potential advantage recreational fishers may have over commercial operations to operate closer to fixed gear would not likely be affected by the type of aquaculture.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Spatial data for recreational fishing in the SCB from 2010 through 2019 was incorporated into the Atlas. The resources used are provided on pp. 29 through 31, as well as in Table 2.9 on p. 38 of the Methods section, as well as in Appendix A of the Atlas (Morris et al. 2021. Alternative 3 is shown in the top right corner of each of the following figures from the Results section of the Atlas (Morris et al. 2021):

- Figure 3.10 on p. 69 shows AIS passenger vessel transits;
- Figure 3.19 on p. 81 shows aggregated CPFV activity; and
- Figure 3.20 on p. 82 shows aggregated individual vessel recreational survey data.

Aquaculture could change baseline fish distribution between the Santa Barbara and Santa Monica Basins. A survey of recreational target species that compared habitat between oil and gas platforms in the Santa Barbara Channel and rocky substrates in Santa Monica Bay showed higher fish densities, but lower species diversity, near the FADs in the Channel than natural habitat in the Bay (Schroeder and Love 2002). In data analyzed from 2004 through 2011, the estimated recreational catch in the south coast region (considered Los Angeles County through San Diego County) fluctuated between 900 to just under 3,000 mt annually (PFMC 2013). These estimated catch rates were lower than all other areas in the SCB. Aquaculture may create new considerations for fishing access in Alternative 3, where potentially little to no competition exists with non-commercial vessels, and few artificial FADs exist relative to Alternative 2. Potential conflicts with CPFV gear and private boat fishing operations may be pronounced in waters deeper than 100 m (328 ft), because these areas have become more accessible to anglers lately because of changes in groundfish regulations, in addition to improvements in fish finder and fishing gear technology (PFMC 2022a). However, this may also spread effort out between the nearshore and waters of the continental shelf and slope.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

Alternative 4: Combination of Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. CDFG CPFV data from 1998-2002 show high recreational landings in both alternative areas already (NCCOS 2005), which may imply minimal impacts to the activity; but it could change how people access the fishing opportunity. Opportunities for recreational fishing could be greatly expanded, or even favored, offshore compared to existing nearshore activity. For example, a decrease in individual vessels, and an increase in CPFV may be observed as a cost-share to access fishing grounds further offshore. This could have a beneficial impact to local businesses.

Siting aquaculture in multiple AOA options across Alternative areas may mitigate the advantage smaller recreational vessels may gain over commercial fleets due to navigation safety and gear compatibility. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified**.** The potential strategic placement and operations discussed for Alternative 4 in commercial fisheries (Section D.i.) may apply similarly to recreational fishing.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

iii. Markets and Regional Food Systems

Affected Environment

Socioeconomics related to the marine economy are considered as sectors that represent establishments, employees, sales, and payroll for seafood processors, wholesalers, and retailers that buy fish from commercial fishermen and distribute them to consumers; it also includes recreational transport, support, and marine operations outside the seafood sector (NMFS 2023h). This section of the DPEIS highlights some of the market values related to the marine economy, seafood industry, and existing aquaculture industry in order to describe the human dynamics that link offshore activities to economic systems on shore. These may vary on a local, regional, state, or nationwide scale. Local and regional are defined in the context of this DPEIS in Appendix 3. It is not possible to identify what markets would be affected by potential projects sited in an AOA without knowing the type of aquaculture that would be pursued, and what products would be part of project designs. However, information is included as examples based on the best available information of stakeholder interest in the SCB, Federal studies, and existing international aquaculture and seafood markets.

It is common for aquaculture businesses in the U.S. to sell directly to restaurants and in doing so they must abide by laws of interstate commerce (Sea Grant 2024a). It is unlawful to import, export, transport, sell, receive, acquire or purchase any plant, fish, or wildlife taken, possessed, transported, or sold in violation of laws or regulations (state, federal or foreign) in accordance to the Lacey Act (16 U.S.C § 3371 et seq., 18 U.S.C. § 42). The Lacey act may factor into project designs for choices of cultivated species, broodstock sourcing, and proper labeling of aquaculture products. Any importation of termed, "injurious" wildlife into the U.S. or transport between states, the District of Columbia, the Commonwealth of Puerto Rico, or any territory or possession must be authorized under a permit issued by USFWS. Injurious specimens are listed under 50 C.F.R. 16. The Lacey Act may be triggered related to aquaculture if state or federal law is violated by a product that has been part of interstate commerce (Rumley 2010). It may also relate to regulations that restrict cultivation of nonnative species (CAA 2023).

The growth in aquaculture production globally has occurred in parallel with global trade (Gephart and Pace, 2015). Global trade of fisheries and aquaculture products is described on pp. 91 through 107 of FAO (2022). Import to export ratios for seven fishery-related species groups is shown in Figure 5 on p. 7 of Naylor et al. (2021). In all marine species groups except demersal fish, the U.S. imports more than it exports. Common global markets and products for macroalgae, shellfish, and finfish aquaculture are included under each alternative, below.

According to the most recent report on the marine economy from the Bureau of Economic Analysis (2023), the marine economy contributes an estimated $432B in goods and services to the annual U.S. GDP and about $730 billion in sales related to recreation, utilities, data, and resources. Nationally, it is estimated that the marine economy supports about 2.3M jobs (BEA 2023). According to the most recent NOAA Fisheries status of the stocks, the total U.S. seafood industry (wild harvest and aquaculture) generated $47 billion in sales impacts, contributed $24.4 billion to the GDP, and supported 588,000 jobs as of 2020 (NMFS 2023g). Global and nationwide consumer trends show that the demand for seafood, and specifically aquacultured-species of seafood, has been steadily increasing over the last few decades. Trends in U.S. seafood consumption from the following resources:

- data from 1987 through 2006 are described on pp. 195 through 197 of Rubino (ed.) (2008);
- data analyzed through 2015 are shown in Figure 4 on p. 6 of Naylor et al. (2021); and
- Figure 1 on p. 2 of Froehlich et al. (2020) compares the rates of marine aquaculture versus marine capture seafood (including fish, molluscs, crustaceans, and plants).

The majority of seafood consumed in the U.S. is sourced from aquaculture-produced species, implying that domestic wild-caught and domestic aquaculture production do not meet demand for the types of seafood most American consumer's desire (Rubino (ed.) 2008, NMFS 2020b, Shamshak et al. 2019, Rubino 2022). It is estimated that 70% of seafood in the U.S. is eaten outside the home, in restaurants (Sea Grant 2024a). Although seafood retail sales increased at the beginning of the COVID-19 pandemic, by 2021 and 2022, data indicate that California consumers reverted back to more normal patterns of food service purchases (Fissel 2024 (draft forthcoming)). This and other information imply some U.S. seafood markets, especially aquaculture products in California, target high-end luxury niche markets (Rubino 2022, CDFW 2022, Dealy et al. 2024.

The west coast marine economy is summarized on pp. 41 and 42 of the NOAA Fisheries Economics of the U.S. 2020 Report (NMFS 2023h). General characteristics of California's ocean-based economy are described on page 13 of the Introduction in the Atlas and are (Morris et al. 2021). Summaries of the marine and coastal economies of Santa Barbara County (near to Alternative 2), Ventura County (near to Alternative 2), and Los Angeles County (near to Alternative 3) may be found at https://coast.noaa.gov/snapshots/.

California is the highest-ranked state in the U.S. for the number of income generated and jobs supported by the seafood sector; and ranks third in the nation for retail seafood sales, highest in seafood retail establishments; and the state ranks first in the nation for wholesale seafood sales (NMFS 2023h). According to a 2018 population of 39.8 million (DOF 2018, as cited in CDFW 2019), a conservative estimate of Californian's annual seafood consumption is 617 million pounds (279,850 mt), which is 400 million pounds (74,000 mt) more than the total harvest (2017) from capture fisheries in the state (CDFW 2019). In data analyzed from 2017 to 2022, California's retail seafood sales averaged $967.7M, with 967.7 lbs in sales volume and an average price of $7.02 (Fissel 2024 (draft forthcoming)). The retail sales value of seafood in California was roughly $800 million from 2017-2019 and increased to roughly $1.1 billion in 2020-2022 (Fissel 2024 (draft forthcoming)). Wild harvest species receive slightly higher prices than farmed species in the state (Fissel 2024 (draft forthcoming)). Still, major fishery resources of the state are exported, while Californians import most of the fish they eat (McGinnis 2006). The number of seafood sector jobs with imports from international markets are estimated around 125,000 in California, whereas the number of seafood sector jobs without imports are estimated to be less than 25,000 (NMFS 2023g).

The overall economic impact of aquaculture in California (sales, employment, etc.) has been estimated to be $200 million, with all of the commercial products considered small-volume, high-value niche markets (CDFW 2022). Naylor et al. (2021) estimated California's aquaculture sector generated around $102 million in sales and distribution for the state and $1.55 billion in sales and distribution in the U.S. Aquaculture entitlements (including registrations, lease rents and privilege taxes, and permits) all contribute to the state's revenue, estimated at an average of $200,000 annually (CDFW 2022). More resources for seafood and aquaculture in the state of California are provided by reference:

- a summary of aquaculture's contribution to the California economy is provided on p. 1-8 of the CDFW Draft PEIS for Marine Aquaculture (CDFW 2019);
- a summary of market values for commercial aquaculture production as of 2018 (shellfish and macroalgae only) is summarized on pp. 10 and 11 of the CDFW Status of Commercial Marine Aquaculture report (CDFW 2020a); and
- the ranks of aquaculture within the state, and its contributions to the national economy compared to other agriculture-based commodities are provided in the commodity-ranks Table on p. 14 of the California Agricultural Statistics Review (CDFA 2022).

Stressors

Baseline stressors for markets and regional food systems include variability in the predictability and stability in supply and consumer demands, disruptions to marketing values and practices, and interactions between aquaculture products with wild-caught seafood. Climatic and oceanographic events have also had significant impacts on the economic health of seafood markets.

The interactions of economic demand for seafood products with the conservation of marine resources is an important existing stressor to markets and food systems. Along with all marine resources, the expansion of the aquaculture industry is dependent on the maintenance of clean growing areas, a supportive regulatory environment, aggressive marketing and dependable sources (CDFW 2010). Market and non-market values are defined in Appendix 3, and can be an important analyzer of cost-benefits for economic resources (NOAA 2009a). Market values may relate to seafood supply, employment, investments, and revenue in both the aquaculture and wild-harvest sectors. Non-market values may relate to public concern and regulations that limit the scale of both sectors (Foelich et al. 2017, Clavelle et al. 2019).

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- introduction of new domestic products;
- increase in the supply of domestic products;
- new or increased interactions with wild-caught seafood products (competition or complimentary); and
- new or increased interactions with existing interstate or international trade markets.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

If an AOA were identified, and aquaculture projects were sited in an AOA, it is likely that there would be economic costs and benefits to local and regional markets, directly and indirectly. Economic benefits are considered to be market and non-market values that impact social welfare positively; and economic costs are considered to be monetary payments and/or the availability of resources that yield a net reduction in social welfare (ERG 2021). Contributions of these costs and benefits are qualitative in this DPEIS, since quantifiable measures of change to the demand or sourcing of regional products and supplies cannot be predicted without knowing specific production schemes or targeted product markets. A hypothetical growth in aquaculture production program based on DOC targets for 205 is described on pp. 623 through 627 of Nash (2004). Components of an economic analysis for offshore shellfish operations are summarized on pp. 2 through 5 of Wright (2020). These economic analyses provide examples of what may be incorporated into a site specific NEPA analysis. In addition, important economic concepts that may be applicable to analyze potential impacts of project-specific production include:

- how new products may apply to the existing reliance on imports;
- estimating potential future growth via economic production concepts;
- potential growth margins and interactions with wild-caught fisheries;
- allocative efficiency measures (measures of yield versus conflict trade-offs);
- production externalities (perceived and/or realized adverse effects of a project that may affect investment capital);
- a defined scope of affected economies;
- how competitive, substitute, or complementary market interactions may affect demand, volumes of supply, and prices of products;
- casual interference (a metric to measure the effectiveness of a project to grow the aquaculture industry);
- economic viability of proposed products; and
- contributions to maintaining working waterfronts (Dealy et al. 2024).

The contribution of aquaculture products potentially-grown in an AOA would likely have an overall beneficial impact on regional, State, and U.S. markets. The aquaculture potential for many species have yet to be demonstrated on a commercial basis; but the potential is considered to be very good because there are known markets for fresh and live products (CDFW 2010). According to studies and reports reviewed in Fujita et al. (2023), offshore aquaculture presents opportunity to generate jobs, export earnings, and increase volume of domestically-produced seafood, even though the sector would likely remain small compared to land-based aquaculture systems (CEA 2018, Fujita et al. 2023). The aquaculture sector has shown globally that it does not just increase global seafood supply; it also reduces uncertainty in supply chains by providing a more consistent, high-quality product (Rubino (ed.) 2008). Offshore aquaculture production may provide a substitute for imported seafood products for local, regional, national and international markets; but the extent of those impacts would depend on global and regional markets, prices, volumes of local production and imports, and product quality and availability. Production costs of domestic seafood products are generally larger relative to production costs of seafood produced in other countries that are traded in international markets; while domestic seafood products would have smaller transportation costs and shorter distances to markets (CEA 2018, Dealy et al. 2024). The most up to date market data should be acquired in a site specific NEPA analysis to sufficiently analyze market impacts from cultivated species and targeted products. New demands could also be created with associated marketing strategies.

In Southern California, there is existing stakeholder interest in aquaculture production to supply local and domestic markets. Products that would be competitive in regional and domestic markets include fresh, frozen, and tinned products, especially for products that target the high-end niche markets (Dealy et al. 2024). Many projects have the potential to contribute significantly to State and local economies based on revenue from registrations, leasing and rentals along the coast, taxes, and permits, as well as some regulatory and management mechanisms (Wright 2020, CDFW 2022). The assumed dependency of offshore operations with coastal auxiliary facilities in regionally-based working waterfronts could help support aquaculture management; and it would likely provide a beneficial contribution to the state's economy associated with existing aquaculture and seafood markets and employment systems (discussed more in Section D.iv. (Ports and Working Waterfronts)).

While overall growth in a market may be considered an economic benefit, local or regionally-scaled costs may occur simultaneously. Financial planning needs related to offshore aquaculture investments are summarized on pp. 21 and 22 of the Offshore Aquaculture in the SCB workshop summary (Aquarium of the Pacific 2015), (Aquarium of the Pacific 2015). High operating and living costs in Southern California and comparatively lower costs of conducting comparable aquaculture operations in other countries, including nearby Mexico, may also make it difficult to achieve economic viability (Dealy et al. 2024). Offshore projects in the U.S. are estimated to be 15% to 30% higher in cost than nearshore production, barring exponential increases in scale (CEA 2018). Operations sited in an AOA would likely need to focus on high-value products targeted at upscale product markets in order to generate revenues to cover operating costs and provide a positive return on investment (Dealy et al. 2024). Disproportionate adverse impacts on existing businesses and employees associated with aquaculture and with fisheries may occur related to a lack of opportunity to access the potential economic benefits of offshore aquaculture (e.g. start up costs), and market displacement over time. Without thoughtful planning for disproportionate impacts to certain communities, offshore aquaculture could adversely impact the current aquaculture and fisheries industries, which are made up of a small number of small businesses in California (Fujita et al. 2023, CDFW 2020a). The high capital investment that would likely be required for start-up including siting surveys, construction, certifications and product-rating schemes, may mean that large, established businesses (domestic or international) would have an advantage over local or regional stakeholders to benefit from the AOA planning process. While collaborative or vertical business pathways may occur to achieve economic viability, vertically-integrated pathways may be favored in the offshore aquaculture industry due to cost considerations. Financial impacts on applicants could also accumulate over time, as the first projects sited in an AOA would set prerequisite baseline conditions for siting and monitoring for any following permit applications.

An increase in aquaculture production may change revenue, value, and profitability of seafood products, creating new interactions between wild harvest, existing aquaculture, and potentially new aquaculture products. National price trends analyzed from 1990 through 2005 showed the cost of aquacultured products decreasing steadily, which indicates a beneficial impact for market development and increased market share (Rubino (ed.) 2008). When the price difference between wild and farmed seafood products increases, consumers tend to purchase more farmed products in California (Fissel 2024 (draft forthcoming)). If the identification of an AOA facilitates the growth of the aquaculture industry, then this potential impact would increase affordability and therefore accessibility to seafood, and may expand products beyond the existing high-end niche markets. This may increase competition with wild-harvested seafood products.

The difference in the structure of costs between aquaculture and wild fisheries has important implications for how the two sectors may experience price interactions. Wild versus farmed products have unique attributes for biological constraints, competing goods, and sales techniques (Asche and Tveteras 2005, Valderrama and Anderson 2010). In the traditional fisheries, the primary costs are labor, fuel and fleet maintenance; and in the aquaculture sector, the primary costs are feed and broodstock (Rubino (ed.) 2008). Aquaculture may have more opportunities to reduce costs in production and management than wild-caught fisheries. Aquaculture products may also supply seafood that is more consistent than season-dependent wild fisheries. This consistency in the supply of a species may be preferable to processors and distributors, who can make production and marketing decisions throughout the year instead of over a concentrated period of time (Rubino (ed.) 2008). However, California market data from 2017 through 2022 show that prices for wild harvested seafood products were more stable compared to aquaculture products, suggesting that farmed products may be more sensitive to inflation pressure and price volatility

(Fissel 2024 (draft forthcoming)). Still, regional, wild-harvested species availability is often inconsistent and limited by natural abundance and fishing regulation (CDFW 2010, 2019). Price and consistent supply may be key trade-off factors when considering market interactions in a site specific NEPA analysis.

In 2020, the COVID-19 pandemic caused large-scale disruptions to the U.S. economy and is an important indicator of how markets and food systems could change suddenly. U.S. seafood producers were hit by the relationship between imports and export supply: international trade and processing facilities shut down for several months, while wild-caught seafood products normally exported could not get out of the country (pers. comm. NMFS 2021a). Seafood exports declined 23%, compared to baseline data through 2019 (NMFS 2023h). Foodservice seafood sales (e.g. restaurants) fell an estimated 40% in the first quarter of 2020, and remained down about 21% through most of the year (NMFS 2023h). Mollusks (e.g. scallops, oysters, mussels) incurred the highest losses (down 60%) (NMFS 2023h). In contrast, seafood retail sales (e.g. supermarkets) increased significantly in 2020 across all seafood categories: frozen, up 36%; fresh, up 25%; and grocery (canned, pouches, etc.), up 21% (NMFS 2023g). Wild-caught fishers and shellfish growers changed their operation practices, delaying seeding or harvesting based on the changes in buyers and demand (Froehlich et al. 2020). Processors also had to pivot to the product volumes, reliability, cut and sizing, and packaging demanded by retailers instead of restaurants (pers. comm. NMFS 2021a). Smaller, community-supported fisheries focused on selling seafood direct to local consumers, while larger businesses (e.g. farmed finfish imports) shifted from restaurant to retail sales (Froehlich et al. 2020). Operational, processing, and marketing shifts during COVID may provide examples of some of the nontraditional or niche markets that may grow fast, sustain multiple affordable options, and represent an important way to sustain US producers, especially smaller scale producers (pers. comm. NMFS 2021a). Other financial restructuring examples may be provided from the existing shellfish industry after the 1990s recession, shortages of hatchery-produced seed, or closures due to sanitary degradation, HABs, and oil spills (CDFW 2010).

A more competitive U.S. aquaculture industry may support the U.S. economy by combating potential sources of illegal, unreported, and unregulated fishing (IUU) fishing and supporting certification programs in sustainable environmental and social business practices. The U.S. reliance on imports to meet the demand for seafood relates to a global concern for IUU fishing as well as humanitarian impacts associated with some imports (Diana 2009, NOAA 2024d). Aquaculture product market expansion is not expected to come from new species but from product differentiation of existing species, which would provide consumers with a new opportunity to source products with reliable standards. In increasingly crowded and competitive markets, consumers demand a need to identify the values, context, culture and other factors that shape what activities are associated with business practices (Murray and D’Anna 2015). Imported sources are harder to trace and increase the likelihood for seafood products to be on the market that lack the same level of environmental and social standards as those produced in the U.S. (NOAA 2024d). Monitoring or influencing changes in international regulations can be more difficult compared to making improvements in U.S. seafood reliability. Certification issues broken down per common species groups are presented in Table 1 on p. 31 of Diana (2009). Certification programs that differentiate products according to set standards that relate back to environmental, health, or other relevant production methods are reviewed on pp. 239 and 240 of Rubino (ed.) 2008.

The AOA planning process supports and strengthens the U.S. priorities to combat IUU and recognizing stewardship of marine resources. Assuming the identification of an AOA would increase domestic production, there would likely be a net-benefit to create jobs and improve Americans’ responsibility for existing seafood consumption decisions (Diana 2009, Froehlich et al. 2020, Helvey et al. 2017, and Rubino 2022). Creating domestic jobs in coastal and agricultural communities and growing seafood under U.S. laws and regulations would support management of an industry designed to ensure food safety, protection of the environment, and worker health and safety (Helvey et al. 2017, Knapp and Rubino 2016, Love et al. 2021a, and Smith et al. 2010).

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

The geographic space and associated resources needed to create other types of protein sources may also be considered cost components under baseline conditions. Saltwater aquaculture development programs that produce one million mt of seafood for human consumption by 2025 are relatively small in size, compared to freshwater, land-based systems, and other types of agriculture (Nash 2004, Diana 2009). It is estimated that less than 500 km^2 (less than 0.01% of the U.S. EEZ) would be enough to produce up to 600,000 mt or more of farmed seafood per year (Nash 2004).

It is evident that aquaculture would continue to grow globally. Based on over 400 aquaculture studies globally, three possible drivers that indicate marine aquaculture may be the leading solution to close the gap between seafood consumption demand and production are suggested in Fong et al. (2023):

- marine taxa are often cash crops of high value with substantial infrastructure investment, which may motivate and facilitate higher yield;
- the feed for marine farmed fishes may rely more on external inputs to provide adequate nutrition compared to fresh-water aquaculture (e.g., salmon vs. carp); and
- macroalgae may outperform freshwater algae (e.g. spirulina), due to a taxonomic focus on large brown seaweeds and rapidly growing reds (e.g. *Laminaria* spp.).

Competition in food markets may exist with or without domestic aquaculture, and current trends show that the U.S. cannot meet consumer seafood demand through wild caught fishing activities alone. Trends that may continue without the growth of domestic aquaculture include reduced market prices for U.S. wild caught and farmed species based on a continued increase in imports of seafood species (Knapp et al. 2007, Anderson and Shamshak 2008). Other forms of protein (such as chicken and beef, or from plant-based sources) would also likely continue to show significant market competition. Modeled data through 2000 for U.S. per-capita consumption of animal protein (grouped by red meat, poultry, and seafood) is portrayed in Figure 11.1, and summarized on p. 232 of Rubino (ed.) (2008).

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

If one or more AOAs were identified in the Alternative, it is likely that at least some, if not the majority, of the economic opportunities would be concentrated in the nearby shore side County of Santa Barbara and County of Ventura, and associated communities of those counties. Summaries of the marine and coastal economies in Santa Barbara County and Ventura County from NOAA's Office of Coastal Management may be found at https://coast.noaa.gov/snapshots/. As of census data through 2021, ocean-based economic activities account for an estimated 4.2% of the total economy (GDP contribution) in Santa Barbara County, employing about 7.5% of the county's workforce, housing 858 businesses and establishments, and about $645.9M in wages (NOAA 2021). Activities related to living resources (commercial fisheries, processors, seafood markets, hatcheries, and aquaculture) account for 0.6% of the county's total ocean economy, employing an estimated 93 people (NOAA 2021). Ocean-based economic activities account for an estimated 2.8% of the total economy (GDP contribution) in Ventura County, employing about 5.2% of the county's workforce, housing 1,025 businesses and establishments, and about $577.4M in wages NOAA 2021). Activities related to living resources (commercial fisheries, processors, seafood markets, hatcheries, and aquaculture) account for 0.9% of the county's total ocean economy, employing an estimated 118 people (NOAA 2021). It is unclear how the identification of an AOA would impact these economic trends; but the information is provided as baseline considerations for any site specific NEPA analysis.

a) Shellfish and Macroalgae

Seaweed markets benefit from the many potential applications of seaweed species, including food, feedstock, fertilizer, medicines, cosmetics, biofuel and raw materials for industrial purposes (Moore and Wieting 1999, Rajkumar et al. 2014, FAO 2018, Sultana et al. 2023, Kite-Powell et al. 2022, and World Bank 2023). The seaweed aquaculture tripled in global output between 2000 and 2019, and makes up approximately half of the global marine aquaculture production by volume (World Bank 2023, Rhodes et al. 2023a). The most valuable types of macroalgae for commercial aquaculture are thought to be kelps and a few species of red algae (Sea Grant 2016). All kelp species also have the same life cycles, so it would enable aquaculture programs to use the same basic cultivation techniques, which may reduce costs (Sea Grant 2016). Marketing and trade information including trends in trade, market outlooks, and certifications are provided in Section 3 on pp. 50 through 64 of FAO (2018). The global market was estimated at 8M tons of production as of 2003, increasing to 35.8M tons with a world market of US$ 11.8 billion by 2022 (Rajkumar et al. 2014, Sultana et al. 2023). The industry is predicted to grow at a compound annual growth rate of 7% through 2031 reaching a total estimated value of $31.1B (World Bank 2023). Fertilizer and agricultural applications are the lead seaweed market globally; but uses in fuel, carbon sequestration, and human nutrition are of high interest in North American markets (USACE 2021, Kite-Powell et al. 2022, and World Bank 2023). The most recent data for total seaweed production in California is summarized on pages 10 and 11 of CDFW (2020a). It is unclear how the identification of an AOA would impact these economic trends; but the information is provided as baseline considerations for any site specific NEPA analysis.

Prominent companies like Cargill, CP Kelco, Dow DuPont, and Seasol International dominate existing global seaweed product portfolios, technological advancements, and strategic mergers or acquisitions (World Bank 2023). CP Kelco, the world's largest commercial harvester of kelp, was originally founded in San Diego, but ended up leaving the region due to high costs (Dealy et al. 2024). Giant kelp is of significant commercial value in central and southern California, where historically 100,000 tons have been harvested annually, and a historic peak value estimated at $40M (NCCOS 2005). Seaweed markets also exist from land-based tanks in California, for human consumption and associated with growing abalone (USACE 2021, Dealy et al. 2024).

Growing seaweed in the offshore environment could cut water inputs to aquaculture systems completely, reduce operating costs, and may expand the product market. The economic cost of land-based seaweed tanks are thought to be higher than marine operations due to water inputs (Dealy et al. 2024). Further, macroalgae does not require any fertilizer or chemical inputs to saltwater systems, and the high sugar content and low lignin makes it a more efficient source than terrestrial plants both for potential fuel and food uses (Rajkumar et al. 2014). The growth in macroalgae markets could have a beneficial impact on energy and water resource use in the region, while potentially adding ecological value to the surrounding marine environment.

Production costs should be considered in site specific NEPA analyses to accurately estimate economic impacts. Facilities would likely generate economic activity during siting, construction, and decommissioning. A recent 86 acre (35 ha) pilot project for kelp production in the SCB stated demonstrating economic feasibility, coastal economic development, and advancing aquaculture practices in its purpose and need (USACE 2021). At facility scales of 1,000 ha or more, a production model by Kite-Powell et al. (2022) suggests that production costs in waters up to 200 km (108 nm) from associated shoreside facilities would range between $200 and $300 per dry tonne; but costs below $100 per dry tonne may be achievable in some settings. Input values for the financial model are provided in Table 2 on p. 440 of Kite-Powell et al. (2022). Components to a similar model of seaweed production costs are provided in Table 2 on p. 440 of Kite-Powell et al. (2022). The effect of distance from shore and scale of production are shown in Figure 5 on p. 441 and Figure 7 on p. 442 of Kite-Powell et al. (2022). Spatial data and sector trade-off analyses by Lester et al. (2018b) in the Santa Barbara Channel showed a potential annuity value (U.S. dollars per year) of $0 to $200,000 for macroalgae offshore aquaculture. Additional considerations to refine an impacts analysis in a site specific NEPA impacts analysis include:

- number of potential harvests in one season;
- detailed biological growth models linked to nutrient dynamics and environmental conditions at specific facility locations;
- optimized planting and harvest schedules based on seasonal variations in growth;
- potential treatment of crop losses due to storms, disease, and grazing; and
- the incorporation of data on yields that may be possible with selective breeding of seaweeds for optimal performance in specific locations/conditions (Kite-Powell et al. 2022).

Shellfish projects in an AOA may target any species, but mollusks are thought to be the most likely group, based on existing stakeholder interest and product viability in the offshore environment. The demand for oyster products nationally far exceeds California's production level (CDFW 2010). The oyster market, in particular, exhibits the potential for product differentiation. Environmental factors such as salinity, pH, SST, and ambient nutrients from the water column all can affect the taste and texture of the final product, which producers target for creative marketing (Chuang 2020). Product differentiation is likely a necessary strategy for economic success in domestic aquaculture product growth on existing markets. Abalone represents an example of a high-valued shellfish that was once fished in the wild, but is now only available from aquaculture producers in the region (NCCOS 2005, Purcell et al. 2023 (draft)). Abalone represents a positive example of how aquaculture species may help take pressure off of wild populations while still meeting market demands for seafood consumption.

An overview of the shellfish industry in California is provided on pp. 6 and 7 of Wright (2020). The most recent data available for total shellfish production in California is summarized on pages 10 and 11 of CDFW (2020a). Shellfish aquaculture in the SCB is applied mostly to regional and interstate luxury foods markets and restaurants, as well as in local markets; it does not compete with large commodity markets (Purcell et al. 2023 (draft), Dealy et al. 2024, and Sea Grant 2024a). This existing trend could potentially change if the AOA planning process facilitated the growth of the industry and increased production. If this change occurred, it may substitute some of the existing shellfish imports, the majority of which come through the Port of Los Angeles or other states along the Atlantic and Pacific Northwest (CDFW 2010, Dealy et al. 2024). With increased production from facilities in an AOA, there may also be new competition with existing local producers. Existing niche producers use their own distributors direct to local markets and restaurants (Dealy et al. 2024). The cost of distributing to large commodity markets would be more expensive. However, increasing supply may drive prices down. This could benefit overall affordability and accessibility, but may put existing local businesses at risk. Employee sectors that may benefit from this new type of market in the region could change from operators to distributors.

The following information provides the best proxy for what could occur in an AOA in the SCB if shellfish were cultivated. Spatial data and sector trade-off analyses by Lester et al. (2018b) in the Santa Barbara Channel showed a potential annuity value (U.S. dollars per year) of $8.5 to $9.5 million for shellfish offshore aquaculture. According to the economic analysis in Wright (2020) for 2,000 acres (809 ha) shellfish operation in the SCB, it was thought the project would generate $18.4M of economic output and support 53 jobs with $2.5M of annual wages. The business proformas and direct fiscal impacts of the proposed 2,000 acre shellfish operation are provided in Exhibits A1 and A2, respectively, in the Appendix of Wright (2020). The project was thought to generate an overall beneficial impact to the Ventura harbor District, as well as surrounding cities through direct output, taxes, and consumer purchases (see Chapter 3, Section iv. (Ports and Working Waterfronts). According to another growth program described in Nash (2004), market priorities in the U.S. would best aim to rejuvenate the oyster industry to a historic high of 150,000 mt, expand the mussel industry to 80,000 mt, clams to 80,000 mt, and abalone to 5,000 mt. The estimated cost of molluskan aquaculture was $25 to $30 per square meter for rafts and $400 to $450 per km of longline systems (Nash 2004). This estimate of capital investment would now be much higher, accounting for increased costs and inflation since 2004. It is unclear how the identification of an AOA would affect these economic trends, but the information is provided to help inform site specific NEPA analyses.

b) All Types of Commercial Aquaculture

A global literature review of market competition between farmed and wild fish was conducted by FAO (2016). Overall, interactions may occur due to sharing common ecosystems, and seafood pricing based on new supply (FAO 2016). Market interactions also depend on consumer demand (Asche et al. 2001). Globally, positive interactions between wild fisheries and aquaculture may occur if new aquacultured products create additional demand for both farmed and wild species, which has been observed in salmon and catfish production in the U.S. Another potential beneficial impact on U.S. supply chains for any marine finfish would be to ensure they are free from forced labor and other illegal trade practices, sometimes associated with fisheries in other countries (NOAA 2024d). If products were exported, it would support and strengthen the sustainable and legal trade of fish products.

Markets likely to be targeted from finfish aquaculture in an AOA would be for human consumption. While U.S. commercial finfish aquaculture may have the most opportunity and the greatest domestic impact by replacing imports, it is likely that the impact to high-commodity international markets from an AOA would be low. This is because the scale at which domestic aquaculture production may occur in the foreseeable future is not predicted to be at a large enough scale to affect international prices (Asche et al. 2001, Asche and Tveteras 2005, Rubino 2022, Young 2023, and Dealy et al. 2024). As of 2014, globally-traded fish products account for 37% by volume of the world production traded internationally (FAO 2014). According to 2015 data, finfish dominate the top ten list of preferred seafood in the U.S. (Nelson et al. 2019). It is unclear how the identification of an AOA would affect these economic trends, but the information is provided to help inform any site specific NEPA analysis.

Finfish aquaculture globally is associated with the potential to increase pressure on forage fisheries. The demand for forage species in feed products for aquaculture is predicted to have a negligible market share, compared to livestock feed and other existing markets for fish oil products (despite any increase in fishing pressure) (Asche and Tveteras 2005, Clavelle et al. 2019, and Cottrell et al. 2020). Existing market trends for forage species are described on pp. 2 and 3 of OIMB (2011). Global forage fish landings for meal and oil have remained around 20 to 30 MMT since the mid-1980s, and the proportion forage fish used in aquaculture feeds is declining, despite steady growth in aquaculture production (Hannesson 2003, FAO 2016, and Clavelle et al. 2019). Despite minimal predicted market impacts in fish feed for aquaculture, continued pressure trends could drive prices up, which may have an indirect beneficial impact to the fishery (discussed in Section D.i. (Commercial Fisheries), as well as an adverse impact to the species if not sustainably managed (discussed under Section C.ii. (Wild Fish Stocks). Increased demand for forage fish may also increase competition with the commercial and recreational fishery sectors that rely on these fish as bait, either live or dead.

The market most likely to be targeted by finfish aquaculture in Southern California is also thought to be high-value fish (Fujita et al. 2023). Such markets would support only a small number of facilities, or would require substantial effort such as branding and building new consumer relationships to build new or wider markets (Asche et al. 2001, Engle et al. 2022). A 2022 study examined 20 marine finfish species as potential candidates for commercialization in the U.S., by analyzing commercial landings data from 1950 through 2019; 17 of the 20 species exhibited declines, potentially offering opportunities for farmed product to capture market share by filling the increasing gaps in supply, along with consistency of volume, size, delivery frequency, and quality (Engle et al. 2022). In California, the fishing industry has fluctuated dramatically in recent years, with market values during low-yield years indicating potentially high demand for targeted species (CDFW 2019). Higher prices for wild fish would tend to occur when supplies are low, so depending on what species may be grown in an AOA, supplies could level out prices in existing regional and domestic markets.

If the identification of an AOA facilitates the growth of marine finfish aquaculture, then there may be more market overlap observed in the region and state. Currently, impacts on the domestic commercial fishery do not come from domestic aquaculture production, but from imported products (Young 2023). Therefore, changes in revenue, value, and profitability of wild-caught fisheries may occur domestically if AOA products replace some of the current import market share in the region and in the U.S. Examples from the European Union, Japan, and within the U.S. show that domestic prices for wild species of fish are impacted by the entry of farmed species to a country's market (Valderrama and Anderson 2010, Nelson et al. 2019). Asche et al. (2001) found that in Norwegian markets, farmed fish did not interact with other fish species produced or other meat products; but there was competition between farmed and wild fish of the same species. If farmed fish in an AOA were assumed to be native species only, this market interaction may be likely to occur.

Aquaculture market share may have an adverse impact on the market share of wild-caught fisheries. As a result, supplies from traditional fisheries would either be expected to remain the same or decline over time (Rubino (ed.) 2008). This potential impact is considered by many stakeholders as high risk, since domestic commercial fisheries already face challenges due to population changes, regulations, climate change, and competition for space-use. Any loss of locally sourced, wild-capture seafood may have an adverse impact on the local seafood economies in those areas (PFMC 2022a). Site specific NEPA analyses based on specific project designs should compare the economic outcomes for business owners and employees between the two sectors, in order to properly analyze and monitor potential disproportionate adverse impacts on existing aquaculture producers and wild fisheries business and employees. Processors and other working waterfront businesses may be associated with both aquaculture and wild-caught businesses.

Production bottlenecks that have inhibited growth in marine fish aquaculture in existing markets include feed production and hatchery methods (Engle et al. 2022). The estimated cost of 12 submersible net-pens as of 2004 was estimated at $1.3M to install (Nash 2004). This estimate of capital investment would now be much higher, accounting for increased costs and inflation since 2004. Spatial data and sector trade-off analyses by Lester et al. (2018b) in the Santa Barbara Channel showed a potential annuity value (U.S. dollars per year) of $0 to $10,000 per development site for finfish offshore aquaculture. While the dollar amounts would need to be updated to account for costs and inflation, these estimates provide examples of what may occur if finfish were pursued in an AOA.

Inputs to a bioeconomic model include the costs associated with raising fish to release size, harvest levels, life history parameters, supply schedules, and price trends; outputs may include the costs per fish, value to each market or fishery, and a cost-benefit ratio to evaluate the efficacy (Asche et al. 2001, CDFG 2010). The start-up costs to operate an offshore aquaculture facility may not favor locally-owned, independent businesses in the way much of the current businesses exist in the SCB. Local cost and short term opportunity versus market growth and more long term effects may need to be analyzed as trade-offs for a sufficient project review. Specific market impacts were not modeled in preparation of this DPEIS, without specific species or production levels. However, the following resources describe potential market interactions between wild fisheries and aquaculture finfish:

- econometric models and time series analyses of market interactions between wild fisheries and aquaculture is provided on pp. 193 through 195 of Rubino (ed.) (2008),
- the seasonality of wild-caught fisheries versus year-round production and trade for aquaculture products is summarized on p. 238 of Rubino (ed.) (2008);
- Section 3.2 on pp. 376 through 378 of Clavelle et al. (2019) highlights reduced prices due to increased supply, resilience to market volatility, and potential changes to consumer preferences and marketing;
- methods to test market interactions and integration are described on p. 8 of Asche et al. (2001); and

- predicted market interactions between farmed with traditional goods, and with wild-caught fish, are described on pp. 141 through 146 of Asche and Tveteras (2005).

In conclusion, the overall impact to domestic and international markets would likely be beneficial; but it is unclear how substantial the economic impact may be. The overall impact to consumers at any spatial scale would be beneficial if overall prices of seafood decreased due to higher supply with steady or increasing demand. However, these benefits may come at a cost to local markets, as well as existing aquaculture and fisheries businesses. The potential cost to local markets and businesses may have a adverse impact on regional seafood economies and community wellbeing. The potential economic opportunity of offshore aquaculture projects would require high initial costs for any applicant/operator.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

If one or more AOAs were identified in the Alternative, it is likely that at least some, if not the majority, of the economic opportunities would be concentrated in the nearby shoreside County of Los Angeles and associated communities. Summaries of the marine and coastal economies in Los Angeles County from NOAA's Office of Coastal Management may be found at https://coast.noaa.gov/snapshots/. As of census data through 2021, ocean-based economic activities account for an estimated 1.9% of the total economy (GDP contribution) in the county, employing about 2.5% of the county's workforce, housing 3,896 businesses and establishments, and about $8.6B in wages (NOAA 2021). Activities related to living resources (commercial fisheries, processors, seafood markets, hatcheries, and aquaculture) account for 3.2% of the county's total ocean economy, employing an estimated 4,150 people (NOAA 2021).

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section. The proxy information provided in sub-alternative (a) of Alternative 2 is also the best available information for Alternative 3, with the exception of spatial data and sector trade-off analyses by Lester et al. (2018b). Spatial data and sector trade-off analyses by Lester et al. (2018b) in Santa Monica Bay showed a potential annuity value (U.S. dollars per year) of $8.0 to $9.0 million per developable site for shellfish (mussel) aquaculture, and a potential annuity value of $0 to $200,000 per developable site for macroalgae offshore aquaculture. Analyzed sites are near to Alternative 3 in the offshore space of Santa Monica Bay.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section. The proxy information provided in sub-alternative (a) of Alternative 2 is also the best available information for Alternative 3, with the exception of spatial data and sector trade-off analyses by Lester et al. (2018b). Spatial data and sector trade-off analyses by Lester et al. (2018b) in Santa Monica Bay showed a potential annuity value (U.S. dollars per year) of $0 to $400,000 for finfish offshore aquaculture in analyzed sites near to Alternative 3.

Alternative 4: Combined Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. AOAs in both areas may distribute opportunities to more communities, which could reduce conflicts. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.

If multiple areas were identified as AOAs under Alternative 4, the potential local and regional market impacts may occur at a broader geographic scale. Overall, coordinated growth that considers the relative value of each site would be beneficial to all types of aquaculture (Lester et al. 2018b). Identifying AOAs throughout the SCB may help inform and encourage this optimal way to grow offshore aquaculture. Any impacts to domestic and international markets are thought to be minimal under any Alternative. If AOAs were sited in more than one geographic location, aquaculture projects sited in those AOAs may be more likely to land product or work with other auxiliary coastal facilities throughout the SCB, rather than the activity concentrated in one area. Any potential adverse impacts to local or regional markets may not be as severe if more businesses across multiple communities and counties were utilized to support a growing aquaculture sector. Potential economic opportunities may be greater, and more accessible for more people if the geographic scale of impacts were broader.

Siting aquaculture in multiple AOA options spread across Alternative areas could also provide a scenario where fishing grounds could be strategically avoided depending on the season and distribution of fish biomass from year to year. The scale of aquaculture practices and adjacent capture fisheries are important modifiers for nearly all ecological interactions between the fisheries and aquaculture industries to influence the trade-off of beneficial or adverse impacts (Lester et al. 2018b, Clavelle et al. 2019). Scaling operations across multiple geographic areas may help wild-harvest seafood products maintain competitive supply and pricing with aquaculture products in seafood markets.

Adverse ecological impacts of facilities sited close to one another (e.g. compounding effects of noise, light, waste, FADs) may affect commercial and recreational fisheries and, indirectly, seafood markets. These effects could be mitigated by siting facilities across a broader geographic context (Gentry et al. 2017, Fujita et al. 2023). Identifying AOAs in both geographic areas could speak to this effect, with the assumption that projects would be encouraged to use spatial distribution as impact mitigation and management. In this case, wild fish populations may maintain distribution patterns more similar to baseline conditions with facilities spaced farther apart across the SCB; spacing facilities further apart from one another and away from other concentrations of wild populations would reduce the transmission rates of disease. Another example associated with ecological impacts is if water quality concerns arise to limit operations in one area, operations may be maintained elsewhere. This may help maintain economic opportunities associated with aquaculture operations and associated working waterfronts

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

iv. Ports and Working Waterfronts

Affected Environment

The Ports and Waterways Safety Act (PWSA) involves increased supervision of vessel and port operations to reduce the possibility of vessel or cargo loss, or damage to life, property or the marine environment and ensure that the handling of dangerous articles and substances on the structures in, on, or immediately adjacent to the navigable waters of the U.S. is conducted in accordance with established standards and requirements (33 U.S.C. § 1221). The USCG is the authority to establish vessel traffic for ports, harbors, and other waters subject to congested vessel traffic. Increased demand on port and harbor district resources, including vessel/product enforcement could occur if the identification of an AOA leads to the growth of offshore aquaculture in the region, and the growth of product moving through ports. More information on vessel traffic and safety is included in Chapter 3, Section D.vi. (Transportation and Navigation).

A port complex is composed of one or more port areas that are geographically linked, or because they are dependent on a common transport system (CDFW 2019). U.S. seaports nationwide are estimated to employ 41,000 workers, move $1.8 trillion of cargo annually, and directly and indirectly support more than 30 million jobs across sectors (NOAA 2022a). As of 2017, foreign trade through U.S. ports was valued at $1.6 trillion (NOAA 2024c). Many of California's centers of commerce are located on the coast. California ranks second in the nation for the number of employers in deep sea freight transportation; the state ranks third in the nation for the amount of employment payroll (NMFS 2023h). The state also ranks in the top three for marinas, cargo handling, and ship and boat building (NMFS 2023h). More details on the California marine economy are provided on p. 50 of the NOAA Fisheries Economics of the U.S. 2020 Report. The SCB includes an area of approximately 78,000 km^2 with a shoreline distance of over 300 km (162 nm) (Dailey et al. 1993).

Port groups and names throughout California are provided in Table 9 on p. 29 of Leonard and Watson (2011). In the SCB, there are two major ports (Los Angeles and Long Beach) and two smaller ports (Hueneme and San Diego) in the SCB (CDFW 2019). The ports of Long Beach and Los Angeles form the largest port complex in the nation, managing approximately a quarter of all container and break-bulk cargo traffic in the U.S. (NOAA 2013). The Ports of Long Beach and Los Angeles also represent two of three ports that account for over three-fourths of the fish and shellfish that are received at or shipped from the west coast (Dealy et al. 2024). The main ports in Southern California for commercial and recreational fisheries are San Pedro, Terminal Island, Port Hueneme, and Ventura (PFMC 2013). Data analyzed from 1981 through 2021 show a high geographic concentration of the CPS fishery in the port of Santa Barbara and Los Angeles (Figure T.1 on p. S-94 in Appendix T of NOAA's 2022-2023 CCIEA Report (Harvey et al. 2023). In addition to ports, coastal counties support harbor districts, public and private marinas, yacht clubs, fuel docks, boat launches, and other boating-related facilities.

Basic maritime economic facts for each shore side county considered in this DPEIS are presented in Table 3.21 on p. 192 of the Results section of the Atlas (Morris et al. 2021). The WCR is ranked second out of eight coastal regions for marine employment. The average wage of marine economy employees in the WCR is $48,831; with marine construction as the highest average wage per employee at $113,449 (NMFS 2023i, NOAA OCM 2024). Trends in businesses, employees, and average wages are all increasing in the region's marine economy. Harbors also provide hoists, docks, boat slips and other amenities that are critical for offloading harvest and storing vessels or products. Marine supply, electronics, and other businesses are essential for keeping vessels operating safely and effectively. Ports in the SCB have shown substantial investments into more seafood processing and aquaculture facilities in recent years.

A viable seafood industry requires not only healthy marine resources and habitat, but also people and businesses to support fisheries and other associated activities that support the economy. A fishing community depends on the businesses and employees directly and indirectly associated with offshore operations to thrive and to get product to consumers. Fishing communities include economic and social groups whose members rely heavily on fishing activities and fishing culture. They are dependent on one another for their livelihood and well-being. As communities, they are connected to each other socially and economically, both locally and across regions.

Stressors

Any future aquaculture project sited within an AOA would be required to consider shore side components to the project and its impacts, which may vary depending on the site, type of aquaculture, species, product, and targeted markets. A brief, high level description of potential auxiliary equipment and operations that may be considered for offshore aquaculture are described in Sections 8 and 9 of Fredriksson and Beck-Stimpert (2019). Potential market overlap between wild-harvested and aquaculture products is included in Chapter 3, Section D.iii. (Markets and Regional Food Systems).

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- increased vessel traffic in and out of coastal areas;
- increased vessel demand in and out of ports, harbors, and storage facilities;
- harvested product moving through coastal facilities; and
- the need for shore side industrial-use infrastructure (e.g. processing, storage).

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact. Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. For the purposes of this DPEIS, all shore side impacts are considered indirect of the potential identification of an AOA in Federal waters. However, any future aquaculture project sited within an identified AOA could be required to consider shore side components to the project and its impacts as part of permitting decisions.

The potential growth of offshore aquaculture within an identified AOA would likely generate economic activity during construction, operations, and decommissioning of facilities. Growing the aquaculture industry in Federal jurisdictional waters would likely contribute to the State and regional economy, assuming products were landed, processed, or sold in coastal facilities in California. The Fishery Economic Assessment Model (FEAM) is a production-oriented input-output model to estimate the contribution of West Coast commercial fishing to the total income of the coastal communities of California (Seung and Waters 2005). This may be useful to analyze aquaculture's contribution, as well as to analyze potential competition among aquaculture and fishery sectors within working waterfronts. In the model, revenues at each stage of the production process are converted into (1) direct income (harvesting sector of the industry); (2) indirect income (regional interest across all industries in response to landings and purchases of a particular species); (3) induced income (expenditures from new household income within the region) (PFMC 2013). An example of the model analysis for California, applied to commercial fishing, is shown in Figure 3.4.24 of PFMC (2013).

Tax revenue may increase from increased production and exports. California budget metrics as of July 2021 indicate that the overall aquaculture program in the state (which includes both marine and over-land regulatory management) is operating at 43% of mission level and a staff capacity near 22% of mission level (CDFW 2022). These numbers may indicate room for growth and potential economic benefits if offshore aquaculture in Federal waters contributed to existing aquaculture-associated facilities and employment systems shore side in California. Many projects have the potential to contribute significantly to State and local economies based on revenue from registrations, leasing and rentals along the coast, taxes, and permits, as well as some regulatory and management mechanisms (CDFW 2022). The way taxes may be factored into an economic analysis on vessel-related industries is summarized in Section 3.2.2 of the NMFS Community Profiles for West Coast and North Pacific Fisheries (Norman et al. 2007). An example of how tax revenue was estimated for an offshore shellfish operation in the SCB is provided in Wright (2020).

The National and Coastal State Input/Output Model can also express economic effects (for sales, income or employment) in the seafood sector directly affected by an activity under consideration. The model has not been used historically to address activities associated with fish aquaculture operations (Kirkley 2009);

however, the methods may be used to address the overlap of fishery and aquaculture sectors in a working waterfront. Primary inputs to the model are harvested and landed products within the state and the foreign imports of seafood into the state (PFMC 2013). Differences between landings values and landings volumes are defined for species that are either low-value/high-volume, or high-value/low-volume. Product flow within the model for landed product to processors, purchases, consumers, and exports are described in Section 4.4 of Leonard and Watson (2011). Once the type of aquaculture, target species, and production volumes were defined in a project design, a site specific NEPA analysis may use the model to provide the following outputs for economic analysis in a working waterfront:

- employment impacts estimate total full-time and part-time or seasonal jobs produced;
    - income impacts that consist of wages and salaries and include self-employment income to business owners;
    - sales impacts that estimate the total sales revenues made by businesses within each sector category; and
    - Value added impact is an estimate of sales revenues minus the cost of the goods and services needed for production. It is the estimate of the industry or industry sector's overall contribution to the U.S. GDP (PFMC 2013).

Employment impacts among all aquaculture-dependent industries, such as aquaculture support industries, processing, markets, restaurants that potentially specialize in a particular aquaculture product, are expected to be greater when compared with the number of new jobs within the facility itself (NMFS 2021a). Economic participants that benefit from the growth of aquaculture may include growers, consumers, investors, businesses in technology, services, supply and transport, as well as exports (Wright 2020, Rubino 2022, and Sea Grant 2024a). An example of how an aquaculture project may support jobs directly associated with the project as well as "upstream" or "downstream" related jobs through product flow is provided in Exhibit 5 on p. 5 and exhibit 10 on p. 16 of Wright (2020). The seafood supply chain could benefit from having a predictable, increased supply of products which would help maintain these new jobs (Rubino (ed.) 2008). There may also be new

Aquaculture could be a new pathway for sustainable seafood to reach consumers and economic opportunity to coastal communities. Demographics and existing economic patterns in fishing and related waterfront activities may act as indicators for the potential level of impacts in employment or participation in economic benefits from an AOA. For example, workforce readiness (including existing local knowledge, need for skilled labor, safety training, or education qualifications) could indicate if new job opportunities would be supported by adjacent communities, or if employment opportunities would draw in new workforce populations outside the region or even internationally. Demographic factors that could be used to analyze workforce readiness are summarized in the introductory table in NCCOS (2022). Additional social dimensions identified by the UN that can provide context-specific social variables related to aquaculture are summarized in Table 2 on p. 4 of Krause et al. (2020). These could be analyzed for potential waterfront communities once areas to land product were determined.

The term "social carrying capacity" as defined by Aguilar-Manjarrez et al. (2017), considers aquaculture and fisheries interactions in a way that development of each sector occurs in such a way that it does not disenfranchise people or result in net economic loss to local communities. Some of the components to measure impacts to livelihood include ecological degradation, exclusion from decision-making, business practices, creation of opportunities for local communities along the aquaculture value chain from manufacture and supply of inputs through to processing, transport and marketing (Aguilar-Manjarrez et al. 2017). There is a persistent connection between industrial ocean activities and ongoing economic costs associated with waterways and beach cleanups, as well as impacts on boat engines, marinas and ports, which are often borne by coastal communities and individual businesses rather than by the producers of marine debris and pollution (Bennett et al. 2022). In addition, NOAA Fisheries has developed social vulnerability indicators for coastal communities engaged in fishing activities to characterize community well-being and resiliency to disturbances (e.g. oil spills, extreme weather events, regulation changes, economic disruption) (Jepson and Colburn 2013, Michaelis 2024 (draft)). Table 1 on p. 4 of Michaelis (2024) describes the details of these indicators. The communities identified through the use of the NOAA social indicators are included under each alternative, below.

Indicators for a wide geography may be necessary to evaluate where and why certain communities may be impacted by AOA-related activities (NCCOS 2022). Communities are often analyzed through geographic places. But, communities dependent on seafood production or fishing (commercial, recreational, or subsistence) also may be defined by shared occupation or interest (Sea Grant 2024b). Kruase et al. (2020) defines “local” as the direct aquaculture production site and its direct neighboring communities; “regional” as combining several adjacent municipalities. For the purposes of this DPEIS, “local” considers the nearest shoreside counties; “regional” is considered the SCB (definitions provided in Appendix 3). Criteria of less than 46 km (25 nm) and access to a port have been used in spatial analyses to define cost effectiveness of offshore aquaculture (Kapetsky et al 2013, Morris et al 2021). Stakeholder recommendations during the development of the Atlas additionally suggested that study areas in SCB focus on aquaculture development at depths from 10 to 150 m (33 to 492 ft) with a maximum distance from shore of 46 km (25 nm) (Morris et al. 2021). While unlikely, it is possible that cultured products could be processed at sea and/or landed outside the SCB region, or even outside of California. Growers may shop between multiple processors and distributors before landing a product. Additional factors extrapolated from case studies in NCCOS (2022) that indicate new aquaculture would be integrated into the SCB region include:

- existing support businesses (high number of processors and retailers, as well as a high number of dealers for existing seafood products);
- high commercial fishing engagement;
- high maritime job presence; and
- high number of ports.

The Regulatory Flexibility Act (RFA) RFA requires government agencies to assess potential effects that regulatory alternatives would have on small entities, including small businesses, and to determine ways to minimize those effects (PFMC 2016). The proposed action to identify an AOA is a planning effort only; it is not a regulatory action. However, cost-benefit procedures provided by the RFA, and other economic thresholds defined by federal and state laws, could inform impacts to certain businesses in regional waterfronts, once identified in a site specific NEPA analysis:

- Under the RFA, if the projected direct or cumulative impact is estimated to exceed $100 million, it may be subject to consider certain procedures for cost benefit analyses.
- The North American Industry Classification System (NAICS) U.S. industry size standards for finfish aquaculture, fish hatcheries, shellfish aquaculture, and other aquaculture, classified a small business as having maximum annual receipts of $3.75 million (13 C.F.R. § 121.201).
- The small business size standards for wild harvest finfish, shellfish, and other marine fishing as having maximum annual receipts of $25 million (13 C.F.R. § 121.201).
- The RWQCB, responsible for NPDES permits for the State’s OREHP, considers a small versus large facility as less than versus greater than 45 mt fish per year, respectively (CDFG 2010).
- A fish-harvesting business is considered a “small” business by the Small Business Administration if it has annual receipts not in excess of $4.0 million (PFMC 2016).
- For fish-processing businesses, a small business is one that employs 500 or fewer persons (PFMC 2016).
- For wholesale businesses, a small business is one that employs not more than 100 people (PFMC 2016).
- For marinas and charter or party boats, a small business is one with annual receipts not in excess of $6.5 million (PFMC 2016).

Additional economic considerations that could inform site specific NEPA analyses in working waterfronts should include, but are not limited to:

- disproportionate impacts to small and large business entities;
- disproportionate impacts to certain communities;
- direct food source, direct income source;
- ports' abilities to participate in a new commodity based on existing investments and plans; and
- existing concentration of different fleets/landings amongst ports to predict higher/lower risk of competition.

Competition for space and investment resources for coastal development could occur with the growth of offshore aquaculture, but is considered out of scope for this DPEIS. All future aquaculture-associated development would be regulated by the local jurisdiction's discretionary review process which would require consistency with land use regulations, zoning requirements, any provisions of a habitat conservation plan (HCP) or NCCP, and other applicable policies (CDFW 2019). The California Coastal Act (CCA) protects the public's right to access the shoreline. Aquaculture development is protected in Article 3 Section 30222.5 of the CCA, but it cannot infringe on the rights of other coastal-dependent industries or interfere with coastal access (Nelson et al. 2019). Any aquaculture expansion on land would likely occur on private property or granted state lands (e.g., often administered by ports and special harbor districts) (CDFW 2022). With consideration to and compliance with existing lease requirements, rules and regulations of local jurisdictions, the expected impacts of aquaculture-associated development in working waterfronts would likely be less than significant on the physical and biological environment (CDFW 2019). Coastal community characterizations and available baseline socioeconomic conditions within those communities are included in this DPEIS to help inform overall implications to be considered in project-specific NEPA analyses.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Alternative 2 is nearest to Santa Barbara and Ventura Counties. Santa Barbara County covers a total land and State water area of just under 9,810 km^2 (4,000 mi^2), with nearly 30% of the county represented by coastal waters (NOAA 2013). San Miguel Island, Santa Cruz Island, Santa Rosa Island and Santa Barbara Island are offshore components to Santa Barbara County. Ventura County, including Anacapa Island and San Nicolas Island offshore, covers a total area of just over 5,720 km^2 (2,000 mi^2), with 16.5% of the county represented by coastal waters (NOAA 2013). The four primary ports and harbors near Alternative 2 include Santa Barbara Harbor, Ventura Harbor, Channel Islands Harbor, and Port Hueneme. Five of the eight AOA options are closest to Ventura Harbor, with the closest (N2-E) located just 8.5 km (4.6 nm) offshore. The others range from 11.7 to 27.6 km (6.3 to 14.9 nm) offshore of Ventura Harbor. Alternative 2 could also be accessed from the harbors of Santa Barbara and Hueneme with distances ranging from 13.9 to 33.2 km (7.5 to 17.9 nm) (Morris et al. 2021). Six of the eight AOA options in Alternative 2 are located within (18.5 km) 10 nm of fishing docks.

Thirteen communities within 25 km (13.5 nm) of Alternative 2 were identified for potential vulnerability profiles, listed in Table 4 on p. 13 of Michaelis (2024 (draft)). Considerations include natural hazards, gentrification, existing environmental justice concerns, climate change, and existing fishing engagement and reliance. Potential vulnerabilities include:

- Santa Barbara, Oxnard, Port Hueneme, and Ventura's existing high reliability on commercial fishing could lead to higher risk of adverse impacts with the introduction and potential competition by offshore aquaculture.
- Oxnard, Port Hueneme, El Rio, and Saticoy indicate a large number of households in these communities that may be limited by resources in various ways (e.g., income, education, English language skills), and therefore may be less able to adapt to changes brought on by a developing new industry such as offshore aquaculture.
- Oxnard, Port Hueneme, El Rio, Channel Islands Beach, Meiners Oaks, Mira Monte, Montecito, Oak View, Ventura, Summerland, and Toro Canyon all experience existing pressures from gentrification and/or urban sprawl.
- Montecito, Summerland, and Toro Canyon show low existing opportunities in the workforce, which could lead to positive impacts with the introduction of a new industry to those areas.

The results for the eastern portion of AOA options within Alternative 2 (those labeled N-2 in Figure 1) are detailed on pp. 10 through 12 of Michaelis (2024 (draft)). The results for the western portion of AOA options within Alternative 2 (those labeled N-1 in Figure 1) are detailed on pp. 16 through 19 of Michaelis (2024 (draft)). More precise, localized data from these communities would be needed to assess potential impacts; but these may provide a starting basis for where to focus efforts in a site specific NEPA analysis.

a) Shellfish and Macroalgae

Market considerations discussed in this DPEIS in Chapter 3, Section D.iii.; navigation safety is discussed in Section D.vi. The general economic benefit that would fulfill public economic interest as predicted from a recent kelp EA in the Santa Barbara Channel provides the most specific examples for port and harbor interactions within the region for seaweed production (USACE 2021). A topic specifically addressed for a seaweed analysis (but would apply to all aquaculture projects) was energy needs. The operation of a vessel and other equipment during construction, monitoring, and decommissioning would increase fuel consumption at coastal access points; however, it was concluded unlikely to change the local availability of fuel (USACE 2021). In addition, future seaweed projects may be developed to expand the U.S. energy supply could be considered a potential long term benefit to ports and waterfronts.

The predicted impacts analyzed by VSE for Ventura represents the best available information for the region of what should be considered or predicted from offshore shellfish operations in the SCB. The VSE analysis may be used as an example, if not a template, for site specific NEPA analyses, provided specific port/harbor details as future project designs are determined. Economic impacts to the Ventura Port District from a proposed 2,000 acre (809 ha) offshore shellfish operation, including expenses and revenues, are provided on pp. 40 through 44 of VSE (VSE 2017). Estimated fiscal impacts on local jurisdictions, in addition to the port, are provided in Exhibit 9 on p. 14 of Wright (2020). Employment benefits in a working waterfront of a 2,000 acre shellfish operation are provided in Exhibit 11 on p. 18 of Wright (2020).

Using global examples from mussel longline production, Krause et al. (2020) found that shellfish aquaculture has a beneficial local impact on employment and community resilience, since most operations can employ people and keep waterfronts open year round. Krause et al. (2020) found that impacts from mussel aquaculture rarely go beyond local. The scale of production would determine the scale of this potential impact; and AOAs may influence larger geographic scales of impact, within the region or the state.

b) All Types of Commercial Aquaculture

In analyzing IMTA, it has been estimated that, for each person employed in aquaculture production, about three others are employed in secondary and related activities (Buchholz et al. 2012; Krause et al. 2015).

Using global examples from salmon production, Krause et al. (2020) also found the finfish industry has positive impacts on local household income and housing; and while limited, new education and training opportunities became available indirectly from university or other public-private partnered programs associated with the industry. The potential creation of finfish aquaculture and IMTA through the identification of an AOA may bring additional jobs, and income protection through diversification and access to new markets. Trends of declining wild catches and increasingly restrictive fishery regulations, finfish aquaculture production may help keep waterfronts, docks, processing facilities, and cold storage units operating for both industries (Rubino (ed.) 2008). This observed share of economic value chains can be viewed as means of increasing productivity and competitiveness while also holding the potential of affecting local labor markets, mainly by affecting demand for different skills groups (Buck et al. 2018). These impacts may create beneficial long-term economic outcomes for waterfronts.

California communities that are considered fishing communities under the MSA at 50 C.F.R. § 600.345(b)(3) may be especially-vulnerable to finfish or IMTA aquaculture. Defined fishing communities in California were analyzed in the NMFS Community Profiles for West Coast and North Pacific Fisheries (Norman et al. 2007). These are consistent with the communities identified with high fishing engagement in Michaelis (2024 (draft)). While the Norman et al. (2007) study was based on 2000 census data, it provides a detailed template on the information that would inform project-specific analyses. Information would need to be updated based on the most recent census data available. Community profiles from the Santa Barbara Channel region, within Santa Barbara and Ventura Counties are:

- Oxnard, pp. 485 through 489;
- Port Hueneme, pp. 497 through 500;
- Santa Barbara, pp. 526 through 529; and
- Ventura, pp. 573 through 576.

A summary of offloads to Port Hueneme is provided on p. 12 of PFMC (2022a). Ventura Harbor and Port Hueneme accept offloads from large commercial fisheries, including CPS, market squid, and tuna (Morris et al. 2021). Santa Barbara Harbor and the Channel Islands Harbor serve smaller trap, dive, and trawl operations (Morris et al. 2021). Figure 5.1 on p. 27 of NOAA's 2022-2023 CCIEA Report (Harvey et al. 2023) shows that three out of the top five fishing communities in Southern California that are reliant on commercial fishing (defined by engagement per capita in commercial fishing landings, revenues, permits, and processing through 2020) are located along the coastline near Alternative 2. Despite high reliance on commercial fishing, the data show that the communities in Santa Barbara, Summerland, and Avalon would experience relatively low community vulnerability if there was a downturn in the fisheries. The higher resilience conclusion is based on demographics, poverty, housing, labor force structure, and other factors. A similar analysis shows slightly different conclusions for commercial fishing engagement in coastal communities: Figure R.1 on p. S-90 in Appendix R of NOAA's 2022-2023 CCIEA Report (Harvey et al. 2023) shows Santa Barbara, Oxnard, and Ventura as three out of the top five communities with the most engagement. Oxnard shows the highest of the three, but still below average, social vulnerability if there was a downturn in commercial fisheries engagement.

More precise, localized data from these fishing communities would be needed to ground-truth the high-level predictions in this DPEIS. Methodologies for organizing an analysis on fishing communities are provided on pp. 34 through 38 of Clay and Colburn (2020). In addition, economic benefits would need to be analyzed in comparison to any social and cultural costs, including potential environmental justice concerns, discussed in Section D.ix.

Information on IMTA aquaculture is limited, but public perceptions exist about its potential beneficial and adverse socioeconomic impacts. Perceived positive and adverse impacts associated with IMTA aquaculture, per stakeholder groups that make up waterfront communities, are summarized in Table 4 on p. 102 of Alexander et al. (2016). Food safety, risk of disease transfer, and unknown management for potential cumulative impacts are among the potential adverse impacts perceived in literature and stakeholder interviews; whereas new income diversity, employment opportunities, ecological and waste mitigation are viewed as potential benefits of IMTA (Alexander et al. 2016). IMTA may be a higher financial risk, associated with higher start-up costs, due to the lack of information available for permitting evaluations.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Alternative 3 is nearest to Los Angeles County. Los Angeles County covers a total land and State water area of just over 10,510 km^2 (4,000 mi^2), with about 15% of the county represented by coastal waters (NOAA 2013). The ports of Long Beach and Los Angeles form the largest port complex in the nation, managing approximately a quarter of all container and break-bulk cargo traffic in the U.S. (NOAA 2013). The Ports of Long Beach and Los Angeles also represent two of three ports that account for over three-fourths of the fish and shellfish that are received at or shipped from the west coast (Dealy et al. 2024).

The nearest two harbors are Marina del Rey and Redondo Beach (King Harbor). AOA option CN1-B is the closest option, located just 9.8 km (5.3 nm) from Marina del Rey, whereas CN1-A is approximately 11.1 km (6.0 nm) away from the same harbor. Redondo Beach is 19.4 km (10.5 nm) from CN1-B and 20.9 km (11.3 nm) from CN1-A. Marina del Rey primarily supports private vessel boat slips for the greater Los Angeles metro area. Similarly, Redondo Beach is primarily a harbor for pleasure and sailing vessels. These two harbors already support some commercial fishing landings; but it is uncertain if either location could support expansion of aquaculture-related shore-based infrastructure (Morris et al. 2021). It is more likely that shore based infrastructure may be considered farther south within the Port of Los Angeles complex, even though this area is nearly 55 km (30 nm) from Alternative 3 (Morris et al. 2021). Los Angeles County provides an estimated 16% of marine jobs in the WCR, and produces 24% of the regional contribution to the marine economy's GDP (NOAA OCM 2023).

Twenty-one communities within 25 km (13.5 nm) of Alternative 3 offshore were identified for potential vulnerability profiles, listed in Table 7 on p. 24 of Michaelis (2024 (draft)). Considerations include natural hazards, gentrification, existing environmental justice concerns, climate change, and existing fishing engagement and reliance. Potential vulnerabilities include:

- Los Angeles existing high reliability on commercial fishing could lead to higher risk of adverse impacts with the introduction and potential competition by offshore aquaculture.
- Los Angeles, Del Aire, Howthorne, Inglewood, Ladera Heights, Lawndale, Lennox, and View Park-Windsor Hills all indicate a large number of households in these communities that may be limited by resources in various ways (e.g., income, education, English language skills), and therefore may be less able to adapt to changes brought on by a developing new industry such as offshore aquaculture.
- All communities except Topanga experience existing pressures from gentrification and/or urban sprawl.
- Hiiden Hills shows low existing opportunities in the workforce, which could lead to beneficial impacts with the introduction of a new industry to those areas.

The results for Alternative 3 are detailed on pp. 20 through 23 of Michaelis (2024 (draft)). More precise, localized data from these communities would be needed to assess potential impacts; but these may provide a starting basis for where to focus efforts in a site specific NEPA analysis.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

b) All Types of Commercial Aquaculture

California communities that are considered fishing communities under the MSA at 50 C.F.R. § 600.345(b)(3) may be especially-vulnerable to finfish or IMTA aquaculture. Defined fishing communities in California were analyzed in the NMFS Community Profiles for West Coast and North Pacific Fisheries (Norman et al. 2007). While this study was based on 2000 census data, it provides a detailed template on the information that would inform project-specific analyses. Information would need to be updated based on the most recent census data available. Community profiles from the South Coast region and within Los Angeles County are:

- Culver City, pp. 399 through 402;
- Long Beach, pp. 443 through 446;
- Los Angeles, pp. 447 through 454;
- Tarzana, pp. 553 through 557; and
- Torrance, pp. 558 through 561.

Figure 5.1 on p. 27 of NOAA 2022-2023 CCIEA Report (Harvey et al. 2023) shows one of the top five fishing communities in Southern California that are reliant on commercial fishing (defined by engagement per capita in commercial fishing landings, revenues, permits, and processing through 2020) is located along the coastline near Alternative 3. Despite high reliance on commercial fishing, the data show that the communities in Marina Del Rey would experience relatively low community vulnerability if there was a downturn in the fisheries. The higher resilience conclusion is based on demographics, poverty, housing, labor force structure, and other factors. A similar analysis shows slightly different conclusions for commercial fishing engagement in coastal communities: Figure R.1 on p. S-90 in Appendix R of NOAA's 2022-2023 CCIEA Report (Harvey et al. 2023) shows Oxnard and Los Angeles as two out of the top five communities with the most engagement. Los Angeles is the higher of the two, but still remains average on the social vulnerability scale if there was a downturn in commercial fisheries engagement. More precise, localized data from these fishing communities would be needed to ground-truth these conclusions.

Alternative 4: Combined Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. AOAs in both areas may distribute opportunities to more communities, which could reduce conflicts. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.

If multiple areas were identified as AOAs under Alternative 4, the potential local and regional market impacts may occur at a broader geographic scale. Overall, coordinated growth that considers the relative value of each site would be beneficial to all types of aquaculture (Lester et al. 2018b). Identifying AOAs throughout the SCB may help inform and encourage this optimal way to grow offshore aquaculture. If AOAs were sited in more than one geographic location, aquaculture projects sited in those AOAs may be more likely to land product or work with other auxiliary coastal facilities throughout the SCB, rather than the activity concentrated in one area. Any potential adverse impacts to waterfronts or fishing communities due to economic disruption may not be as severe if more businesses across multiple communities and counties were utilized to support a growing aquaculture sector. Potential economic opportunities may be greater, and more accessible for more people if the geographic scale of impacts were broader.

Siting aquaculture in multiple AOA options across Alternative areas could also provide a scenario where fishing grounds could be strategically avoided depending on the season and distribution of fish biomass from year to year, which may affect fishing communities indirectly. Scaling operations across multiple geographic areas may help wild-harvest seafood products maintain competitive supply and pricing with aquaculture products in seafood markets. Adverse ecological impacts of facilities sited close to one another (e.g. compounding effects of noise, light, waste, FADs) could be mitigated by siting facilities across a more broad geographic context (Gentry et al. 2017, Fujita et al. 2023). Identifying AOAs in both geographic areas could speak to this effect, with the assumption that projects would be encouraged to use spatial distribution as impact mitigation and management. These mitigative solutions from siting facilities in multiple geographic areas, rather than together, may also impact seafood markets indirectly. This may help maintain economic opportunities associated with aquaculture operations and associated working waterfronts.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

v. Tourism and Other Recreation

Affected Environment

The CZMA (described under Chapter 3 Section A.i.) encourages states to provide public access for recreational purposes in coastal areas of environmental, recreational, historical, esthetic, ecological, or cultural value (16 U.S.C. § 1452 (2)(E)). Generally, waters below the high tide line are held in trust for the public, open to all for dedicated or customary use such as swimming, fishing, and other recreational uses. E.O. 13840 states that it is the policy of the United States to expand recreational opportunities; in support of that policy, expanding tourism and recreation opportunities in America's oceans is one of the lines of effort in NOAA’s Blue Economy Strategic Plan (NOAA 2021b). According to the most recent Bureau of Economic Analysis report, tourism and recreation was the marine sector with the largest contribution to annual US GDP compared to other marine sectors, at an estimated $231.8B (BEA 2023).

The AOA options in each Alternative are located between various ports/harbors and the nearby Channel Islands National Marine Sanctuary (CINMS) and Channel Islands National Park (CINP). Recreational use on federal lands and waters in and around the Channel Islands is protected and managed by a variety of statutes and regulations including the National Marine Sanctuaries Act, The National Parks and Recreation Act, Federal Lands Recreation and Enhancement Act, and CINP and CINMS’ implementing regulations. E.O. 13287 also promotes preservation through heritage tourism. There are listed historic properties in the CINP that may attract tourism and recreation, for additional discussion on historic properties, see Chapter 3, Section E. Potential impacts on tourism and recreation associated with the proposed Chumash Heritage National Marine Sanctuary are not expected due to distance, and are not discussed further.

Management of the coastal zone requires consideration of stakeholder interests and science based recommendations to determine the best option for development within the marine environment (Nelson et al. 2019). Other CA statutes recognize marine resources for their public use benefits, aesthetic value, and recreational enjoyment (Marine Life Management Act) and seek to increase California’s share of the national travel and tourism market (California Tourism Marketing Act).

Tourists are drawn to coastal communities to explore diverse outdoor environments. Attractions include marine reserve sites, ecotourism, the seascape, historical ports, lighthouses, mission sites, art galleries, shopping, fishing, diving, sailing, boating, and local seafood. Many West Coast communities boast of their maritime and commercial fishing history to help attract visitors (Norman et al. 2007). The SCB has many important elements beneficial to tourism and recreation, including relatively mild climate and water temperatures for activities such as year-round boating, diving, and whale watching excursions, and proximity to the Channel Islands. In general, most recreational activities occur relatively close to the shorelines of the mainland and the adjacent islands. Recreation activities in open and offshore waters are more limited to those accessed by marine craft, including boats, jet skis, kayaks, and surfboards because of the distance from shore. The activities, therefore, are limited primarily to fishing, surfing, kayaking, canoeing, snorkeling, scuba diving and sightseeing from watercraft (CDFW 2019). Whale watching and other types of wildlife viewing are very popular attractions along the coast of California. Trips are offered year round with different peaks of activity for different species. Generally, using recreational vessel movement as a proxy, there is more activity in the summer and less in the winter (USCG 2023).

Stressors

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- fixed gear and other equipment placement in the water column and surface;
- increased vessel traffic in and out of coastal areas;
- new areas where wildlife aggregations may occur; and
- changes in ecosystem services that support tourism and other recreational activities.

Further details on how the Proposed Action may have an indirect impact on tourism and recreation via ecosystem services that support recreation and tourism (e.g. marine debris impacting the value of the seascape, entanglement risk for whale species targeted by whale watching tours, the need for shore side industrial-use infrastructure, viewscape analysis, etc.) is provided throughout other sections of this chapter. For example, recreational SCUBA divers care about water clarity and visibility in kelp forest and rocky reef ecosystems, but a detailed discussion of potential impacts to water quality is not repeated here.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The growth of offshore aquaculture within an identified AOA may impact tourism and other recreational activities in the SCB due to geographic, ecological, and aesthetic interactions. Impacts may be adverse and beneficial, direct and indirect. The identification of an AOA would not disqualify tourism or other recreational activities. However, recreational ocean users may experience changes in transit patterns and/or access due to increased vessel traffic or safety restrictions around fixed gear and other equipment placed in the water column or surface. Safety buffers may be set up around project sites during survey operations, construction, maintenance, and decommissioning activities. Nuisance impacts may include aesthetics, dust emissions, water quality degradation, and increased traffic that disrupt the recreational experience (CDFW 2019). Offshore facilities would be identified with appropriate markings for safety of navigation to identify facilities to other ocean users in the area and avoid potential conflicts, for more detail see Chapter 3, Section D.vii. (Public Health and Safety). With the exception of permanent restricted access zones that may be established, many of these impacts would likely only affect tourism and other recreational activities temporarily while work was underway. There are disagreements in the literature regarding how the visual impact of aquaculture operations interacts with the tourism sector (Agular-Majarrex et al. 2017); for additional discussion of visual impacts see Chapter 3, Section B.v. (Air Quality and Aesthetics).

Wild fish aggregate around aquaculture facilities (Rhodes et al. 2023a). Having new reliable wildlife aggregation locations could create new opportunities for tourism and other recreational activities; for example, snorkel and scuba tours get close to aquaculture facilities in Hawaii to view aggregating wildlife

(DLNR 2007). Considering the interaction of oil and and gas platforms in the SCB with recreational fishing activities as a proxy, vessels under 30.5m (100 ft) are allowed within the standing, long-term buffer (BOEM 2018). Most recreational vessels are likely small enough to operate within an AOA and very close to a project footprint, in order to take advantage of wildlife aggregations that may occur. However, certain vessels could be excluded completely due to new operation practices (e.g. increased fuel consumption by vessels having to avoid project footprints in an AOA and higher expenditures on fuel). New types of tourism and recreation could develop associated with aquaculture, like festivals or aquaculture tours (Marcus 2022), however aquaculture facilities generally attract little tourism (CDFW 2019).

The chance of displacement/disruption and the severity of impact on tourism and recreational activities would depend on how changes in traffic and/or access interact with existing recreational areas and with ecosystem services that attract dynamic recreation. The timing and location of many tourism and recreational activities may be variable across the SCB because they respond to dynamic ocean conditions. Aquaculture projects may vary in terms of size, complexity, location and operational patterns, therefore impacts are expected to be variable and highly localized, and would be considered in site specific NEPA analyses. It is likely that projects sited in an AOA would be subject to the same or similar conditions applied in other aquaculture projects adopted to minimize spatial and temporal overlap and user conflicts, see Table ES-1 CDFW (2019). Given the size of these facilities in comparison to the available space for offshore recreation, and patterns of historical recreation estimated via vessel movement, the risk of adverse effects that displace, impede or disrupt tourism and other recreation is low.

Socioeconomic interactions between the aquaculture sector and the tourism/recreation sector are generally associated with ports and working waterfronts, for more detail see Chapter 3, Section D.iv (e.g. potential economic costs and benefits to shore side businesses). All of the activities discussed in this section contribute to the local economy and employment (Sea Grant 2023). Tourism and recreation is estimated to employ 64% of the WCR marine economy (NOAA OCM 2023). The extent to which potential changes in ecosystem services, experience, and patterns of access or transit may impact patterns of business or have direct or indirect effects on the economic value associated with tourism and recreation would be considered in site specific NEPA analyses. The tourism and recreation sector includes a wide range of businesses that attract or support marine-based tourism and recreation, such as eating and drinking establishments, hotels and lodging, scenic or wildlife viewing tours, aquariums, parks, marinas, boat dealers, recreational vehicle parks and campsites, and associated sporting goods manufacturing. Many of the activities associated with this sector, such as hotels and restaurants, are not always directly marine dependent (Sea Grant 2023). Considerations should include, but are not limited to:

- travel and opportunity costs;
- disproportionate impacts to small and large business entities; and
- disproportionate impacts to certain communities.

Recreation can also contribute to community well-being and the maintenance of historic ties, and constitute a traditional or cultural use for both tribal and non-tribal communities (see also Chapter 3, Sections E.i and E.ii).

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Spatial data for tourism and other recreation was captured via recreational vessel movement in the SCB from 2010 through 2019 and incorporated into the Atlas (Morris et al. 2021). The resources used are provided on pp. 60 through 73, as well as on p.27 of the Methods section, as well as in Appendix A of the Atlas (Morris et al. 2021). Smaller vessel types important for recreation and tourism that are not required to use AIS (e.g., small pleasure and sailing vessels) may be under-represented, but it is reasonable to assume the vessel activity observed likely represents where those vessels primarily operate and that unsuitably high-use areas have been avoided, minimizing impacts on tourism and other recreation (USCG 2023, PACPARS and Morris et al. 2021).

The tourist business is of prime importance to the economy of the area. Of the total ocean economy for Ventura County as measured by GDP, tourism and recreation made up 56.5%, or $677.5 million, with an average of $44,600 GDP per employee in 2018 (BOEM 2022). Tourists are drawn year-round by the mild climate and ocean-side location. Beaches, fishing piers, marinas and shoreline parks are available and the harbor area of the city of Santa Barbara is a popular center for boating, deep-sea fishing, and other water sports (BOEM 1971).

The nearby Channel Islands are used by the public for tourism and recreational purposes (e.g., various kinds of boating, diving, tourism, surfing, swimming, hiking, and camping, and wildlife viewing). These activities originate from harbors, coves, and marinas along the mainland coast, generally by ferry or boat from Ventura, Santa Barbara, or Channel Islands Harbors. Whale watching occurs year-round, but is more extensive in the region in the spring and summer (during the annual gray whale northward migration and peaks for humpbacks and blue whales); bird watching and marine mammal observation are popular year-round. Recreational diving at shipwrecks and natural areas around the Channel Islands is also popular (National Park Service, 2015). The Santa Barbara Channel is one of the best spots in the world for boat-based blue whale watching (O'Connor et al. 2009) and has been designated as an international Whale Heritage Area (REF in comment).

The chance of displacement or disruption to the recreational experience and the severity of impact on tourism and recreation would depend on the site-specific and variable interactions between changes in access, transit, and ecosystem services that attract tourism and recreation. Passenger transit routes from Ventura and Oxnard have been avoided, but more detailed information on site-specific areas of interest for recreation, including whale-watching routes, would be considered via project-specific planning and site specific NEPA analyses. Data gathered in the Atlas show the highest number of vessel transits in the area from the "other" category, which may actually encompass some tourism and recreational uses, followed by "passenger", then pleasure and sailing transits (Morris et al. 2021). For a detailed description of potential impacts on vessel traffic, see Chapter 3, Section D.vi. (Transportation and Navigation).

Each AOA option within Alternative 2 ranges from 1,500 to 2,000 acres (607 to 809 ha) and the total combined acreage in Alternative 2 is 15,000 acres (6,070 ha), or 60.7 km^2 (23.4 mi^2), see Table 2 .Given the size of these facilities in comparison to the available space for offshore recreation, and patterns of historical recreation estimated via vessel movement, the risk of adverse effects that displace, impede or disrupt tourism and other recreation is low.

a) Shellfish and Macroalgae

Kelp aquaculture is a winter crop, and peaks of operational activity could coincide with generally seasonally lower vessel traffic and tourism/recreation. Aggregations of marine mammals, seabirds, predatory fish and schooling fish are observed near marine aquaculture worldwide, regardless of the species farmed (Rensel and Forster 2007, Bath et al. 2023, and Rhodes et al. 2023a). In addition to functioning as FADs, shellfish and seaweed aquaculture may provide ecosystem services that benefit regional tourism and recreation activities (clean the water, protect and stabilize shorelines, provide habitat for wild marine species, etc., Nelson et al. 2019). Each of these benefits indirectly improves the ability of these areas to be used for tourism by allowing for cleaner, more stable, and more productive habitats that provide services that are desirable for visitors (NOAA 2023).

b) All Types of Commercial Aquaculture

There may be less seasonality and more frequent vessel operations associated with aquaculture operations targeting finfish that may displace or disrupt tourism and recreation compared to Alternative 2a, and different impacts to ecosystem services that support tourism and recreation (see Chapter 3, Section B.iv. (Water Quality).

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Santa Monica Bay, offshore of Greater Los Angeles, provides crucial habitat for marine life. The bay and its beaches attract residents and visitors alike. More than 45 million people visit the bay's beaches each year, helping to support a regional tourism industry of $10 billion annually (USGS 2003). Santa Monica Bay is used for fishing, sailing, swimming, diving, and many other recreational activities. The abundant recreational facilities (including 22 public beaches, a 22-mile-long beach bike path, six piers, small craft harbors with 6,000+ slips, and nine artificial reefs) make the area attractive for a wide range of water-dependent activities (CRWQCB 1997). Tourism and recreation targeting the Northern Channel Islands, which include the bulk of CINP and CINMS, are less likely to depart ports and harbors in Santa Monica Bay compared to Alternative 2, however there is a ferry from Santa Monica to Santa Catalina Island in the southern Channel Islands, and some multi-day cruises that visit the Channel Islands depart from LA.

Spatial data for tourism and other recreation was captured via recreational vessel movement in the SCB from 2010 through 2019 and incorporated into the Atlas (Morris et al. 2021). The resources used are provided on pp. 60 through 73, as well as on p.27 of the Methods section, as well as in Appendix A of the Atlas (Morris et al. 2021). Smaller vessel types important for recreation and tourism that are not required to use AIS (e.g., small pleasure and sailing vessels) may be under-represented, but it is reasonable to assume the vessel activity observed likely represents where those vessels primarily operate and that unsuitably high-use areas have been avoided, minimizing impacts on tourism and other recreation (USCG 2023, Morris et. al 2021). Additionally, USCG has noted an increase in traffic over the last decade that appeared to be predominantly associated with pleasure craft near the port of LA and concluded that it may be indicative of increased voluntary carriage of AIS on these boats, but not necessarily an actual increase in traffic volume (USCG 2023). The Harbor Safety Plan for the Ports of Los Angeles and Long Beach has recommended for small craft to carry AIS equipment (MESC 2023).

Based on AIS data analyzed in Morris et al. (2021), there are less than 100 transits by pleasure, sailing, and fishing craft through the area in a year. The two AOA options within Alternative 3 are 500 and 1,000 acres (202 and 405 ha), for a combined total of 1,500 acres (607 ha), or 6.1 km^2 (2.4 mi^2), see Table 3. Because there is less recreational vessel traffic in the Alternative 3 area overall and the potential total footprint is smaller, impacts to tourism and recreation may be reduced compared to Alternative 2.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

Alternative 4: Combined Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. AOAs in both areas may distribute opportunities to more communities, which could reduce conflicts. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.

Impacts under Alternative 4 assume that if multiple AOAs were identified, then more aquaculture may develop in the identified areas. If aquaculture increased in scale, so would vessel traffic volume and operations that may displace or disrupt recreation. It is possible that more geographically broad operations would interfere with the efficient movement of dynamic wildlife viewing tours compared to siting in a more concentrated area. If facilities were to be sited more broadly throughout the SCB or west coast, the range and scope of impacts on tourism and other recreation may also be more broad and unpredictable. Alternatively, ecological impacts of facilities sited close to one another that may have direct and indirect effects on tourism and recreation (e.g. compounding effects of noise, light, waste, FADs) could be mitigated by siting facilities across a more broad geographic context (Gentry et al. 2017, Fujita et al. 2023).

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

vi. Transportation and Navigation

Affected Environment

Section 10 of the Rivers and Harbors Act prohibits the creation of any structures that may alter the navigable capacity of any of the waters of the US. Section 4(f) of the OCSLA (described under Section B.iii. (Seafloor Characteristics)), and extends the jurisdictional authority of USACE under Section 10 throughout the outer continental shelf within the EEZ (43 U.S.C. § 1333(e)). The USACE issues a Section 10 permit for any activities in the OCS that would result in obstructions to navigation (33 C.F.R. Parts. 320, 322, 325, 329, and 330). Aquaculture facilities sited in an AOA would likely need a Section 10 permit for any moored structures or other fixed gear.

USCG is responsible for safeguarding navigation on the high seas and navigable waters of the U.S. (33 C.F.R. Part 1) and administers the U.S. Aids to Navigation System (33 C.F.R. Parts 60-76). All US flag vessels must adhere to the international and inland “Rules of the Road” for navigation in the International Regulations for Preventing Collisions at Sea (72 COLREGS, as amended), and the U.S. Inland Navigation Rules (33 CFR 83). USCG has the authority to establish vessel traffic service/separation schemes for ports, harbors, and other waters subject to congested vessel traffic, and enforce port safety and security regulations. Permission to build any structure requiring personal aids to navigation (PATONs), as well as permission to place PATONs in navigable waters, is required from the USCG (33 C.F.R. 66, 14 U.S.C. 542, 543, 544 and 43 U.S.C. 1333). A PATON is a buoy, light, or beacon that is owned and maintained by any individual or organization other than USCG. The need for and type of PATON is reviewed by the USCG; installation and maintenance of the PATON is the responsibility of the owner or operator. To gain a PATON permit, an applicant would need to submit a CG-2554 Private Aids to Navigation permit application after obtaining the Section 10 permit from USACE. The USACE permit number is required as part of the USCG application. USCG consults local resources in the permit review process ensuring that a permitted aid is not creating a hazard to mariners using that water way (pers. comm. USCG 20230502).

Overall, the SCB has a high volume of vessel traffic, ranging from sailing and pleasure craft to major shipping, oil tankers, and military vessels. Southern California has two of the largest and busiest commercial marine ports in the United States (Los Angeles and Long Beach), and Newport Beach is a popular recreational boating area, which creates significant vessel traffic around the Santa Barbara and Santa Monica alternative areas of analysis. There are a variety of vessel routing measures adopted to ensure safety of navigation that shape existing traffic patterns, including traffic separation schemes, fairways, and corridors (Morris et al. 2021). Vessel traffic data are collected in real time by USCG using very high frequency maritime-band transponders called the automatic Identification system (AIS); this system is capable of handling over 4,500 reports per minute and updates every two seconds (USCG 2020). Generally, the majority of vessels in the SCB are recreational vessels, followed by cargo vessels; cargo vessels tend to follow typical routes 25-40 NM offshore while passenger and recreational vessel transits are more dispersed (Morris et al. 2021, USCG 2023). There is seasonal variability in the number of vessels, number of transits, and distance traveled, while generally high traffic is in the summer and the lowest traffic in the winter (USCG 2023). There is a voluntary 10 knot or less speed reduction zone to reduce air pollution, ocean noise and whale strikes that encompasses most of the SCB; it is in effect from May to December each year, targeted towards vessels 300 GT or larger, and is incentivized in some zones near ports (USCG 2024).

Since the completion of the Atlas, USCG published an updated Pacific Coast Port Access Route Study (PACPARS), examining vessel traffic data from the past decade to determine whether new or modified vessel routing measures were needed to ensure safety of navigation along the U.S. Pacific Coast due to evolving demands for use of coastal waters. The analysis found that fishing, recreational, passenger, ‘other’ ship types, and vessel traffic overall off the Pacific Coast had increased over time, and that Los Angeles/Long Beach showed the most noticeable increase of any port area (USCG 2023). None of the updated routing measures that resulted from this effort should cause any significant changes to traffic or traffic density considered in the spatial planning process; new voluntary fairways were designed to encompass past and current vessel traffic. While both the Atlas and the PACPARS used AIS data to characterize vessel traffic and not all vessel types (fishing, recreational, etc) are required to broadcast AIS, it is reasonable to assume that the vessel activity observed likely represents where those vessels primarily operate (USCG 2023). Generally more detailed and up to date site-specific navigational risk assessments, including vessel traffic analyses, are likely to be part of the permitting process for future projects.

Stressors

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- Fixed gear, other equipment in the water column and surface; and
- Changes in vessel traffic volume and patterns.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Only potential impacts on transportation and navigation at sea are considered here; shore side impacts are not considered.

If an AOA were identified and aquaculture projects were sited in an AOA, there could be potential for direct adverse impacts on transportation and navigation associated with the potential introduction of new structures, obstructions, or hazards to navigation. Interactions with other vessels could include buoy/marking misinterpretation, allision, collision, and entanglement with fixed gear or derelict gear that has separated and become loose and potentially unmarked. See Figures 2-3 through 2-7 in CDFW (2019) for examples of nominal gear configurations and information about the types of lines and anchors used for different types of aquaculture operations. Vessel interactions may also lead to damaged gear, loss in revenue, and human health and safety risks. However, all future aquaculture facilities would be required to comply with federal regulations adopted to ensure safe marine vessel movement, including appropriate marking (PATONs). In data analyzed from 2015 through 2018, nine out of 16 marine mammal entanglements with gear from an unknown source still had buoys attached (NMFS 2023d). There is no alternative location that could avoid the risk of a line or anchor separating. Projects sited in an AOA would be subject to the same or similar conditions designed to minimize impacts (e.g., requirements for gear maintenance, remote monitoring, response time and recovery, etc.) as those required for other aquaculture projects, see CDFW 2019, USACE 2021. Assuming all permit conditions are followed and no lines or anchors separate, the risk of vessel interaction is low.

The growth of offshore aquaculture within an identified AOA could disrupt established navigational patterns of marine vessels and increase vessel traffic volume, both offshore and near ports and harbors. Factors that may influence the extent of impacts AOA-associated vessel traffic may have on transportation and navigation include vessel speed, the number of vessel trips needed to install and tend to gear, distance traveled, existing volume and density of vessels in the area, and seasonality or timing of vessel operations. These factors and the impact they may have on existing transportation and navigation would vary by operation and location relative to ports, processing, and shipping infrastructure, and would likely be considered and minimized in permit conditions for in-water work. Safety buffers, speed reductions and exclusion zones may be implemented near and within project sites during certain kinds of work or permanently. The actual surface footprint of an aquaculture facility that may impact transit patterns is expected to be smaller than the lease area, see Figure 2-2 and Table 2-2 of CDFW (2019).

An environmental assessment for twenty 100 acre (40 ha) aquaculture sites (2,000 acres (809 ha) total) offshore of Ventura estimated a vessel increase of 20 to 40 small boats traveling to lease sites on an average of 3 times per week to daily (VPD 2018), and the navigational risk assessment determined that this amount of added vessel traffic would not be a significant increase given the existing vessel traffic coming in and out of Ventura Harbor (VPD 2020). See Tables 4-8.3 and 4-8.4 in CDFW (2019) for an estimated number of vessel trips associated with various kinds of aquaculture facilities and operational phases. If all the AOA options were selected and 3-5 projects operated at each site, thousands of additional vessel trips could be added to the SCB annually, plus more during periods of installation/decommissioning. However, all AOA-associated vessels would comply with all navigation and vessel regulations, including vessel traffic service/separation schemes for ports, harbors, and other waters subject to congested vessel traffic. For additional discussion on individual AOA option proximity to and expected impacts on particular ports and working waterfronts, see Chapter 3, Section D.iv. Site-specific navigational risk assessments would consider if the increase in vessel traffic in and out any port/harbor would constitute a meaningful change from baseline conditions or post a significant risk beyond what can be safely handled by the port/harbor.

The quantity and impact of future vessel traffic and new structures, obstructions, or hazards to navigation are unknown at this time, and impacts on transportation and navigation would be highly localized. Overall, impacts to transportation and navigation are minimized because the AOA options that were selected as a result of spatial modeling in the Atlas avoid conflicts with established shipping lanes/fairways, traffic separation schemes, routes frequently traveled by other commercial and recreational vessels, and other important sites like harbor pilot boarding areas. Fixed gear in the water would not change the navigable capacity of the waterspace as long as compliance measures for navigation are followed, discussed in Chapter 3, Section D.vii (Offshore Energy and Public Services), below. Enforcement of navigation and vessel regulations and permit conditions would ensure that hazards to navigation and impacts on vessel traffic patterns are minimized to the extent feasible. Safety concerns associated with accidents or noncompliance are discussed in Chapter 3, Section D.viii (Public Health and Safety). For discussions on the potential impacts of vessel strikes on protected species, see Chapter 3, Section C.i. For discussions on water quality, air quality, and noise concerns associated with vessel traffic, see Chapter 3, Section B.iv. through B.vi., and for discussion of the cumulative impacts of all vessel traffic in the Action Areas, see Chapter 4, Section B.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Spatial data for vessel movement in Alternative 2 from 2015 through 2020, divided by AOA option and vessel type, are summarized in Tables on pp. 130, 133, 136, 156, 159, 162, 165, and 168 of Morris et al. (2021). Generally, the majority of transits through the AOA options are from the "other" and "passenger" vessel categories. Smaller vessels that are not required to use AIS may be under-represented in the Atlas, but it is reasonable to assume the vessel activity observed likely represents where those vessels primarily operate and unsuitably high traffic areas have been avoided. Smaller commercial passenger and recreational vessels may be piloted by less experienced operators who are less adept at spotting and avoiding aquaculture operations compared to licensed Captains with extensive experience piloting large commercial vessels like cargo ships.

Each AOA option within Alternative 2 ranges from 1,500 to 2,000 acres (607 to 809 ha). The total combined acreage in Alternative 2 is 15,000 acres (6,070 ha), or 60.7 km^2 (23.4 mi^2). Depending on the number of AOA options selected, this could result in many projects, with their associated vessel traffic and infrastructure. Upon receiving the PATON permit application for a project, USCG could determine if a site-specific Navigation Safety Risk Assessment (NSRA) is required.

Alternative 2 overlaps with a military training route for activities at the Point Mugu Sea Range (PMSR). It is not anticipated that this interaction may cause conflict, because consultation with the Navy during the spatial analysis process suggests that the AOA options in Alternative 2 may be compatible with military operations, though they may be subject to certain stipulations and final design review (e.g. aquaculture facilities may have height restrictions and lighting requirements). Even with this overlap, there was minimal military vessel transit in Alternative 2 over the 2015-2020 period considered, with only one transit noted through AOA options (Morris et al. 2021). While it does not overlap, the AOA option closest to Ventura harbor is also 0.5 km (0.27 nm) from a corridor used by service vessels for nearby oil and gas platforms.

a) Shellfish and Macroalgae

In addition to the general impacts discussed above, different types of aquaculture operations may have different requirements for vessel speed, the number of vessel trips needed to install and tend to gear, seasonality or timing of vessel operations. These factors would likely be incorporated into permit conditions for in-water work. Kelp aquaculture is a winter crop, and peaks of operations could coincide with generally seasonally lower vessel traffic. See Chapter 3, Section C.i for additional details on types of lines typically used in different aquaculture systems and the associated risk to become derelict gear that may create hazards to navigation. The risk of impacts on transportation and navigation would depend on the number and operational tempo of vessels associated with a project and its associated infrastructure. The type of aquaculture may be less of a consideration relative to project footprint and production size.

b) All Types of Commercial Aquaculture

In addition to the general impacts discussed above, there may be less seasonality and more frequent vessel operations associated with aquaculture operations targeting finfish compared to Alternative 2a. It is estimated that finfish operations would require more vessel trips during general operations, possibly daily, compared to shellfish and macroalgae operations, but less during installation and decommissioning (CDFW 2019).

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Spatial data for vessel movement in Alternative 3 from 2015 through 2020, divided by AOA option and vessel type, are summarized in Tables on pp. 188 and 191 of Morris et al. (2021). The AOA options in Alternative 3 have less existing vessel traffic than AOA options in Alternative 2 and the vessel traffic that does occur is done by smaller vessel types; no cargo, military, or other large vessel types were reported. Based on AIS data analyzed in Morris et al. (2021), there are less than 100 transits by pleasure, sailing, and fishing crafts through the AOA options in a year. Smaller vessels that are not required to use AIS may be under-represented in the Atlas, but it is reasonable to assume the vessel activity observed likely represents where those vessels primarily operate and unsuitably high traffic areas have been avoided. Because there is less vessel traffic in the Alternative 3 AOA options overall, impacts to transportation and navigation may be reduced compared to Alternative 2. The two AOA options within Alternative 3 are 500 and 1,000 acres (202 and 405 ha), for a combined total of 1,500 acres (607 ha), or 6.1 km^2 (2.4 mi^2). Depending on the number of AOA options selected, this could result in several projects and their associated vessel traffic and infrastructure, which is less in aggregate than Alternative 2. Upon receiving the PATON permit application for a project, USCG may determine if a site-specific NSRA is required.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

Alternative 4: Combined Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified. If aquaculture increased in scale, so would vessel traffic volume and the introduction of new structures, obstructions, or hazards to navigation. Choosing one AOA option from each area, the nearest to shore, could enable the most efficient transportation between offshore sites and coastal facilities and further reduce potential impacts on transportation and navigation. Enforcement of navigation and vessel regulations and permit conditions would ensure that impacts on vessel traffic patterns and hazards to navigation are minimized to the extent feasible.

a) *Shellfish and Macroalgae*

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) *All Types of Commercial Aquaculture*

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

vii. Offshore Energy and Public Services

Affected Environment

This section provides a brief background and discussion of the potential impacts of the Proposed Action on offshore energy and public services not addressed in other portions of the EIS, including offshore oil, gas and wind energy, marine minerals, submarine utilities (cables and pipelines), direct ocean-outfalls, and scientific research and surveys, which would result from the Project, action alternatives, and ongoing and planned activities in the geographic analysis area.

Oil and Gas

The Bureau of Ocean Energy Management (BOEM) is responsible for managing and regulating offshore activities in the Outer Continental Shelf (OCS), such as oil and gas, alternative energy, and marine minerals operations. The Agency's mission is to manage and regulate development of energy, mineral, and geological resources in an environmentally and economically responsible way. BOEM manages the energy resources in the OCS under the authority of the Outer Continental Shelf Lands Act (OCSLA). The OCSLA implemented federal regulatory control of the OCS, defined as all submerged lands beyond the lands reserved to the States up to the edge of the United States' jurisdiction and control. In addition to the OCSLA, the Submerged Lands Act (SLA) was passed to give individual states the right to the natural resources of submerged lands from the coastline to 5.6 km (3 nm) into the Atlantic, Pacific, the Arctic Oceans, and the Gulf of Mexico, except off Texas and the west coast of Florida, where state jurisdiction extends from the coastline to no more than three marine leagues 16.2 km (9 nm) into the Gulf of Mexico. In 2005, the Energy Policy Act amended the OCSLA to extend BOEM's authority to manage marine renewable energy projects on Federal offshore lands, and other projects that make alternative use of existing oil and natural gas platforms. Besides this jurisdiction and regulatory authority, BOEM also relies on other Federal mandates to manage offshore energy structures and the environment, such as the Oil Pollution Act, NEPA, and CZMA.

The OCS is a significant source of oil and gas for the Nation's energy supply. In FY 2020, offshore Federal production reached about 641 million barrels of oil and 882 billion cubic feet of gas, almost all of which was from the Gulf of Mexico (BOEM 2021). The current assessment of undiscovered oil and gas resources estimates most of the potential energy resources are in the Gulf of Mexico and Alaska regions; however, the Pacific (U.S-Canada border to U.S-Mexico border) ranks third for gas potential and fourth for oil (BOEM 2021). Most of the resources in the Pacific are predicted to be in the Southern California Planning area (north of Point Sal to the U.S-Mexico border). In fact, only the Southern California OCS Planning Area has oil and gas leases and development (Argonne National Laboratory 2019). Currently, there are 38 existing Federal leases and 23 constructed platforms in the Southern California OCS Planning Area (BOEM 2021). Among these lease areas, 14 oil and gas fields are actively producing energy from 21 platforms (20 producing and 1 processing platform); 13 platforms are located offshore of Santa Barbara County, four platforms offshore of Ventura County, and four platforms offshore Long

Beach, near the boundary of Los Angeles and Orange Counties (Argonne National Laboratory 2019). The 23 platforms are located 6-17 km (3.2-9.2 nm) from shore. There are oil and gas platforms within 5 km of all of the Alternative 2 AOA options except N2-D (see Figures 3.47 and 3.64 in the (Morris et al. 2021)). The last new platform installed was in 1994, so most of the platforms are near their operational lifespan; seven structures are being considered for decommissioning (BSEE 2020). In state waters, California prohibited oil drilling in 1969 and the authority was reinforced under the California Coastal Sanctuary Act in 1994.All existing platforms have been avoided in the spatial planning process, however BOEM has the right to lease the outer continental shelf at any time in the future.

Alternative Energy

The development of alternative energy is a relatively new industry in the U.S despite its long history outside the country. In 2016 and 2018, BOEM began evaluating potential wind energy development in the OCS and announced the designation of the Humboldt Wind Energy Area (WEA) and the Morro Bay WEA in 2021. The Humboldt WEA is located approximately 32 km (20 mi) offshore the northern California coastline and encompasses 132,369 ac (206.8 mi^2). The Morro Bay WEA is located approximately 32 km (20 mi) offshore the central California coastline and comprises around 240,898 ac (376 mi^2). BOEM held a lease sale in 2022. Currently, BOEM has federal oversight authority on five WEA leases in the OCS off California, two in northern California off Humboldt County, and three in Central California near Morro Bay. BOEM is currently doing programmatic environmental planning to analyze potential impacts of offshore wind energy development activities on the five offshore wind lease areas, which includes funding numerous studies to collect information about the marine environment to support decisions concerning offshore renewable energy development. The active five WEA leases are outside and away from the Alternatives and there are no other WEAs being considered at this time.

Marine Minerals

The OCSLA provides the Secretary of the Interior the authority to manage other minerals besides oil, gas, and sulfur on the OCS. The Department of the Interior's (DOI's) jurisdiction over exploration, leasing, and recovery of non-energy marine minerals, or hard minerals, extends to the subsoil and seabed of all submerged lands seaward of state boundaries to the OCS (except where modified by international law or convention or affected by the Presidential Proclamation of March 10, 1983, regarding the Exclusive Economic Zone [EEZ]). Under this authority, BOEM developed the Minerals Program to address erosion on coastal beaches, dunes, barrier islands, and wetlands. The Marine Mineral Program (MMP) identifies large sand resource areas and then partners with USACE, states, and local authorities to designate sand borrow areas. Based on the Marine Minerals Information System, there are no active OCS lease areas for marine minerals within or in the vicinity of the AOA options. There are only two marine minerals offshore study areas in Southern California; one is near Oceanside and the other is off San Diego. Both sand resource areas are away from all AOA options.

The Agency also responds to commercial requests for valuable OCS minerals, such as gold, manganese, or other hard minerals. Pursuant to Executive Order 13817, the MMP and the U.S. Geological Survey are collaborating to determine which 35 critical minerals are located on the OCS. In international waters, outside of U.S jurisdiction, companies funded by international countries are proposing to mine nodules in the central Pacific Ocean over the next 5 to 7 years under the governance of the International Seabed Authority. In the United States, the Deep Seabed Hard Mineral Resources Act (30 U.S.C. Chapter 26 – Deep Seabed Hard Mineral Resources) establishes an interim domestic licensing and permitting framework for deep seabed hard mineral exploration and mining in international waters pending adoption of an acceptable international regime. The U.S. has two active exploration licenses (USA-1 and USA-4), both held by Lockheed Martin for five-year terms, that were last reissued for 2022-2027. Currently, there are no ongoing or proposed mineral mining activities within or adjacent to any of the AOA options.

Submarine utilities

Submarine cables have been used to transport telecommunications data over great distances for over 150 years. Cables transport information and power (electrical) under the seabed often connecting countries around the world. Despite the importance of satellites, undersea cables are still essential for the internet, global financial markets, and military applications, especially fiber optic cables. Undersea cables are scattered off every coastal state along the east and west coasts of the United States, including Southern California. Fiber optic cables provide high speed data transmission connecting California cities, California to Hawaii, and the U.S. to other countries across the Pacific Ocean, while submarine power cables provide shore-based power to several offshore oil platforms. The laying and placement of submarine cables requires coordination, and the installation, maintenance, repair, and removal of cables in certain areas may have an adverse impact on the marine environment and other valuable resources. To help ensure the coordination of cable placement and minimize potential adverse impacts, several federal (NOAA, USACE, BOEM, FERC, and FCC) and state agencies (within state waters) have legal authority to regulate the laying and maintenance of cables under various laws, such as the OCSLA.

Industrial pipelines and direct commercial and public point source (publicly owned treatment works [POTW]) ocean outfalls are also found along the coast in many regions, including the offshore waters off Southern California, which contribute to local nutrient (phosphorus and nitrogen) loads. In Southern California, pipelines are generally associated with oil and gas operations, while outfalls are primarily associated with public treatment plants. Regulated point source pollution includes numerous permitted outfalls from industrial (oil and gas operations) and commercial sources, including six POTWs that discharge into the Santa Barbara Channel (Argonne National Laboratory 2019). These structures are found on the seafloor and function to transport and diffuse treated wastewater from onshore treatment plants.

Various types of submarine utilities infrastructure are present on the seafloor near the Alternatives, which includes submarine cables (fiber optic and power), oil and gas pipelines, and ocean outfalls (see Table 3.3 and Figure 3.5 in Morris et al. (2021)).There are no oil and gas pipelines found within any of the AOA options. Similar to oil platforms, a 500 m (1,640 ft) setback from cables and pipelines was established for potential future aquaculture operations and the nearest pipeline is 0.8 km (0.4 nm) from AOA option N1-C. The setback distance for all outfall pipes and diffusers was at least 5.5 km (3 nm).

Ocean Research and Monitoring

Various federal, state, and educational organizations regularly conduct scientific research, including aerial-and ship-based scientific surveys, within the geographic analysis area. Marine surveys are conducted from federal and state vessels, chartered fishing vessels, planes, and autonomous vehicles using a variety of techniques and gears. These oceanographic surveys include long-term and seasonal scientific surveys conducted by NOAA for several regional programs, such as the California Current Ecosystem Survey and marine mammal population assessment surveys. The California Cooperative Oceanic Fisheries Investigations (CalCOFI) also conducts quarterly surveys off southern and central California to collect environmental and marine ecosystem data. Researchers use these data to study the California Current, manage its living resources, and monitor the indicators of El Niño and climate change. Under a partnership with NOAA and Scripps Institution of Oceanography, CalCOFI conducts quarterly surveys from north of San Francisco Bay to San Diego, which extend 500 km (300 mi) offshore, spanning state, national, and international waters. Historically, various marine research projects have been conducted within and around the Channel Islands National Marine Sanctuary. The proposed Alternatives off Santa Barbara and Santa Monica are nearby existing state, federal, and academic oceanographic research study sites.

Stressors

The main offshore activities that are introducing stressors (air and water pollutants) to the local marine environment within or vicinity of the Alternatives are primarily associated with oil and gas operations, pipeline (direct ocean outfalls), and vessel traffic. It should be noted the largest contributor of hydrocarbons are naturally occurring oil and gas seeps found in Southern California, including within the SCB (~ 26 tons/day). Produced water (water, oil, and gas mixture from extraction) from oil and gas operations represents the greatest discharge of petroleum-related chemical constituents followed by well completion and treatment fluids (Argonne National Laboratory 2019). Drilling and liquid (e.g., cooling water and fire control system water) waste is also discharged into the local waters from oil and gas operations. Despite these discharges, offshore oil and gas operations are considered a minimal contributor of pollution in the Santa Barbara Channel, but the amounts of hydrocarbon pollutants are higher than other anthropogenic sources (Lyon and Stein 2010); discharges from oil and gas platforms are smaller in volume and constituent mass then POTWs (Argonne National Laboratory 2019). There are six POTWs that discharge into the Santa Barbara Channel; however, they use secondary treatment and discharge less than 25 mgd (Continental Shelf Associates 2005). All discharges are restricted to uncontaminated or properly treated effluents that require best management practice or numeric pollutant concentration limitations as required through the US EPA National Pollutant Discharge Elimination System (NPDES) permits and USCG regulations. Another significant ongoing stressor is pollutants from marine vessels, which are responsible for contributing to GHG. It is well-documented that marine vessels with diesel engines emit pollutants contributing to GHGs, especially large ocean-going vessels (See Chapter 3 Section B.v).

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- Fixed gear, other equipment in the water column and surface; and
- Changes in vessel traffic volume and patterns.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Offshore energy (oil, gas and wind), marine minerals, submarine utilities (cables and pipelines), direct ocean-outfalls, and scientific research and surveys could be impacted by the proposed action, action alternatives, and ongoing and planned activities in the geographic analysis area. The potential impacts could vary in severity and magnitude. For instance, potential impacts could vary from an accidental anchoring issue along an oil and gas pipeline to impeding a scientific research survey.

In general, oil and gas operations, marine mineral operations, submarine utilities, and direct ocean-outfalls are not anticipated to be impacted by Alternatives 2-4 given the geographical distance to the structures and standard setbacks. Also, the offshore activities in the BOEM Wind energy areas may not be impacted by the Alternatives 2-4 given the closest WEA is offshore Morro Bay, which is more than 150 km (81 nm) away. The growth of offshore aquaculture within an identified AOA could disrupt established navigational patterns of marine vessels and increase vessel traffic volume that may have indirect impacts on operations associated with offshore energy and public services; for detailed discussion see Chapter 3 Section D.vi. (Transportation and Navigation). It is possible that oceanographic surveys could be impacted by the Proposed Action, but marine vessels operating in the area are used to spotting and avoiding structures/equipment and transiting vessels, such as commercial fishing gear and vessels. Any future offshore aquaculture structure (e.g., submerged cages) may need to use visible floats and lights as required by BOEM and USCG, which may reduce potential risk. Future oceanographic surveys may need to alter or adjust the sampling locations. Although the risk is low that Alternatives 2-4 may impact ongoing offshore activities in the region, there is potential risk that offshore activities could impact aquaculture operations. For instance, an oil and gas pipeline could accidentally rupture and release oil impacting aquaculture species or a marine vessel traversing near the area could collide with the aquaculture equipment destroying it and releasing the harvested species. Overall, the risk is low but the magnitude would be severe. In addition, inclement weather or unexpected aquaculture mooring system failure could cause aquaculture equipment to break away and potentially impact ongoing and planned offshore activities, such as becoming entangled with a random vessel traversing through the area.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The Santa Barbara Channel AOA options are located between 10.02 and 19.72 km (5.41 and 10.65 nm) offshore of Santa Barbara and Ventura Counties. Existing oil and gas operations, marine mineral operations, submarine utilities, ocean disposal, and direct ocean-outfalls are not anticipated to be impacted by Alternative 2 given the geographical distance to the structures. Offshore activities in the BOEM Wind energy areas may not be impacted by Alternative 2 because the closest WEA is more than 150 km (81 nm) away, offshore of Morro Bay. Alternative 2 (AOA options N1-A, N1-C, N2-C, and N2-E) overlaps with active BOEM lease blocks where leases could occur in the future. A 500 m (1640 ft) setback was used for existing oil and gas platforms because aquaculture operations and oil and gas operations in the same space are not expected to be compatible.

Since potential aquaculture equipment would be anchored and stationary, ongoing and planned oceanographic surveys may need to alter or adjust their sampling locations, such as the CalCOFI survey. The nearest CalCOFI site is 0.7 km (0.4 nm) from AOA option N2-D. Derelict gear could potentially impact ongoing and planned offshore activities, such as becoming entangled with a vessel traversing through the area.

Overall, it is probable the potential impacts on offshore energy and public services associated with Alternative 2 would be minimal. Offshore activities could also impact aquaculture operations. For instance, an oil and gas pipeline could accidentally rupture and release oil impacting aquaculture species or a traversing vessel could collide with the aquaculture equipment destroying it and releasing the harvested species. Future oil and gas leases could create incompatible use conflicts. Overall, the risk is low but the magnitude could be severe.

a) Shellfish and Macroalgae

There is most likely no difference between shellfish and macroalgae and finfish operations since impacts on offshore energy and public services are mediated solely by geography, for discussions on differing impacts between different types of aquaculture operations on vessel traffic, see Chapter 3, Section D.iv.

b) All Types of Commercial Aquaculture

There is most likely no difference between shellfish and macroalgae and finfish operations since impacts on offshore energy and public services are mediated solely by geography, for discussions on differing impacts between different types of aquaculture operations on vessel traffic, see Chapter 3, Section D.iv.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The Santa Monica Bay AOA options are located between 8.06 and 8.82 km (4.35 and 4.76 nm) offshore of Los Angeles County. Similar to Alternative 2, existing oil and gas operations, marine mineral operations, submarine utilities, ocean disposal, and direct ocean-outfalls are not anticipated to be impacted by Alternative 3 given the geographical distance to the structures and standard setbacks. The offshore activities in the BOEM Wind energy areas may not be impacted by Alternative 3 since the closest WEA is offshore Morro Bay. There are no active lease blocks in Alternative 3. Potential impacts to oceanographic research and monitoring may be reduced compared to Alternative 2, because there are no current CalCOFI sampling sites within 5 km (2.7 nm).

Overall, potential impacts associated with Alternative 3 would be negligible to minimal.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

Alternative 4: Combined Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. AOA options in both areas may result in fewer impacts than either alone should this alternative encourage more dispersed aquaculture activities. Alternatively, effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.

Similar to Alternatives 2 and 3, oil and gas operations, marine mineral operations, submarine utilities, and direct ocean-outfalls are not anticipated to be impacted by Alternative 4 given the geographical distance to the structures and standard setbacks, however the growth of offshore aquaculture within an identified AOA could disrupt established navigational patterns of marine vessels and increase vessel traffic volume that may have indirect impacts on operations associated with on-going offshore activitesImplementing Alternative 4 would probably have the same risks associated with potential storms and equipment failures as the other Alternatives.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

viii. Public Health and Safety

Affected Environment

Public health and safety may be thought of in a few different ways in the context of offshore aquaculture. Safety may relate to human welfare at sea, including homeland security and military defense; it may include work over water, exposure to rough conditions and gear interactions, and navigation safety. Public health may relate to marine debris, seafood safety, and nutrition. Without knowing what type of aquaculture, or product markets, may be pursued in potential aquaculture projects, it is difficult to speculate on the impacts of these topics. However, background information and a discussion of risk is provided since any site specific NEPA analyses would likely need to analyze the following topics as they relate to specific project descriptions.

Human Safety and Welfare at Sea

The Code of Federal Regulations Title 32 contains laws and regulations pertaining to national security and military readiness, including the Armed Forces, intelligence, and defense logistics (32 C.F.R. § 6). Guidance on compatibility of aquaculture operations in the study areas with DOD activities was provided through consultations with the Military Aviation and Installation Assurance Siting Clearinghouse (Morris et al. 2021). The way in which national security was incorporated into the Atlas is described in the following portions of the Atlas (Morris et al. 2021):

- Methods section Table 2.6 on p. 36 and Table 2.12 on p. 48;
- Results section pp. 51 through 55;
- Results section Figure 3.8 on p. 67;
- Results section p. 100; and
- Appendix A, p. A-1.

Future project applicants that may potentially-overlap with a military Operating Area (OPAREA) would also need to go through the DOD clearinghouse to ensure the most up to date information was applied to permitting decisions and any site specific NEPA analyses.

The USCG is responsible for homeland security and emergency services anywhere within the U.S. EEZ in accordance with international conventions to which the U.S. is a signatory party. Examples of international conventions that may apply to offshore aquaculture facilities include the following:

- the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) establishes safety at sea training and certification standards including radio communications, emergencies, and watchkeeping (USCG 2020);
- the International Convention on Maritime Search and Rescue establishes coordinated efforts, resources, trainings, and developed common search and rescue (SAR) plans for the safety of life at sea (USCG 2016); and
- the United Nations International Convention on Prevention of Pollution from Ships (MARPOL), the international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. In the United States, the convention is implemented through the Act to Prevent Pollution from Ships (APPS) (33 U.S.C. § 1905-1915).

The USCG assists other Federal and State authorities in the performance of their activities for the protection of the marine environment, as well as the enforcement of U.S. laws for the safety of life and property at sea (14 U.S.C. §2, 141). Under its authority in both the Ports and Waterways Safety Act (PWSA) and the Maritime Transportation Security Act (MTSA), the USCG may assess and regulate measures to address access control within territorial waters, defined as 0 to 12 nm from shore. Under the PWSA, USCG may control vessel traffic if it is warranted by hazardous conditions, and establish minimum safety equipment standards for structures located in, or adjacent to, territorial waters (33 U.S.C. § § 1225(a)). Under the MTSA, USCG may conduct security evaluations and vulnerability assessments, and enforce customs laws (46 U.S.C. § 70103). Permission to build any structure requiring private aids to navigation (PATONs), as well as permission to place PATONs in navigable waters, is required from the USCG (33 C.F.R. 66, 14 U.S.C. 542, 543, 544 and 43 U.S.C. 1333). PATON and other navigational safety considerations are included in Section D.vi. (Transportation and Navigation).

The USACE decision to issue a permit is based on an evaluation of impacts and the proposed activity's intended use on public interest, so that decisions reflect national concern for both the protection and utilization of resources. All aquaculture projects proposed in an AOA that would require a Section 10 permit from USACE would also be required to evaluate the public interest factors written in 33 CFR 320.4(a). The action to identify an AOA does not require a permit from any Federal agency; therefore public interest factors are not detailed explicitly in this DPEIS. However, the information provided in the impacts analysis and appendices of this DPEIS would help future applicants and the USACE in project-specific evaluations.

Seafood Safety

There is potential that aquaculture sited within an AOA would be for human consumption. The U.S. has a rigorous process for ensuring seafood products are safe for human consumption. There are seafood safety and sanitation programs, as well as therapeutic and drug approval systems established as they relate to public health and animal health (see Chapter 3, Section C.iv. (Potentially-Farmed Species) for animal topics. The FDA is the regulating body for ensuring food for human consumption is safe under the Federal Food, Drug, and Cosmetic Act (FDCA) (21 U.S.C. § 301). It is of note that the Minor Use and Minor Species Animal Health Act of 2004, which modified FDCA to make more medications for animal species and uncommon diseases legally available for veterinarians and animal owners, is not used for animal species that are used as food for humans or other animals (FDA 2024*)*. Additional FDA frameworks for regulating food are described on pp. 80 through 83 of Janasie (2023). FDA regulations that apply to aquaculture facilities are described on pp. 23 through 25 of the federal Guide to Permitting Marine Aquaculture in the United States (NMFS 2022b). FDA works to ensure consumer safety in conjunction with the NMFS Seafood Inspection Program (Nelson et al. 2019). The Seafood Inspection Program assures compliance with all applicable food regulations in fishing or transport vessels, at processing plants, and at retail facilities under the authority of the Agricultural Marketing Act, amended 2016 (50 C.F.R. § 260). The USDA Animal and Plant Health Inspection Service Veterinary Services (USDA APHIS VS), authorized under Animal Health Protection Act (AHPA) oversees the prevention, detection, control, and eradication of animal diseases in aquaculture (7 U.S.C. § 8322 and 10401) (see Chapter 3, Section C.iv. for animal health topics). The California Department of Public Health and the California Office of Environmental Health Hazard Assessment (OEHHA), a department within the California EPA, also have regulatory responsibility over seafood product safety in conjunction with the USDA and Federal EPA (CDFW 2010). Existing programs and protocols for biosecurity and seafood safety are specified under recommended mitigation, below.

Public Health Topics Related to Seafood Nutrition

The global human population is currently estimated at 7.9 billion people, and that number is expected to steadily climb to 8.5 billion by 2030 (UNEP 2019). Aquatic foods make a significant contribution to improve and diversify dietary intakes and promote nutritional well-being among most population groups (Brugere et al. 2010). Seafood comprises nearly 20% of animal protein consumed around the world, providing vital nutrition across developing countries and growing middle-class communities (Gephart et al. 2017). Modern human health sciences have recognized seafood for a myriad of health benefits to sustain and optimize human well-being and nutrition (Kromhout et al. 1985; Mozaffarian and Rimm 2006; Costello et al. 2020, Morris et al. 2021). The policy drivers described in Section 2 on pp. 2 and 3 of Rubino (2022) incorporate topics of public health including access to nutrients, access to protein, and climate resilient food systems. Public health topics related to nutrition and food security are likely to affect seafood consumption, and the drive for aquaculture, in the U.S. (Rubino (ed.) 2008).

Consumers seek out seafood products due to their associated health benefits. Seafood is an excellent source of high quality proteins and long chain omega-3 fatty acids that can contribute to good cardiovascular health, improved cellular function, and overall brain and nervous system function (Seierstad et al. 2005; Kris-Etherton et al. 2002; Guallar et al. 2002; Connor, 2000; Kromhout et al. 1985, Morris et al. 2021). Possible relationships between omega-3 fatty acids and disorders such as Alzheimer's disease, arthritis, depression, and asthma are also being studied (Nelson et al. 2019). Fish in the diet of pregnant women may also contribute to better brain and neural system development (FOA 2010). Using recommendations from doctors and nutritionists, the USDA and FDA 2020-2025 dietary guidelines for Americans encourage americans to eat more seafood, and include seafood as one of the core elements of a healthy dietary pattern to maintain good health (Mozaffarian and Rimm 2006, Institute of Medicine 2006, Steinberger et al. 2016, FDA 2023a). Advances in aquaculture production would be required to meet this expected demand (Rubino (ed.) 2008, CDFW 2019).

Plastics in the marine environment can enter the food web through leaching or through ingestion. Microplastics have been found in drinking water, and in marine and terrestrial organisms that humans consume (Coffin et al. 2022, Unuofin and Igwaran 2023, Milne et al. 2024). Seafood is a potential exposure pathway for humans to consume microplastics in the tissues of organisms. Aquaculture operations can be a source of plastic pollution (Skirtun et al. 2022, Lin et al. 2022). Smith et al. (2018) summarizes potential human exposure to contaminants from plastics through seafood in Table 2 on p. 378 of the study.

Stressors

Existing human health and seafood safety issues facing U.S. aquaculture, as identified by Sea Grant (2016) include:

- maintaining existing or developing new regulatory requirements to ensure a safe and sustainable seafood supply for export and import;
- developing rapid, affordable and FDA-approved tests to detect human pathogens and toxins;
- identifying and reducing impacts from existing and emerging contaminants and biotoxins;
- enhancing product quality and consumer confidence; and
- managing a sustainable resource.

The SCB is a busy ocean space with existing concerns for public health and safety. Stressors established in baseline conditions include vessel traffic, water quality concerns related to pollutants and marine debris, and associated health risks for seafood consumption harvested from such waters. The baseline public health impacts of ocean-based marine debris and its existing implications to California communities is summarized on pp. 38 and 39 of the California Ocean Litter Prevention Strategy (CalOPC 2018). Health risks from consumption of seafood organisms in the SCB have been historically-linked to petroleum, DDT, and PCBs in fish tissues, as well as harmful biotoxins in shellfish tissues (Schiff et al. 2000, LARWQCB 2011, Klasing and Brodberg 2015, McLaughlin et al. 2021). Globally and nationally, there are also existing perceptions about human health related to the potential consumption of bioengineered, genetically-modified products that may be produced from aquaculture.

Stressors that may be introduced to the baseline conditions if aquaculture was sited in an AOA include:

- fixed gear and other equipment in the water column and surface;
- more people working overwater in offshore environment;
- challenges for offshore monitoring and compliance, oversight and enforcement;
- challenges for seafood safety oversight; and
- changes to consumer trends and public health topics related to seafood.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Human Safety and Welfare at Sea

Aquaculture operations in an AOA could increase demand on offshore regulation compliance enforcement, and demand on emergency services. This could affect public health and safety in the offshore environment. During the development of the Atlas, DOD affirmed that offshore aquaculture in the SCB could be compatible with certain military training and operations; but projects would be subject to certain stipulations and final design review, depending on the most up to date military activities and information (Morris et al. 2021). Specific military-related information for each alternative area are provided below. Projects sited in an AOA would benefit from having this information ahead of project applications, potentially saving time and resources during permit consultations. However, due to the nature of military activities to vary over space and time, additional formal DOD clearinghouse coordination would likely be necessary at the time of permitting decisions in regard to aquaculture compatibility.

Restricted access zones may have an impact on new fixed gear and construction areas in the offshore space for the safety of human life and to prevent interactions with gear. Restricted access may be reserved during certain construction or maintenance activities, or for the lifespan of a project, depending on the activity and project design. Concerns about private property (e.g. aquaculture gear and the cultivated species) intruding on public space in the open ocean may arise.

During construction, operations, and decommissioning, there may be fixed gear and increased vessels in an area. All types of aquaculture operations may create safety concerns due to submerged gear and surface markers if proper awareness and prevention measures are not followed. Aquaculture gear in the offshore environment would likely have an array of anchors, lines, and moored structures or vessels. Structures may also include submerged pipelines, cables, and water intakes. Risks include a vessel colliding with a structure, vessel collision, structural damage due to environmental factors, or exposure to hazardous materials in the case of accidental spills or gear loss, and risk of marine debris. Vessel propellers may get caught in derelict gear, which could pose high health and safety risks. Public safety concerns may apply to occupants of structures as well as vessel passengers and crew. Incidents could also potentially involve commercial vessels and recreational vessels passing through the area.

Consideration would need to be given to the impact of the project on the safety of navigation in the immediate vicinity of the project, as well as other portions of the waterway or safety fairway that may reasonably be impacted by the project. As part of the USCG and USACE review of any moored structure, aids to navigation, or other changes to navigable waters, a risk assessment would be required to identify primary threats to waterway safety as well as to determine if a more extensive, technical risk analysis is necessary. Public interest factors that must be considered by the COTP are limited to reducing the possibility of personnel injury or loss of life; damage or loss of vessels, cargo, or structures in, on, or immediately adjacent to the navigable waters of the United States; and, damage to the marine environment (U.S.C. § 1221(c)).

Offshore waters provide certain benefits for aquaculture related to public health and safety. There is more space and depths relative to coastal environments for aquaculture to expand capacity and production while reducing social conflict, and lower exposure to terrestrial-sourced pollution (Bath et al. 2023). However, the design and engineering would also have to have advanced capabilities to withstand dynamic offshore environments. Gear loading and integrity may depend on the level of stocking, material buoyancy, and submerged depths; environmental exposure factors include wind, waves, and currents. Offshore aquaculture facilities would be located in areas that could experience large storms or tsunami waves, potentially resulting in damage, generating debris, or uncontrolled discharge of pollutants (CDFW 2019). These environmental factors may increase the risk of vessel and structural damage that could result from mishaps, or due to wear and tear over time. Engineering design factors would need to be analyzed to account for environmental-related uncertainties in the offshore environment. To analyze safety factors, a component's capacity for failure would need to be compared to the design response (Fredriksson and Beck-Stimpert 2019). Failure occurs when the strength of the component is less than that experienced from the environmental loading, and depends on the gear's ability to withstand or resist stress (e.g. materials' ability to withstand UV exposure, line tension under different current conditions, or ability of a net pen to maintain shape under impacts from waves) (Fredriksson and Beck-Stimpert 2019). Biofouling would likely occur at any growout facility. Biofouling, if left unmanaged, can increase the weight and drag of aquaculture gear which may be a concern for gear integrity (Fitridge et al. 2012).

Marine debris presents a number of public health and safety concerns, including navigational hazards. Marine debris accidentally dispersed from aquaculture projects may also have costs to shipping, recreation and tourism, and fishing (Mouat et al. 2010). Interactions with marine debris at an aquaculture facility may result in higher safety risks and in economic losses to aquaculture producers as a result of damage to vessels and equipment, time and resources spent for the removal of debris, and staff downtime while incidents or removal are reconciled (UNEP 2009). If marine debris became tangled in aquaculture gear, it may require divers to clear the debris and depending on the sea state, the work may be highly risky (Macfadyen et al. 2009). A study from Scotland that attempted to quantify the cost of dealing with marine debris at aquaculture facilities found that on average one hour per month was spent removing debris and disentangling fouled propellers could cost up to £1,200 (approximately $1,500 USD) per incident, costing the industry an estimated average of € 155,548 ($169,248 USD) per year, nationally (Hall 2000).

Seafood Safety

Industrial practices for human food are related to public health concerns related to organism health and disease management. Globally, intensified aquaculture production has led to increased pressures to improve production performance and the widespread movement of aquatic animals, increasing the likelihood of disease issues and transport (Brugere et al. 2010). Human infectious diseases that are zoonotic (carried by animals) can be fueled directly by changes in the environment related to intensive systems of husbandry and farming monoculture, and indirectly by changing patterns of animal movements (Webster et al. 2015). Toxins and chemical contaminants in the marine environment have also been found to enhance the rate of emerging diseases in people and wildlife, relating water quality issues to human health (Keller et al. 2005, Braaten 2007, Price et al. 2013, Webb 2014, Mashkour et al. 2020, Klasing and Brodberg 2015, Rhodes et al. 2023b). Seafood safety measures are already well established in the U.S. and in California for wild-harvested species, international aquaculture imports, and domestic nearshore aquaculture products. The biosecurity measures described in this DPEIS are existing regulatory mechanisms to minimize risk of disease by establishing strategic and integrated approaches into U.S. policy and regulatory frameworks aimed at analyzing and managing risks relevant to human, animal and plant life and health, including associated environmental risks. Any aquaculture projects sited in an AOA would need to coordinate with state and local agencies for appropriate transport, testing, and other established regulatory requirements. Biosecurity and seafood safety measures are specified under each sub-alternative, below.

If the identification of an AOA influences a growth of seafood supply in the region, there may be an increased demand on seafood safety compliance and quality control systems. The new amount of product from large-scale, offshore operations would likely be much greater than the current small operations in the region and WCR. Initially, this could cause bottlenecks in transport, testing, or other stages of regulatory systems for seafood safety. Bottlenecks in regulatory processing may impact product viability, and business costs. Healthy products are required by U.S. biosecurity regulations. In addition, healthy products are more competitive in global markets (Brugere et al. 2010). Strong biosecurity programs can indirectly help communities by increasing incomes, and improve resiliency by enabling them to effectively respond to the impacts of production risks (Brugere et al. 2010). Overtime, increased demand for biosecurity logistics in the U.S., as well as potential increased demand for products produced under U.S. biosecurity controls could stimulate increased market supply and private investments to support efficient production.

Public Health Topics Related to Seafood

If the identification of an AOA leads to a competitive domestic aquaculture industry, it may provide Americans' better access to affordable and nutritional protein options. This benefit would be realized as a combined result of increased seafood production, targeted sales and marketing, and increased social license of aquacultured products. Beyond providing food, involvement in aquaculture has shown globally to strengthen people's capacity to exercise their right to food through employment, community development, generating income and accumulating other assets (Brugere et al. 2010).

Marine debris is related to risks associated with leached chemicals or microplastics entering the marine foodweb. Human impacts from marine debris are described on pp. 12 and 13 in the EPA report, Marine Debris in the North Pacific (2011). Microplastics in seafood have the potential to impact food security and human health (Smith et al. 2018, Andreas et al. 2021, Bennett et al. 2022, Unuofin and Igwaran 2023). Studies indicate that there is little difference, or mixed results depending on the country of origin, in the amount of microplastics found among different types of animal protein, including comparing cultured and wild sources; however, there is a difference indicated by the amount of processing in the food product (Andreas et al. 2021, Ramasamy and Subramanian 2021, Alberghini et al. 2023, Milne et al. 2024). Seafood products may be less processed than other plant and animal protein choices, as shown in Figure 2 on p. 4, and in Table 1 on p. 7 of Milne et al. (2024). If the identification of an AOA increases minimally-processed, seafood-sourced protein for human consumption, it could help to address the risk of microplastics in animal-based protein choices.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

The following drivers of biodiversity may continue with or without the identification of an AOA or the potential growth of aquaculture in the U.S. Changes in biodiversity globally are related to public health and economic trends, including changes in demographics, in consumer demands, and in international trade dynamics (Brugere et al. 2010). Ecosystems around the world are becoming increasingly fragmented, and species used for food and medicine are at an increasing risk of extinction (Brugere et al. 2010). In addition to the decline in wild species populations, there has also been a decline in genetic diversity, both in natural ecosystems and in systems of crop, livestock, and aquaculture production (Brugere et al. 2010). Increased reliance on cultivated species, in combination with loss of diversity in natural and cultivated populations, would be a concern for the sustainability of any species used to sustain human livelihoods (Brugere et al. 2010). Marine aquaculture could counteract other global practices of agriculture and land-based aquaculture that contribute to unsustainable practices in water consumption, use of pesticides and fertilizers, land development, and conversion of natural habitats (finfish aquaculture would still rely on either wild harvest or terrestrial sources of feed produced through agriculture) (Brugere et al. 2010).

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

All N2 AOA options in Alternative 2 (the eastern side) overlap with the Military Training Route (MTR) and special use airspace (SUA). Due to the nature of military activities to vary over space and time, additional formal DOD clearinghouse coordination would likely be necessary at the time of permitting decisions in regard to aquaculture compatibility. This may create additional time and cost to permit application processes in order to sufficiently coordinate with the DOD and FAA. It could also create additional public safety risks relative to other areas due to military training activities that could occur. The MTR and SUA also impose limitations on civilian aircraft operations, which may impose additional considerations for operations and maintenance.

Predominant wind and ocean currents in the Santa Barbara Channel may help to alleviate pressures related to land-based marine debris and pollutants; but aquaculture projects would need to consider site location relative to other aquaculture facilities and offshore infrastructure to properly assess risk of marine debris and effluents from other ocean-based sources. Significant and complex eddies in the Santa Barbara Channel can entrain and trap waters carrying contaminants, such as oil from natural seeps or anthropogenic sources (Rhodes et al. 2023a). Evidence from Channel Islands beach surveys show heavier debris, mostly associated with fisheries gear, gathers on offshore beaches more than on the mainland (Miller et al. 2018, Steele and Miller 2022). Localized changes to hydrology due to gear placement may also act to accumulate materials close to facilities, and close to wildlife aggregations.

a) Shellfish and Macroalgae

Macroalgae

An example of how USACE Section 10 public interest factors were analyzed for a kelp facility in the Santa Barbara Channel are summarized in Table 4 on pp. 17 through 21 of USACE (2021). In addition to surface buoys or anchored lines that would be present for all types of aquaculture operations, growing vegetation or shellfish on longlines at facilities could entangle vessels transiting through the area which could cause vessel damage and safety incidents. Required structural performance monitoring was incorporated into the EA for offshore kelp aquaculture in the Santa Barbara Channel. It is likely that any offshore aquaculture facility sited in an AOA would be subject to the same or similar requirements. These conditions are described in Section 12.2 of USACE (2021).

The food market is thought to be one of the most profitable markets for macroalgae that may be grown in offshore aquaculture. If the identification of an AOA led to higher availability of seaweed food products on the market, there may be a new opportunity for consumer access and affordability due to increased availability, or from new products and marketing. Seaweeds and macroalgae are used in many food markets as a nutritious additive. Seaweeds are rich in macronutrients including calcium, magnesium, potassium, as well as micronutrients including iodine, iron, zine and others (FAO 2018, Kamal et al. 2023). Added nutritional value of different seaweed products are provided in Table 5 on p. 7 of Sultana et al. (2023). Benefits come with certain biohazard risks. Seaweed and macroalgae serve as a substrate for other biological organisms in the marine environment, so there are risks of housing biofouling organisms and transporting undesired organisms, even with healthy-looking crops (Rhodes et al. 2023b). Salmonella, heavy metals, bacteria and viruses may be associated with harvested seaweeds (Kamal et al. 2023, Janasie 2023). A list of potential chemical exposures from seaweed and macroalgae products, required under the California Safe Drinking Water and Toxic Enforcement Act (Prop. 65) is provided on Maine Coast Sea Vegetables' website (SeaVeg n.d., accessed May 2024).

Seafood safety topics surrounding seaweed aquaculture in the U.S. are still developing at state and Federal levels. Federally, seaweed is recognized as a raw agricultural commodity, with no Federal oversight during growth or harvest (NSGLC 2023). Typically after harvest, cleaning and fallowing or cleaning and disinfection (e.g., sun-drying) is used to break pathogen transmission between crop cycles (Rhodes et al. 2023b). Once processed, the Food Safety and Modernization Act's Preventive Controls for Human Foods (PCHF), which includes current Good Manufacturing Practices, and the FDA's Seafood Hazard Critical Control points (HACCP) regulations are used to regulate seaweed food safety. The PCHF and Seafood HACCP regulations focus on preventive food safety programs that are designed to identify significant hazards and implement controls to prevent those hazards from occurring. Existing regulatory mechanisms, programs, and protocols applicable to seaweed/macroalgae aquaculture that would minimize risks of seafood safety impacts are included under recommended mitigation, below

Consistency in quality products relates to how well a company understands what is necessary to produce a safe product. The system places the logistical burden to ensure safety on state and federal government, which in turn affects public confidence in the safety and wholesomeness of these products (60 FR 65096). In addition, preventative controls differ depending on the type of seaweed product produced, the specific actions that go into processing the product, and if the business meets the threshold to be considered a small business (see Appendix 3) (Janasie 2023, NSGLC 2023). It is likely that projects sited in an AOA would be large businesses, due to the start-up costs for an offshore project. In this case, the identification of an AOA could streamline large businesses to overtake seaweed food markets because they may be favored in a more straightforward way with current safety measures. This could perpetuate the disparity in large businesses being able to dominate the potential economic opportunities from an AOA (see similar discussion in Section D.iv (Working Waterfronts)).

Shellfish

Structural capacities of the mooring lines, longlines, and anchor systems for a proposed shellfish operation have been studied in the Santa Barbara Channel, and provide the best available information for potential gear integrity, related to public health and safety. One project, calculated minimum required capacities of structural components for shellfish facilities under three design scenarios, in accordance with offshore industry standards that require certain safety factors (the ratio of ultimate capacity (e.g. breaking strength) to the maximum expected demand (e.g. the maximum expected tension)). Buoyancy, line length, submerged depths, and predator avoidance methods were also factored into gear integrity modeling. Similarly, another study evaluated gear strengths to meet or exceed required structural capacities, as well as minimal breaking strength with break-away links to prevent entanglement or cascade effects due to gear failure. These modeled scenarios may provide a template for future projects sited in an AOA, which would need to calculate these components per individual project designs.

The risk from pollutants that may leach from plastics or other disposed materials in the marine environment could accumulate in the tissues of cultivated shellfish. Water quality issues for invertebrate pathogens and public health pathogens are related (FDA 2020, Rhodes et al. 2023b). However, these risks are similar in farmed and wild seafood, with most samples in the U.S. being below FDA approved levels (Smith et al. 2018, Nelson et al. 2019). A more prominent risk in the SCB for shellfish cultivation is the risk of oil spills or HABs. Bivalve mollusks cannot swim away from a pollutant, and do not metabolize potential carcinogens as rapidly as finfish and some other shellfish (Klasing and Brodberg 2015). The risk of biotoxin uptake in shellfish may be higher between May 1 and October 31 when phytoplankton uptake is higher in shellfish (CDFW 2010). Existing regulatory mechanisms, programs, and protocols applicable to shellfish aquaculture that would minimize risks of seafood safety impacts are included under recommended mitigation, in Appendix 1.

b) All Types of Commercial Aquaculture

Structural integrity for finfish systems carry all the same risks to public health and safety as macroalgae and shellfish gear, related to risk of collision, entanglement, and marine debris. There are some additional considerations for finfish systems that would be needed in engineering evaluations, compared to shellfish and macroalgae gear systems. For example, in offshore finfish operations, it is likely that automated feed systems would be utilized. Large feed system mooring systems may be designed and evaluated separately from the containment system; and additional dynamic loading analysis may need to be modified to incorporate specific motion response characteristics in both the typical and extreme loading conditions, as well as with full versus empty configurations (Fredriksson and Beck-Stimpert 2019). Engineering evaluations would also need to address the risk of compromised gear allowing cultured animals to escape (Fredriksson and Beck-Stimpert 2019). Another human safety concern that may be more pronounced associated with finfish aquaculture is the risk of shark or marine mammal interactions. FADs are a confirmed impact of marine finfish aquaculture facilities. Potential Shark and marine mammal entanglements pose danger not only to marine life, but to human operators as well (Bath et al. 2023). Pinniped attacks on cage divers have also been reported in finfish aquaculture (Price and Morris 2013). Recreational fishers and divers that may be drawn to the area may also be at higher risk of shark interactions, in addition to marine mammals, around FADs.

Fish provide unique nutritional benefits, but also serve as a potential exposure pathway for several chemicals of concern. The risk from pollutants found in the SCB could accumulate in the tissues of cultivated finfish, as has been found evident in commercially and recreationally-targeted species in the SCB (Schiff et al. 2000, LARWQCB 2011, Klasing and Brodberg 2015, Spyrka 2017, McLaughlin et al. 2021). Potential human health concerns related to finfish aquaculture production include the potential increase in use of formulated food, and the use of antibiotic or other husbandry materials. If these aquaculture practices potentially lead to elevated levels of antibiotic residuals, antibiotic-resistant bacteria, persistent organic pollutants, metals, parasites, and viruses in cultured finfish, then people working in and around aquaculture facilities and consumers could be at potential risk of exposure to these contaminants (Sapkota, et al. 2008). However, these risks are similar in farmed and wild seafood, with most samples in the U.S. being below FDA approved levels (Nelson et al. 2019). Cultured finfish could additionally ingest plastics occurring in the marine environment. Microplastics pose health risks to both wildlife and humans (Smith et al. 2018, Andreas et al. 2021, Unuofin and Igwaran 2023). Based on the literature reviewed in preparation of this DPEIS, more research is needed to indicate if there are differences in the potential accumulation of plastics in the consumed tissues of cultivated finfish versus shellfish, or between cultivated and wild-caught finfish. Existing regulatory mechanisms, programs, and protocols applicable to finfish or IMTA aquaculture that would minimize risks of seafood safety impacts are included under recommended mitigation, below.

Information on commercial IMTA is limited; but stakeholders also have food safety concerns associated with the potential technologies that would grow multiple species or trophic levels together. It is unclear what cumulative impact may arise from combining different systems in an offshore facility. An example in IMTA is if shellfish were used to utilize fish waste or mitigate nutrient loading, any exposure pathway from fish to humans may also be created in the shellfish. Ratcliff et al. (2016) found that seaweeds cultivated in IMTA had raised heavy metal concentrations compared to monoculture seaweed production; however, concentrations of metals were within the range of those from algae collected from undisturbed wild populations. Concentrated metals were found not to exceed regulatory limits, with the exception of arsenic (regulatory limits in the UK, see Table 4 on p. 241 of Ratcliff et al. (2016) for quantified results that may be compared to FDA and USDA limits in the U.S.). According to literature and stakeholder interviews reviewed in Alexander et al. (2016), consumer concerns associated with IMTA is a lack of proof of concept, regulations, and inadequacies in planning and management. Public perceptions are important to factor into financial risk and product viability because they can influence policy and consumer choices (Alexander et al. 2016). IMTA may have higher start-up costs due to these unknowns.

Despite the risks, fish are an excellent source of protein, beneficial fats, and other micronutrients that are essential to human health. Still, there are trade-offs to be aware of in analyzing these benefits. Aquaculture products may have a nutrition profile differing from wild counterparts, particularly in relation to the content of the beneficial long-chained omega-3 fatty acids (Brugere et al. 2010). According to studies reviewed in Hicks et al. (2019), smaller fish species have higher concentrations of important micronutrients (e.g. zinc, calcium, iron). An important ecological trade-off to be aware of is that if finfish aquaculture in the region increased fishing pressure on smaller species and forage species for feed purposes, it could leave less nutrient-rich in the ecosystem available to marine life and recreational or subsistence fishers.

Concerns regarding food safety in fish products globally have placed focus on the value of expanding a domestic supply, as well as economic and environmental considerations related to “food miles” as seafood products are transported over great distances for packaging and final marketing (CDFW 2010). If the identification of an AOA increased domestic fish seafood supply, under the stringent regulatory mechanisms for U.S. seafood sourcing and quality testing, it would potentially help alleviate some of these concerns. In addition, using global examples from salmon production, Krause et al. (2020) found that finfish aquaculture companies invest in community initiatives which promote positive health outcomes, directly by increasing the availability of seafood as well as indirectly by increasing attention, viability, and capital into communities. Literature review and stakeholder interviews in Alexander et al. (2016) also showed that socio-economic benefits from aquaculture are recognized as positive outcomes related to consumers and animal welfare.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

According to the spatial analysis and military coordination in the development of the Atlas, there are no currently-known MTRs in Alternative 3. All documented formerly-used defense sites occur south of the alternative area. The overlap of the San Pedro Channel Operating Area (see Figure 3.1 on p. 53 of the Atlas is not anticipated to be a major constraint for aquaculture development, based on review by the DOD provided for the Atlas, as Appendix D in Morris et al. (2021). Due to the nature of military activities to vary over space and time, additional formal DOD clearinghouse coordination would likely be necessary at the time of permitting decisions in regard to aquaculture compatibility.

Rapid population growth and industrialization in the greater Los Angeles area have historically strained the marine environment of Santa Monica Bay. Many of the pollutants that wash into the Bay from land based run-off are known to pose health hazards for people and for fish and other wildlife (Schiff et al. 2000, USGS 2003, LARWQCB 2011). There has been a lot of research and conservation work done in the area to monitor and determine the distribution of contaminants; and an understanding of the work with effective management of any aquaculture project in the area would be necessary to minimize the risk of public health impacts. For example, advisories for recreational fishers are posted when advisory tissue concentrations of DDTs and PCBs exceed threshold limits set by the State, restricting consumption (Schiff et al. 2000, McLaughlin et al. 2021). Cultivated species grown within Alternative 3 may be impacted by these baseline water quality concerns. It is not likely that aquaculture projects would have higher risk of accumulating toxins or microplastics than wild-harvested species (which is limited to recreational catch, with seasonal health advisories). BMPs and contingency management would be important to implement in Alternative 3 so that any potential water quality impacts or risk of spills from an aquaculture project would not create cumulative impacts with baseline stressors. BMPs for preventing marine debris and other spills are included under mitigation in Chapter 3, Section B.iv. (Water Quality). BMPs for seafood safety are included under recommended mitigation in this section, below.

Predominant currents towards the southeast and swell from the west in the offshore area of Santa Monica Bay may help to alleviate pressures related to marine debris and pollutants from coastal resources (Morris et al. 2021). However, NPDES data show that movement of discharge plumes in Santa Monica Bay during storms and high flow events is highly variable (LARWQCB 2011). Complex eddies in the Santa Monica Basin can entrain and trap waters carrying contaminants, such as oil from natural seeps or anthropogenic sources (Rhodes et al. 2023a). Santa Monica Canyon is the closest bathymetric feature that may accumulate debris at the seafloor, located south, within 2 nm from both AOA options within Alternative 3. This canyon may help to mitigate against higher concentrations of existing contaminants that are concentrated near the Palos Verdes Shelf, a designated Superfund site by the EPA. Palos-Verdes shelf is located further south and down-current of Alternative 3 and Santa Monica Canyon.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section. Historic environmental concerns related to water quality in Santa Monica Bay may exacerbate public concern, planning and management logistics, and operation costs related to potential public health and safety concerns in the area.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

Alternative 4: Combined Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. AOAs in both areas may distribute risks to more communities. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from shellfish and macroalgae aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

ix. Environmental Justice Considerations

Affected Environment

Environmental justice means (EJ) the just treatment and meaningful involvement of all people, regardless of income, race, color, national origin, Tribal affiliation, or disability, in agency decision-making and other Federal activities (EPA 2022, NMFS 2023k). EJ topics are considered in Federal actions, including under NEPA, so that people are fully protected from disproportionate and adverse human health and environmental effects (including risks) and hazards, including those related to climate change, the cumulative impacts of environmental and other burdens, and the legacy of racism or other structural or systemic barriers; and have equitable access to a healthy, sustainable, and resilient environment in which to live, play, work, learn, grow, worship, and engage in cultural and subsistence practices (EPA 2024b).

A series of Executive Orders (E.O.s) establish federal policy on equity and environmental justice: Executive Order E.O. 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (E.O. 12898) (1994, amended 1995), E.O. 14008, "Tackling the Climate Crisis at Home and Abroad" (E.O. 14008) (2021), and E.O. 13985, "Advancing Racial Equity and Support for Underserved Communities Through the Federal Government" (E.O. 13985) (2021), and E.O. 14096, "Revitalizing our Nation's Commitment to Environmental Justice for All" (E.O. 14096) (2023). These are summarized on pp. 2 and 3 of the EPA's Environmental Justice and Civil Rights in Permitting Frequently Asked Questions (EPA 2022). Policy mandates are also outlined on pp. 7 through 9 of the NOAA Fisheries Equity and Environmental Justice Strategy, (NMFS 2023k). These executive orders build upon civil rights laws Title VI of the Civil Rights Act of 1964, 42 United States Code §§ 2000d to

2000d-7 (Title VI); Section 504 of the Rehabilitation Act of 1973, as amended, 29 U.S.C. § 794; Title IX of the Education Amendments of 1972, as amended, 20 U.S.C. §§ 1681 et seq.; Age Discrimination Act of 1975, 42 U.S.C. §§ 6101 et seq.; Federal Water Pollution Control Act Amendments of 1972, Pub. L. 92-500 § 13, 86 Stat. 903 (codified as amended at 33 U.S.C. § 1251 (1972)); 40 C.F.R. Parts 5 and 7 (EPA 2022). EJ principles and practices call for mitigation measures that reduce or eliminate unfair treatment and/or effectively address adverse and disproportionate impacts.

Stressors

Common concerns voiced by communities affected by EJ concerns related to project development often include potential noise issues, visual impairments, possible environmental impacts that could then potentially also lead to public health impacts (in humans or local animals). Impacts to the environment and health are intertwined with cultural impacts, as EJ communities may view the health and aesthetics of the area as part of their cultural heritage and values (see Chapter 3, Section E). There may be beneficial and adverse socioeconomic impacts that may affect the cultural expressions of communities working in fishing, tourism, and other industries.

Lack of representation has historically been a central EJ issue nationwide, and those considerations would apply in the offshore aquaculture sector. Engagement policies and best practices championed by applicable agencies help, but there are still not many community advocacy groups dedicated to aquaculture. The potential lack of representation and capacity for engagement can be a stressor to communities experiencing EJ concerns, who want to participate in the process of identifying (or choosing not to identify) AOAs.

Community resilience is the capacity of individuals and households to absorb, endure, and recover from health, social, and economic impacts (U.S. Census Bureau 2022). The term is often used to analyze impacts from a disaster, such as an earthquake or pandemic; but may be used to think about a community's ability to withstand the effects of an action or event. Variation in individual and household characteristics can determine the capacity and resources to overcome obstacles over time and potentially-brought about by change (Schlosberg et al. 2017, U.S. Census Bureau 2022, Michaelis 2024 (draft)). These may include income, caregivers in a household, language spoken, age, disabilities, access to transportation, access to internet, access to health resources and insurance. Disadvantaged community is defined in California law (SB S3S, Health and Safety Code § 39711) and takes into consideration environmental pollution and other hazards that can lead to negative health effects, exposure, or environmental degradation, as well as concentrations of low income, high unemployment, and other socioeconomic factors that may leave communities disproportionately vulnerable adverse impacts (CSLC 2018).

There is a persistent relationship between the exposure to environmental burdens and socio-economic and health vulnerabilities that affects low-income communities, communities of color, Tribal nations and other disadvantaged groups. The U.S. and California's history includes segregation, redlining, discrimination in land use, permitting and enforcement practices that have resulted in industrial facilities, landfills, ports and rail yards, and high pesticide use clustered around low-income communities of color (Zeise and Blumenfeld 2021). Race/ethnicity compositions and age distribution is an important context with which to understand environmental inequity in California, with the highest percentages of people of color living in the most highly impacted communities (Zeise and Blumenfeld 2021). Human activities in the SCB, including oil and gas exploration and exploitation, oil pipeline construction and operation, shipping and transportation, aquaculture operations, desalination plants, and coastal cities with inadequate liquid and solid waste management generate high pollution footprints that are linked to EJ concerns for community health, livelihoods, and human rights (Bennett et al. 2022).

Environmental quality has improved over the last few decades as evidenced by CWA, CAA, decreased pesticide use, continued cleanup of hazardous waste sites, and reduced waste dumping into waterways. However, efforts and the resulting health and environmental benefits are not uniformly distributed across the state, within a region, or among all population segments (Ziese and Blumenfeld 2021). Choices made in cost-benefit analyses can unintentionally or intentionally devalue the experiences and needs of certain groups; and present-day power to inform decision-making can be hindered based on historic representation in politics and ability to participate in management systems (Schlosberg et al. 2017, CSLC 2018, Bennett et al. 2022). This history implies that there is potential for disadvantaged communities to occur near ports and other industrial coastal areas where shore side auxiliary facilities for offshore aquaculture facilities may be utilized. Therefore, the growth of an offshore aquaculture industry has the potential to perpetuate existing stressors on those communities.

Communities and individuals who rely on the ocean may also experience higher social vulnerabilities compared to other individuals in the same geographic coastal area. EJ concerns associated with strong ocean use include access to subsistence fishing or other harvests, exposure to toxins in harvested food, biodiversity and ecosystem service declines, and other factors associated with climate change in the ocean. Globally and nationally, indigenous groups, small-scale fishers, Afro-American communities, women and children are disproportionately impacted (Bennett et al. 2022).

There are historic social stressors related to gender and racial equity, human rights, and inclusivity in aquaculture and the seafood sector that may leave certain individuals more or less vulnerable to the potential impacts from changes in the industry, and more or less likely to realize potential benefits of an action. Business owners that have faced historic institutional barriers linked to racial discrimination in the U.S. now face economic and market barriers related to disempowerment and low starting levels of capital (Baboolall et al. 2020). Data analyzed through 2019 show that black business owners in the U.S. hold less equity in their businesses than white counterparts, and have been disproportionately affected by the COVID-19 pandemic-linked economic downturn (Baboolall et al. 2020). Women and children often experience adverse impacts disproportionately because they are already disadvantaged socioeconomically (Bennett et al. 2022). Women's contributions to fisheries and seafood sectors are still often unrecognized and understood poorly, linked to sociocultural assumptions and intertwined with unrecognized labor or responsibilities to support family well-being – especially in family-owned or otherwise small-scale income scenarios (Calhoun et al. 2016, Szymkowiak and Rhodes-Reese 2020, World Bank Group 2020, World Ocean Initiative 2022).

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The potential impacts associated with physical, biological, and socioeconomic environments are described in Chapter 3, Sections B, C, and D, respectively. Impacts on the natural and human environment are all interconnected to potential EJ concerns. However, without knowing specific components of a project, the differences in impacts between types of aquaculture may not inform the programmatic analysis that can be provided in this DPEIS. Therefore, the sub-alternatives are not discussed further than in previous sections of this DPEIS.

EJ practices and mitigation measures depend on the unique circumstances of each permit, the community in which the pollution source is or would be located, and other factors that have not yet been determined in preparation for this DPEIS. This DPEIS does, however, put together some background information and tools that would inform EJ considerations in any site specific NEPA analysis and future permitting decisions for any aquaculture project sited in an AOA. This subsection of the DPEIS applies to EJ topics related to economic and public health and safety resources, in contrast to EJ considerations more closely related to cultural and historic resources, discussed in Chapter 3, Section E.iv.

Methodologies for conducting environmental justice analyses create opportunities for considering a range of mitigations that can be pursued if appropriate under federal or state environmental and environmental justice laws, and can also be relevant to consideration of civil rights compliance (EPA 2022). If there are no mitigation measures the permitting authority can take, whether within or outside the permitting program, that can address the disparate impacts, and there is no legally sufficient justification for the disparate impacts, denial of the permit may be the only way to avoid a violation. Whether denial of a permit is required to avoid a violation is a fact-specific determination that would take into account an array of circumstances, including whether the facility may have an unjustified racially disproportionate impact, as well as the less discriminatory alternatives available.

U.S. census tracts are commonly used to inform EJ analyses. Census tracts are the smaller geographic unit for nationwide demographic data (Zeise and Blumenfeld 2021, CEQ 2023). There are approximately 8,000 census tracts in California (Zeise and Blumenfeld 2021). Federal resources and potential impacts from Federal actions may also affect smaller demographic units, including cities, regional community representative organizations, or individual households. Methods to account for these smaller geographic and demographic units are described on p. 8 of the CEQ's Climate and Economic Justice Screening Tool (CEJST) Instructions (CEQ 2023). The U.S. Census Bureau has also developed new small area estimates, identifying communities where resources and information may effectively mitigate the impact of disasters (U.S. Census Bureau 2022). Some of those methods may be applied to any community disruption.

The following tools may be used to identify communities that may be at risk of EJ concerns, once project-specific location details are known:

- The U.S. Council on Environmental Quality (CEQ) developed the CEJST in accordance with E.O. 14008 and the Justice40 Initiative. The publicly-available tool has an interactive map and uses nationally-consistent datasets from U.S. census tracts that are indicators of environmental burdens. The tool uses this information to identify communities that are experiencing those burdens, and identifies the communities as disadvantaged because they are overburdened and underserved (CEQ 2023). Materials are available in English and in Spanish. The screening tool is available online at https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5. Instructions for Federal agencies on using the tool are also available online at https://screeningtool.geoplatform.gov/en/about. Agencies should use all categories of burdens and the collective list of disadvantaged communities identified by the tool as a starting point. Agencies may prioritize within the list of disadvantaged communities. Agencies may use their own data and metrics to prioritize certain communities within the set of disadvantaged communities identified by the CEJST, to the extent permitted by law.
- EJSCREEN is the EPA's mapping and screening tool that provides a nationally consistent dataset and approach for combining environmental and demographic indicators. The mapping tool is available online at https://ejscreen.epa.gov/mapper/. In addition, the EPA offers EnviroAtlas, which provides geospatial data, easy-to-use tools, and other resources related to ecosystem services, their chemical and non-chemical stressors, and human health. This tool is available online at https://www.epa.gov/enviroatlas.
- California EPA's CalEnviroScreen 4.0 is an online tool to identify disadvantaged communities in accordance with California State Bill 535 (2022), and cumulative impacts in California communities by census tract. It is a science-based screening tool to demonstrate, from a geospatial perspective, who is most affected by environmental injustice, based on environmental conditions or a population's vulnerability to environmental pollutants (Zeise and Blumenfeld 2021). Materials are available in English and in Spanish. The online mapper and associated reports can be found online at: https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40.
- NOAA Fisheries Online Social Indicators Tool, used in Michaelis (2024 (draft)), characterizes community well-being for coastal communities engaged in fishing activities, and can help to evaluate a community's vulnerability and resilience to disturbance. Three of the indicators in the NOAA Fisheries Community Social Vulnerability Toolbox can be used for mandated EJ analyses: poverty, population composition, and personal disruption. The communities identified

through the use of the NOAA social indicators are included under each alternative, below. This tool should be revisited with the most up to date information at the time of future permitting decisions under any site specific NEPA analysis. The tool is available online at https://www.st.nmfs.noaa.gov/data-and-tools/social-indicators/. In addition, the NOAA Fisheries Community Profiles for West Coast and North Pacific Fisheries (Norman et al. 2007) provides population structure and demographics for fishing communities in California. The statewide results are shown on pp. 20 through 23 of the report.

The following topics should be considered in any site specific NEPA analysis for specific aquaculture projects to address potential EJ concerns:

- local history of discrimination and/or racism in economic opportunity (e.g. fisheries exclusion);
- public health topics associated with seafood safety and pollutant exposure;
- principles of food justice, related to nutrition, access to healthy, affordable seafood and other proteins; and
- potential for progressive barriers to entry due to financial impacts that may accumulate over time, as the first projects may set prerequisite baseline conditions for siting and monitoring for any following permit applications.

Potential economic benefits of an AOA would likely be realized by large businesses or investors with established capital in the aquaculture industry due to the high start-up costs required for offshore infrastructure (see discussions in Section D.iv. (Ports and Working Waterfronts) and Section D.viii. (Public Health and Safety, sub-alternative (a) seaweed and food safety). The disproportionate advantage for large-scale businesses to take part in AOA-siting benefits may perpetuate disparities in business ownership, employment, and income, depending on where shore side components of an aquaculture project took place.

If existing local businesses were not able to participate in the potential growth or facilitation of the offshore aquaculture industry, then there may be disproportionate risk to small-scale businesses being outcompeted in markets if an AOA were identified. Without thoughtful planning for disproportionate impacts to certain communities, offshore aquaculture could adversely impact the current aquaculture industry, which is made up of a small number of small businesses in California (Fujita et al. 2023, CDFW 2020a). Even if production is increased, it may still be necessary to target new product distribution to improve food security and nutritional outcomes (Fujita et al. 2023). See Chapter 3, Section D.iv. for more information about how small businesses in the aquaculture and wild-harvest seafood sectors are defined and considered.

In contrast, new opportunities in employment and trade, if brought about by the identification of an AOA, may help to alleviate some of the race and gender gaps in socioeconomic participation in ocean-related industries. According to a 2015 Department of Commerce (DOC) Minority Business Development Agency (MBDA) report, minority-owned businesses are twice as likely to export goods; three times as likely to already have international operations and six times as likely to transact business in a language other than English (Freeman 2015). These operational factors could strategically position minority-owned businesses to participate in potential economic benefits from the growth of the aquaculture industry for any exported products, and could aid in any increase in competitiveness in domestic and global markets. Engagement in international sales and trade can lead to stronger businesses domestically, create new jobs, and contribute to economic sustainability (Freeman 2015). When women are employed in sectors with high levels of exports, they are more likely to be formally employed in a job with better benefits, training and security (World Bank Group 2020). Global data shows that trade increases women's wages and increases economic equality (World Bank Group 2020).

Potential impacts that may be caused by future permitting decisions may be even greater when considering cumulative impacts from other stressors. In the context of NEPA and EJ, the EPA's Office of Research and Development defines cumulative impacts as, "the total burden – positive, neutral, or negative – from chemical and non-chemical stressors and their interactions that affect the health, wellbeing, and quality of life of an individual, community, or population at a given point in time or over a period of time. Cumulative impacts include contemporary exposures in various environments where individuals spend time and past exposures that have lingering effects. Total burden encompasses direct health effects and indirect effects to people through impacts on resources and the environment that affect human health and well-being. Cumulative impacts provide context for characterizing the potential state of vulnerability or resilience of the community, i.e., their ability to withstand or recover from additional exposures under consideration" (EPA 2022). See Chapter 4, Section B for a discussion on:

- cumulative losses for commercial and recreational fisheries;
- global perspective on human rights, and diversity, equality, inclusion, and accessibility (DEIA) concerns in the seafood industry; and
- potential interactions of AOA planning with other regional social-justice efforts.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

The proposed AOA(s) in the Santa Barbara Channel does not authorize any aquaculture to take place and so, in and of itself, would not have adverse or disproportionately adverse impacts on communities that may be experiencing EJ concerns. Aquaculture can be proposed and permitted regardless of the presence of AOAs.

The identification of one or more AOAs in the Santa Barbara Channel could encourage aquaculture developers to focus on that area for proposed projects and result in a higher concentration of aquaculture in the AOA(s) than would occur otherwise. The use of AOAs to create a predictable area for aquaculture development may have a beneficial impact on communities in creating predictability and focusing aquaculture in an area that has been evaluated and assessed to be the most suitable in Southern California (Morris et al. 2021) in the context of minimizing use conflict and impacts to wildlife and habitats that are culturally important to Tribal and non-tribal communities that may experience EJ concerns. The potential adverse impacts of aquaculture itself, described in other sections of the DPEIS, could contribute to EJ concerns in addition to socioeconomic impacts. Cultural EJ concerns would likely be closely related to socioeconomic impacts.

Michaelis (2024 (draft)) identified Oxnard, Port Hueneme, El Rio, and Saticoy as communities that may be limited by resources in various ways (e.g., income, education, English language skills), and show high vulnerability from existing gentrification pressures. Gentrification is associated with increased community disruption and stress, leading to decrements in health (Smith and Thorpe 2020). It often perpetuates inequities and health disparities, contributing to public health concerns for already vulnerable communities (Smith and Thorpe 2020). These communities may be less able to adapt to changes brought on by a developing new industry such as offshore aquaculture (Michaelis 2024 (draft)). Oxnard, Port Hueneme, Ventura, and Santa Barbara show high existing reliability on commercial fishing, which could make them especially-vulnerable to potential impacts from finfish or IMTA aquaculture. See Chapter 3, Section D.iv., sub-alternative (b) for more information on these community profiles.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Michaelis (2024 (draft)) identified that Los Angeles, Del Aire, Howthorne, Inglewood, Ladera Heights, Lawndale, Lennox, and View Park-Windsor Hills all indicate a large number of households in these communities that may be limited by resources in various ways (e.g., income, education, English language skills), and therefore may be less able to adapt to changes brought on by a developing new industry such as offshore aquaculture. All of these communities also experience existing pressures from gentrification and/or urban sprawl. Marina del Rey and Los Angeles, among others in the southern portion of the SCB, show high existing reliability on commercial fishing, which could make them especially-vulnerable to potential impacts from finfish or IMTA aquaculture. See Chapter 3, Section D.iv., sub-alternative (b) for more information on these community profiles.

An additional consideration for Alternative 3 are the intermittent health advisories associated with harvested seafood from Santa Monica Bay. Most advisories have occurred historically in the Palos Verdes area, as well as near the Los Angeles and Long Beach Harbors (south of the alternative area); and the exposure pathways were associated with Latino and Asian (Schiff et al. 2000).

Alternative 4: Combined Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. AOAs in both areas may distribute impacts to more communities. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified. Any differences or compounding impacts that may affect participation in any existing fisheries, including any artisanal commercial, recreational, ceremonial, or subsistence fisheries in offshore marine waters should be considered carefully for potential EJ concerns.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

E. Cultural and Historic Environment and Potential Impacts

i. Tribal Resources and Cultural Practices

National Historic Preservation Act (NHPA) Section 106 (1966) - Section 106 of the NHPA requires review of any project funded, licensed, permitted, or assisted by the federal government for impact on significant historic properties, including consultation with Tribes. Federal agencies must allow the State Historic Preservation Officer (SHPO) and the Advisory Council on Historic Preservation (ACHP), a federal agency, to comment on a project. NHPA includes provisions for Tribes to assume the responsibilities of the SHPO on Tribal lands and establishes the position of a Tribal Historic Preservation Officer (THPO). Tribal lands are defined in the NHPA and the Section 106 regulations (36 CFR Part 800) as, 1) all lands within the exterior boundaries of any Indian reservation; and, 2) all dependent Indian communities. NMFS has not initiated consultation with the California SHPO or THPOs for the DPEIS as the action is a planning exercise without project-specific details and does not permit aquaculture activity to take place in any identified AOAs. Specific project proposals would result in consultation by authorizing federal agencies as relevant prior to obtaining permits for any aquaculture project sited in an AOA.

Cultural resources have been defined as prehistoric and ethnohistoric archaeological sites, historic archaeological sites, historic buildings, and elements or areas of the natural landscape which have traditional cultural significance (CDFW 2014). Tribal cultural resources in California have been defined as sites, features, places, cultural landscapes, sacred places, and objects with cultural value to a California Native American tribe that are either included or determined to be eligible for inclusion in the California Register of Historical Resources or included in a local register of historical resources, or a resource determined and supported by substantial evidence to be significant (Los Angeles City Planning 2017). Historical and archaeological resources may also be tribal cultural resources (Los Angeles City Planning, 2017). Tribal resources and cultural practices are present in the proposed AOAs and are considered below.

Affected Environment

The U.S. government operates under a unique relationship with Tribal governments based on provisions of the U.S. Constitution, Congressional legislation, treaties, Executive Orders, Secretarial Orders, and judicial decisions that recognize reserved rights of Native Americans to protect their property and their way of life. The relationship between Federally-recognized Indian Tribes and the federal government is one of sovereign to sovereign and has been described at length by the federal judiciary and referred to in federal law promoting Tribal self-determination and self-governance (NOAA 2023a). Indian Tribes on the West Coast have long-standing and strong spiritual and cultural ties to marine species and habitats based on thousands of years of cultural use, subsistence, and commerce (NOAA 2023a).

There have been multiple Executive Orders (E.O.s) issued that address engagement and coordination with Indian Tribes and Nations. Key EOs are briefly summarized below.

E.O. 13175 Consultation and Coordination with Indian Tribal Governments (2000) was issued by U.S. President Bill Clinton on November 6, 2000. This executive order requires federal departments and agencies to consult with Indian Tribal governments when considering policies that would impact Tribal communities (65 FR 67249).

E.O. 13007 Indian Sacred Sites (1996) directs federal land managing agencies to accommodate access to, and ceremonial use of, Indian sacred sites by Indian religious practitioners and to avoid adversely affecting the physical integrity of such sacred sites (61 FR 26771, BOEM n.d.).

E.O. 13287 Preserve America (2003) directs federal agencies to advance the protection, enhancement, and contemporary use of federal historic properties and to promote partnerships for the preservation and use of historic properties, particularly through heritage tourism (68 FR 65238).

E.O. 14112 Reforming Federal Funding and Support for Tribal Nations to Better Embrace Our Trust Responsibilities and Promote the Next Era of Tribal Self-Determination (2023) aims to ensure that federal programs, to the maximum extent possible and practicable under federal law, provide Tribal Nations with the flexibility to improve economic growth, address the specific needs of their communities, and realize their vision for their future (BIA 2024).

In addition to EOs, there have been other orders and memoranda addressing Tribal sovereignty and government-to-government engagement. The Presidential Memorandum of January 26, 2021 (Tribal Consultation and Strengthening Nation-to-Nation Relationships), and the Presidential Memorandum of November 30, 2022 (Uniform Standards for Tribal Consultation), reiterated the U.S. commitment to, and established uniform standards for, Tribal consultation. Department of Commerce orders and policies include the following:

- Secretarial Order 3206 (June 5, 1997) American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act;

- Department of Commerce American Indian and Alaska Native Consultation and Coordination Policy (March 30, 1995) followed by Tribal Consultation and Coordination Policy of the U.S. Department of Commerce (August 2013);
- Department of Commerce Department Administrative Order 218-8: Consultation and Coordination with Indian Tribal Governments (April 26, 2012); and
- NOAA Procedures for Government-to-Government Consultation with Federally-Recognized Indian Tribal Governments (June 2023).

The Native American Graves Protection and Repatriation Act (NAGPRA, 25 U.S.C. ch. 32 § 3001 et seq) requires federal agencies and federally assisted museums to return "Native American cultural items" to the federally recognized Indian Tribes or Native Hawaiian groups with which they are associated. Regulations by the National Park Service are located at 43 CFR 10. Chapter 3, Section E(iii) addresses the rights of lineal descendants, Indian Tribes, and Native Hawaiian organizations to certain Native American human remains, funerary objects, sacred objects, and objects of cultural patrimony found in federal agencies and institutions that receive federal funds and addressed trafficking of these materials by private individuals.

The American Indian Religious Freedom Act of 1978 (42 U.S.C. § 1996) protects the rights of Native Americans to exercise their traditional religions by ensuring access to sites, use and possession of sacred objects, and the freedom to worship through ceremonies and traditional rites. The Act says that the U.S. Government will respect and protect the rights of Indian Tribes to the free exercise of their traditional religions; the courts have interpreted this as requiring agencies to consider the effects of their actions on traditional religious practices.

The Magnuson Stevens Fishery Conservation and Management Act (MSA, 16 U.S.C. ch. 38 § 1801 et seq) Section C.ii. (Wild Fish Stocks) requires all Fishery Management Plans to contain a description of Native American treaty fishing rights in a fishery. Associated with marine resources, a Treaty Tribe exercises its management authorities within specific areas for subsistence and cultural fishing locations adjudicated within the federal court system or confirmed by federal administrative procedures (Pacific Fishery Management Council [PFMC] 2013). While fisheries are recognized to be, and have been, important to California Tribes since time-immemorial for cultural purposes, subsistence, and commerce-related activities, there are currently no Federally-recognized Treaty Tribes in Southern California (PFMC 2013 2016). Certain coastal California Tribes (Yurok and Hoopa Valley Tribes) have treaty fishing rights to salmonids that range from western freshwater streams to the high seas of the Pacific Ocean (PFMC 2013). The right to fish in "usual and accustomed" areas has been interpreted by the courts as not restricted to any species, nor dependent on whether the species was historically exploited by the tribe (U.S. Commission on Ocean Policy 2004b). The interest of California tribes in fishery management and shared resource allocation has also been recognized by Congress by requiring the appointment of a Tribal representative to PFMC (42 U.S.C. § 4331(a)).

In addition to Congressional Acts, at the state of California, AB52, enacted in 2014, amends sections of California Environmental Quality Act (CEQA; 1970) related to Native Americans and established a new category of cultural resources, Tribal cultural resources, and states that a project that may cause a substantial adverse change in the significance of a Tribal cultural resource may have a significant effect on the environment.

Santa Barbara, Ventura, and Los Angeles counties are the nearest onshore areas to the proposed AOAs. These counties are the ancestral and present-day homes to the coastal Chumash and Gabrieleno-Tongva Tribes (Gabrielino-Tongva Indian Tribe 2024a; Santa Ynez Band of Chumash Indians n.d.a). The primary ports that may be associated with aquaculture operations in the proposed AOAs are Santa Barbara Harbor, Ventura Harbor, and Port Hueneme (Morris et al. 2021).

Tribal communities have a close relationship with the natural world and rely on stable fishing stocks to provide for their communities. The first inhabitants of the Southern California Bight (SCB), the diverse coastal Tribes of the Chumash people, shaped the general ecology of the region (McGinnis 2006). The Chumash people lived in villages along the south-central California coast from the present-day sites of Malibu Point to Morro Bay and extended to the northern Channel Islands. The Chumash had a population of about 18,000 people among 150 independent villages by the time Spanish missionaries arrived. It is believed this high population level was brought about by intensified fishing, possibly a result of the plank canoe, or tomol, about 2,000 years ago. Barbed harpoons and shell hooks also allowed the Chumash to harvest an expansive array of fish species. (Norman et al. 2007). The Gabrieleno-Tongva people were and are also coastal people and lived from Palos Verdes to San Bernardino, from Saddleback Mountain to the San Fernando Valley (Gabrieleno-Tongva Indian Tribe 2024a).

The Chumash consider the northern Channel Islands a special place. They still paddle these waters in tomols or special wooden canoes. The first tomol to be owned by the Chumash people since the 1880s is ‘Elye’wun, which was built by the Chumash community in 1996–1997 under the leadership of the Chumash Maritime Association. The building of ‘Elye’wun (“swordfish”) and the crossing to Santa Cruz Island was undertaken to reconnect and restore the Chumash’s relationship to the sea and northern Channel Islands. (McGinnis 2006).

The marine component of the Chumash diet traditionally consisted of over 150 types of marine fishes and a variety of shellfish including crabs, lobsters, mussels, abalone, clams, oysters, chitons, and other gastropods. Abalone are also a traditional staple of the Chumash diet. Shellfish were essential to the Chumash economy and material culture. The Chumash produced the majority of shell bead money used by indigenous peoples throughout southern California. (McGinnis 2006). Like the Chumash, the Gabrieleno-Tongva people were and are a seafaring tribe, fishing for sheepshead, shark, barracuda, halibut and other fish from small plank canoes, or ti’ats; they also hunted seals and other mammals and harvested abalone, mussels, and clams (Gabrielino-Tongva Indian Tribe 2024b). The Gabrielino-Tongva also relied on the ocean for commerce, trading abalone shells (Gabrielino-Tongva Indian Tribe 2024b).

For thousands of years before Spanish, Tsarist Russian, and European settlers occupied the West Coast, Native Americans harvested oysters (CDFW 2010). Also, use of *Mytilus* mussels for food in California extends back over 10,000 years. These are the most common shellfish found in island and coastal middens (CDFW 2010). In the Pacific Northwest, Tribes used “clam gardens” to cultivate clams (Lepofsky and Caldwell 2013). In addition, red sea urchins (*Mesocentrotus franciscanus*) were and are important for Tribal subsistence fishing (USFWS 2022). The Santa Barbara Channel region has a rich history in fishing dating back to the Chumash people as evidenced by the occurrence of large middens (Erlandson et al. 2005).

Overall, the Tribal environment associated with the proposed AOAs includes a rich history and culture of ocean use, harvest, and traditional practices extending to the present day. It is difficult to describe the Tribal environment as a separate affected environment from the physical, biological, and socioeconomic environments described in Chapter 3, Sections B, C, and D, respectively. The Chumash have collaborated with the Channel Island National Marine Sanctuary, including authoring a Chumash Ecosystem Services Assessment (Cordero et al. 2016). Cordero et al. (2016) describes traditional Chumash ecological views, including an interdependency between marine and terrestrial systems, without differentiation between consumptive and non-consumptive services. The Chumash view their relationship to the natural world as reciprocal and regenerative, making an economic assessment of the natural world incompatible with a world view that values the intangible and sacred (Cordero et al. 2016). The Chumash view community wellness, sense of place, and psychological, spiritual, and physical health as ecosystem services. Cordero et al. (2016) describe the Chumash tradition as one in which people belong to the land and waters and the land and waters belong to the people in a manner that is not just ownership but is a sense of responsibility to protect, care for, love the land and waters and to make decisions and choose actions reflective of those responsibilities.

Past and ongoing activities contributing to the baseline condition of cultural and historic EJ concerns associated with Tribal resources include the history of harm to Native Americans in California. Wishtoyo Chumash Foundation (2022) states that the Chumash and Gabrielino-Tongva peoples were the first human inhabitants of the Channel Islands and Santa Monica Mountains areas and that numerous archaeological sites have been uncovered in the past decade some of which date to 15,000 years. Tribes continue to practice traditional culture and pass this heritage to youth to preserve it for future generations (Wishtoyo Chumash Foundation 2022). The Gabrielino-Tongva history is described by the Tribe (Gabrielino-Tongva Indian Tribe 2024c) and includes lost treaty rights, a devastating "assimilation policy" by the U.S., and eventual recognition by the State of California in 1994, though the federal government has not recognized this Tribe (89 FR 944). The Chumash are federally recognized as the Santa Ynez Band of Chumash Mission Indians of the Santa Ynez Reservation, California (89 FR 944). As with the Gabrielino-Tongva, the Chumash experienced colonization, and their numbers were decimated due largely to European diseases (Santa Ynez Band of Chumash Indians n.d.a). The Santa Ynez Reservation was established on December 27, 1901 (Santa Ynez Band of Chumash Indians n.d.b). The Chumash continue to pass their traditional practices on to their children to preserve their heritage and way of life (Santa Ynez Band of Chumash Indians n.d.c). In Chumash country, there has been an increase in collective healing as the community has strengthened its maritime culture with modern and ancestral tomol traditions, reestablished relationships with traditional medicines and foodways, acquired "seats at the table" for managing homelands and waters, and fought for protections against potential harms to ecosystems and traditional lifeways (Cordero et al. 2016). The common ground between EJ and historic preservation is the ethic of stewardship, in which there is a responsibility to be a custodian or caretaker of the resources and to pass those resources on to another generation.

Stressors

The stressors associated with physical, biological, and socioeconomic environments are described in Chapter 3, Sections B, C, and D, respectively. These stressors to the environment become stressors to Tribes and Tribal practices, values, and subsistence when they adversely affect aspects of the ecosystem and its balance and interconnectedness. Access to traditional areas is also important to Tribes, and aquaculture sited within AOAs may create areas that are potentially not accessible for traditional fishing or other practices.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Aquaculture can be proposed and permitted regardless of the presence of an AOA. The identification of one or more AOAs in the Santa Barbara Channel could encourage aquaculture developers to focus on that area for proposed projects and result in a higher concentration of aquaculture in the AOA(s) than would occur otherwise. The use of AOAs to create a predictable area for aquaculture development may have a beneficial impact on Tribes in creating predictability and focusing aquaculture in an area that has been evaluated and assessed to be the most suitable in Southern California (Morris et al. 2021) in the context of minimizing use conflict and impacts to wildlife and habitats that are culturally important to Tribes.

The potential adverse impacts of aquaculture itself, described in Chapter 3, Sections B, C, and D of this DPEIS, could have adverse impacts on Tribes as further described below. Exclusion from any areas within the AOA that may result from commercial activities and navigational hazard may also affect Tribes that use the area.

Cordero et al. (2016) describes the stress of feelings of failure to meet cultural responsibilities for traditional ecosystems and awareness that ecosystem health is declining due to exploitation by colonial culture. The Chumash consider the Channel Islands and surrounding waters cherished family and feel a responsibility to maintain their well-being, so adverse impacts to this system can cause acute and chronic psychological distress (Cordero et al. 2016). Tribes can experience grief and stress from loss of access to management and inability to fulfill what they see as an obligation to other people and their religious convictions (Cordero et al. 2016). Cordero et al. (2016) point out that what many currently see as an idealized, untouched, wild, and pristine California landscape prior to European colonization was actually a result of thousands of years of reciprocal relationship, tending, and cultivation by the Native peoples of these areas. Thus, adverse impacts to the ecology or biology of the area may affect Tribes in psychological and spiritual ways. The impacts from siting aquaculture in one or more AOAs in the Santa Barbara Channel are expected to be minimal due to deconfliction and mitigation, so impacts to the cultural resources of Tribes would also be expected to be minimal.

a) Shellfish and Macroalgae

The importance and practice of harvesting seaweeds in Indigenous cultures of North America has been passed down through generations of families and Tribal communities. Location, timing, and traditional practices contribute to the importance of the resource. Timing and the amount of harvest to remain a sustainable practice is an ongoing struggle between California tribes and colonized areas (Bigelow Laboratory for Ocean Sciences 2024). For example, historic and ongoing restrictions in California coastal access have shown to impact Tribes because both Tribal and non-tribal harvesters share some areas that may be traditional areas, but do not necessarily have access to the same traditional ecological knowledge of how or desire to maintain seaweed bed/garden productivity for future generations (Bigelow Laboratory for Ocean Sciences 2024). As described above, there is a history of subsistence living associated with California tribes with shellfish species along the coast and in the SCB. Therefore, potential impacts associated with native populations of seaweed and shellfish, marine habitat, ecological functions, as well as other resources of the physical, biological, and socioeconomic environments that are described in Chapter 3, Sections B, C, and D, respectively, all may play a role in analyzing potential impacts to Tribal cultural resources.

b) All Types of Commercial Aquaculture

The Chumash people have been heavily dependent on a healthy marine environment (McGinnis 2006). Tribal communities have a close relationship with the natural world and rely on stable fishing stocks to provide for their communities. The potential impacts associated with wild fish stocks, marine habitat, ecological functions, as well as other resources of the physical, biological, and socioeconomic environments that are described in Chapter 3, Sections B, C, and D, respectively, all may play a role in analyzing potential impacts to Tribal cultural resources. Impacts on the natural and human environment are interconnected to cultural systems; and all aspects of aquaculture (no matter what type) would need to be considered carefully for potential impacts to Tribal cultural and historic resources.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

From a macro Tribal impact perspective there is likely little difference between Alternatives 2 and 3. The entire region was and is inhabited by Tribal communities who used and continue to use the waters for fishing, spiritual, and recreational purposes. The potential beneficial and adverse impacts of identifying one or more AOAs in Santa Monica Bay are similar to those for identifying one or more AOAs in Santa Barbara Channel.

a) Shellfish and Macroalgae

The best available information to describe potential impacts from macroalgae and shellfish reflected under Alternative 2a is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

b) All Types of Commercial Aquaculture

The best available information to describe potential impacts from all types of aquaculture reflected under Alternative 2b is the same as reflected under Alternative 3. Impacts between the two geographic spaces may differ, based on variations in geography, resources, and human activity, among others, as described above in this section.

Alternative 4: Combined Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

AOAs in both areas may distribute impacts to more communities. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified. Identification of a larger geographic area may encourage more aquaculture to be proposed and thus lead to greater impacts, as described for Alternatives 2 and 3, to Tribal resources and cultural practices. These impacts are expected to be minimized through further engagement with Tribes as projects are proposed.

a) Shellfish and Macroalgae

The impacts reflected under this sub-alternative may be the same as Alternatives 2a and 3a, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b is the same as reflected under Alternative 4a.

b) All Types of Commercial Aquaculture

The impacts reflected under this sub-alternative may be the same as Alternatives 2b and 3b, except they could take place across the Santa Barbara Channel and Santa Monica Bay area. The best available information to describe potential impacts from all types of commercial aquaculture reflected under Alternatives 2b and 3b are the same as reflected under Alternative 4b.

ii. Non-Tribal Cultural and Traditional Practices

Oceanic resources have provided cultural, economic, and recreational opportunities for human civilizations along the California coastline for generations. The ocean provides a stable source of economic support and diverse food security. Tribal resources and cultural practices are described in Chapter 3, Section E.i. Here we consider non-tribal cultural and traditional practices. Culture is defined and described under the NHPA at 54 U.S.C. § 300101. More broadly, it includes inherent values, ways of life and social expression that influence human systems in family, education, media, politics, work, public programs, and the built environment (Hawkes 2001).

Public interests in the marine environment have traditionally included navigation, fishing, and commerce. As the body of social science develops, the public has influenced policy to protect recreation, environmental protection, research, and preservation of scenic beauty and cultural heritage (U.S. Commission on Ocean Policy 2004b). Even when there may be private ownership or other property interests in public trust lands or waters, the government has a duty to ensure that the public's interest in those areas is protected.

Affected Environment

There are E.O.s and other legal frameworks that address engagement to preserve historic and cultural resources. Key administrative documentation is briefly summarized below.

E.O. 13287 Preserve America (2003) directs federal agencies to recognize and manage historic sites and objects in regard to contributing to the vitality and economic well-being of the nation's communities, including to promote heritage tourism (68 FR 65238).

NHPA Section 106 (1966) is described in Chapter 3, Section E.i. and extends beyond tribal consultation to consultation associated with non-tribal historic and cultural resources. NHPA sets forth government policy and procedures regarding "historic properties" defined as districts, sites, buildings, structures, and objects included in or eligible for the National Register of Historic Places. Section 106 of NHPA requires that federal agencies consider the effects of their actions on such properties, following regulations issued by the ACHP (36 CFR 800). The National Register of Historic Places is a list maintained by the Department of the Interior, defined in 16 U.S.C § 470(a)(1)(A).

The National Marine Sanctuaries Act (1972) and **E.O. 13158 Marine Protected Areas (2000)** also protect cultural and historic resources. E.O. 13158 is described in Chapter 3, Section B.ii. National Marine Sanctuaries and Marine Protected Areas can be designated for the purpose of protecting areas of cultural and archeological significance.

Non-Tribal Resources and Cultural Practices

Coastal communities in and visitors to the SCB have cultural ties to the local resources, including activities and businesses built on coastal aesthetics and natural resources. Commercial and recreational fisheries, tourism, and other recreation are described in Chapter 3, Sections D.i., D.ii., and D.v. These practices are not just economic in nature but also carry cultural value. Historic and traditional places and viewsheds are also important to both Tribal and non-tribal cultural practices in the SCB. Access to and health of the SCB provides jobs, food, economic opportunities, recreation, and spiritual and aesthetic value to people.

Overexploitation of resources is an unfortunate part of the history of the California Current Ecosystem and has influenced the management of marine resources (McGinnis 2006, PFMC 2013). Fisheries overexploitation is detailed in Section 3.4.1 on pp. 51 through 56 of the PFMC's (2013) Pacific Coast Fishery Management Plan for the U.S. Portion of the California Current Large Marine Ecosystem, incorporated herein by reference. Under the MSA, a "fishing community" is a community that is "substantially dependent on or substantially engaged in the harvest or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew and U.S. fish processors that are based in such community" (16 U.S.C. §1802). Social scientists have used that definition to develop profiles of West Coast fishing communities (Norman et al. 2007) and to define and quantify community involvement in commercial fisheries and their vulnerability to changes in fishery conservation and management measures (Sepez et al. 2007, Clay and Olson 2008, and Alsharif and Miller 2012). Norman et al. (2007) provides detailed social and demographic analyses of over 100 West Coast communities. Fisheries resources are culturally important to SCB communities and impacts to these resources have both commercial and cultural ramifications. In addition to fisheries and fishing, ocean-related heritage, traditions, social identity, political values, and community well-being are important considerations in assessing impacts to non-tribal cultural and traditional resources.

Southern California was home to large fishing fleets of seine operators and to numerous tuna processing canneries (Felando and Medina 2012). By the early 1980s, most of the canneries had gone out of business or relocated to U.S. territories or other countries due to lower processing costs, fisheries management challenges, and the shifting of fishing operations to the western Pacific to avoid conflicts with dolphins and porpoises (Sea Grant 2024d). Despite the decline in the tuna fishery, the fishing communities of the region persist due to the continued productivity of the ocean ecosystem, proximity to large urban communities, and an extensive and large port infrastructure that provides ready access and connection to both domestic and global markets (Sea Grant 2024d).

Aquaculture is also a tradition of the SCB. A substantial commercial oyster fishery began in the 1850s, when settlers from the east coast attracted to California by the prospect of gold and new opportunities created larger markets for oysters (CDFG 2001b). Public hatchery production of salmonids in California also has a long history.

Stressors

The stressors associated with physical, biological, and socioeconomic environments are described in Chapter 3, Sections B, C, and D, respectively. These stressors to the environment become stressors to non-tribal cultural practices. Infrastructure itself is a potential stressor, possibly causing limits to access to small areas of ocean and having the potential to affect views and increase traffic. Potential for aquaculture to conflict with fisheries activities can be both a cultural and commercial stressor.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact. Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. The potential impacts associated with the administrative, physical, biological, and socioeconomic environments are described in Chapter 3, Sections A-D. Impacts on the natural and human environment are all interconnected to potential non-Tribal cultural and historic concerns.

Aquaculture can be proposed and permitted regardless of the presence of an AOA. The identification of one or more AOAs in the Santa Barbara Channel could encourage aquaculture developers to focus on that area for proposed projects and result in a higher concentration of aquaculture in the AOA(s) than would occur otherwise. The use of AOAs to create a predictable area for aquaculture development may have a beneficial impact on communities in creating predictability and focusing aquaculture in an area that has been evaluated and assessed to be the most suitable in Southern California (Morris et al. 2021) in the context of minimizing use conflict and impacts to wildlife and habitats that are culturally important to non-tribal groups. The potential adverse impacts of aquaculture itself, described in Chapter 3, Sections B, C, and D of this DPEIS, could have adverse impacts on communities.

Exclusion from the AOA that may result from commercial activities and navigational hazard may also affect communities that use the area. Fishing communities may be vulnerable socially and economically to potential effects to commercial fisheries and recreational fishing opportunities. Identification of potentially affected historic properties would occur at the project authorization stage, but no currently designated historic properties are within the proposed AOAs. The distance from shore and low profile of aquaculture operations makes visual/aesthetic impacts unlikely.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

a) Shellfish and Macroalgae

The impacts may vary depending on the types of aquaculture undertaken (e.g., algae, shellfish, finfish) and would need to be further assessed at the project proposal stage. Potential impacts associated with native populations of seaweed and shellfish, marine habitat, ecological functions, as well as other resources of the physical, biological, and socioeconomic environments that are described in Chapter 3, Sections A- D all may play a role in analyzing potential impacts to non-tribal cultural and traditional practices.

b) All Types of Commercial Aquaculture

The impacts vary depending on the types of aquaculture undertaken (e.g., algae, shellfish, finfish) and would need to be further assessed at the project proposal stage. Potential impacts that are described in Chapter 3, Sections A-D all may play a role in analyzing potential impacts to non-tribal cultural and traditional practices.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

From a macro community impact perspective there is likely little difference between Alternatives 2 and 3, though different communities and individuals may be affected. The potential beneficial and adverse impacts of identifying one or more AOAs in Santa Monica Bay are similar to those for identifying one or more AOAs in Santa Barbara Channel.

a) Shellfish and Macroalgae

The impacts may vary depending on the types of aquaculture undertaken (e.g., algae, shellfish, finfish) and would need to be further assessed at the project proposal stage. Potential impacts associated with native populations of seaweed and shellfish, marine habitat, ecological functions, as well as other resources of the physical, biological, and socioeconomic environments that are described in Chapter 3, Sections A-D all may play a role in analyzing potential impacts to non-tribal cultural and traditional practices.

b) All Types of Commercial Aquaculture

The impacts may vary depending on the types of aquaculture undertaken (e.g., algae, shellfish, finfish) and would need to be further assessed at the project proposal stage. Potential impacts that are described in Chapter 3, Sections A-D all may play a role in analyzing potential impacts to non-tribal cultural and traditional practices.

Alternative 4: Combined Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

AOAs in both areas may distribute impacts to more communities. Effects could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified. Identification of a larger geographic area may encourage more aquaculture to be proposed and thus lead to greater impacts, as described for Alternatives 2 and 3, to non-tribal resources and cultural practices. These impacts are expected to be minimized through further engagement with communities and the required public processes as projects are proposed.

a) Shellfish and Macroalgae

The impacts may vary depending on the types of aquaculture undertaken (e.g., algae, shellfish, finfish) and would need to be further assessed at the project proposal stage. Potential impacts associated with native populations of seaweed and shellfish, marine habitat, ecological functions, as well as other resources of the physical, biological, and socioeconomic environments that are described in Chapter 3, Sections A-D all may play a role in analyzing potential impacts to non-tribal cultural and traditional practices.

b) All Types of Commercial Aquaculture

The impacts to may vary depending on the types of aquaculture undertaken (e.g., algae, shellfish, finfish) and would need to be further assessed at the project proposal stage. Potential impacts that are described in Chapter 3, Sections A- D all may play a role in analyzing potential impacts to non-tribal cultural and traditional practices.

iii. Archaeological Resources

The Archaeological Resources Protection Act (1979) defines ‘‘archaeological resource’’ as any material remains of past human life or activities which are of archaeological interest. Tribal and non-tribal cultural resources can be categorized as archaeological resources.

<u>Affected Environment</u>

Administrative

The Archaeological Resources Protection Act (ARPA; 1979) was enacted "to secure, for the present and future benefit of the American people, the protection of archaeological resources and sites which are on public lands and Indian lands…" (16 U.S.C. §470aa (b)). With regard to the marine environment, ARPA applies only in federal marine protected areas or other submerged lands to which the U.S. Government retained title and did not transfer to states under the Submerged Lands Act or other otherwise owns or controls through agreements with states (NOAA n.d.a). ARPA was enacted to deter looting of archaeological sites located on federal lands (NOAA n.d.a).

The Abandoned Shipwreck Act (ASA; 1987) establishes the federal protection of certain shipwrecks that are historic and eligible for inclusion in the National Register of Historic Places (43 U.S.C. §§ 2101, 2102). Any discovered shipwreck that may be eligible for title under the ASA must go under public notice and must be reviewed by the National Park Service (43 U.S.C. §§ 2105(b)). Shipwrecks that meet the ASA criteria are then transferred to the responsibility of the State (43 U.S.C. §§ 2105(c)). The law of salvage and the law of finds apply to abandoned shipwrecks that do not meet the criteria of the ASA and do not otherwise have some sort of legal protection (U.S. Commission on Ocean Policy 2004b).

The National Marine Sanctuaries Act (1972) includes protection of areas of cultural and archaeological significance as sanctuary resources.

NAGPRA recognizes that human remains of any ancestry "must at all times be treated with dignity and respect." Human remains and other cultural items removed from federal or Tribal lands belong, in the first instance, to lineal descendants, Indian Tribes, and Native Hawaiian organizations.

NHPA Section 106 requires potential project areas to file protocols for inadvertent archaeological discoveries. The California SHPO evaluates if the project may cause significant impact to known historic resources. The Department of Interior has authority under NHPA to ensure that permitted actions do not adversely affect significant historic properties and has also created guidance for the discovery of, and avoidance of adverse impacts to, any archeological resource discovered in offshore waters within the U.S. Exclusive Economic Zone (30 C.F.R. §§ 250.194, 250.203(b)(15), 250.203(o), 250.204(b)(8)(v)(A), 250.204(s), and 250.1007).

Archaeological Resources

There are two basic types of archaeological sites off the California coast: Native American archaeological sites and historic-era shipwrecks, cargo spills, or landing sites (Foster 2024). Archaeological resources in federal waters could include shipwrecks, sunken aircraft or other machinery, lighthouses, and prehistoric archaeological sites that have become inundated due to the global sea level since the height of the last ice age (ca. 19,000 years ago; National Oceanography Centre 2010). Typical characteristics of archaeological resources in the SCB region are described on p. 13 of the Introduction of Morris et al. (2021) and are incorporated here by reference.

The two Tribes most likely to have historic habitations and artifacts offshore where the AOAs are proposed are the Chumash and Gabrieleno-Tongva Tribes, who are described in Chapter 3, Section E.i. Artifacts found in the marine environment have helped archaeologist's piece together Chumash trade networks, fishing practices, and submerged village sites (McGinnis 2006). Thousands of years ago the sea level was at least 150 feet lower than it is today and the northern Channel Islands were joined as one island, and some submerged artifacts may have been deliberately deposited in the water during religious ceremonies, washed to the sea from shore, or been deposited in the water through cliff erosion (McGinnis 2006).

There are identified wrecks in Santa Monica Bay and the Santa Barbara Channel (NOAA n.d.b). There are no known wrecks in any of the Alternatives (Morris et al. 2021). As noted above, sunken vessels and aircraft discoveries are governed by federal laws that determine how they are preserved and accessed.

Stressors

Stressors to archaeological resources include activities like geotechnical surveys, infrastructure installation, and anchoring. Public knowledge of and access to archaeological resources can also be a stressor.

Potential Impacts

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact. Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Potential impacts to archaeological resources include disturbance or damage from bottom disturbing activities. Public knowledge and access can result in divers or other people damaging or looting wrecks, habitations, or other important sites. The potential impacts associated with physical, biological, and socioeconomic environments are described in Chapter 3, Sections B, C, and D, respectively. Without knowing the specific location, potential seafloor disturbance actions, and any baseline environmental surveys, the impacts to potential archeological resources are unknown.

Aquaculture can be proposed and permitted regardless of the presence of an AOA. Identification of one or more AOAs could create more certainty around permitting and encourage developers and academic organizations to focus data collection on the AOA(s), including geophysical surveys that could provide information on archaeological resources present in the area prior to significant resource commitment to development of aquaculture or issuance of any sort of leases or easements, improving consultations and engagement. This pre-construction activity could allow proposed projects to avoid impacts to archaeological resources, regardless of the type of aquaculture undertaken.

Alternative 1: No Action

Under the no action no AOAs would be identified, and there would be no changes or impacts to baseline conditions.

Alternative 2: Santa Barbara Channel

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

a) Shellfish and Macroalgae

The impacts may vary depending on the types of aquaculture undertaken (e.g., algae, shellfish, finfish) and would need to be further assessed at the project proposal stage.

b) All Types of Commercial Aquaculture

The impacts may vary depending on the types of aquaculture undertaken (e.g., algae, shellfish, finfish) and would need to be further assessed at the project proposal stage.

Alternative 3: Santa Monica Bay

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

There is likely little difference between Alternatives 2 and 3, though different archaeological resources would potentially be present. The proposed Chumash Heritage National Marine Sanctuary is adjacent to the Channel Islands National Marine Sanctuary and closer to the Santa Barbara Channel than the Santa Monica Bay, potentially indicating the likelihood of Chumash archaeological resources to be present is higher in Santa Barbara Channel than Santa Monica Bay, but presence of archaeological artifacts or sites must be assessed through surveys to identify specific wrecks, artifacts, and habitations.

a) Shellfish and Macroalgae

The impacts may vary depending on the types of aquaculture undertaken (e.g., algae, shellfish, finfish) and would need to be further assessed at the project proposal stage.

b) All Types of Commercial Aquaculture

The impacts may vary depending on the types of aquaculture undertaken (e.g., algae, shellfish, finfish) and would need to be further assessed at the project proposal stage.

Alternative 4: Combined Geographic Areas

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here.

Identification of a larger geographic area may encourage more aquaculture to be proposed and thus lead to greater potential for impacts, as described for Alternatives 2 and 3, to archaeological resources. Risk could be compounded due to larger total acreage and potential total facilities that may be sited if more total AOAs are identified.

a) Shellfish and Macroalgae

The impacts may vary depending on the types of aquaculture undertaken (e.g., algae, shellfish, finfish) and would need to be further assessed at the project proposal stage.

b) All Types of Commercial Aquaculture

The impacts may vary depending on the types of aquaculture undertaken (e.g., algae, shellfish, finfish) and would need to be further assessed at the project proposal stage.

Chapter 4: Cumulative Impacts and Climate Change

A. Past, Present, and Foreseeable Actions

i. Climate Change

Evidence of climate change and its impacts have been detected for at least the past 50 years globally and are expected to continue for decades into the future (Intergovernmental Panel on Climate Change [IPCC 2023). Multi-decadal projections of future climate change are available (IPCC 2023). At some time and geographic scales, the "signal" of climate change in available projections cannot be distinguished from the "noise" of natural climate variability over short time periods. In a review of available literature, NMFS West Coast Region Protected Resources Division concluded that, for at least 10 years into the future, and up to 50 years at the regional scale, predicted climate is dominated by annual and decadal natural variability and the signal of climate change is difficult to distinguish or project. When choosing a period for climate-scenario or population-response projections, it is important not to confuse the uncertainty in rate or magnitude of change with uncertainty in directionality. Although the precision of estimates of global temperature increase is low, for example, an increase in mean global temperature is virtually certain (IPCC 2023). When the direction of change is clear, projections of species status under climate change should not be discounted solely because the magnitude of projected change at a particular time is highly variable. As such, effects of the proposed action are described in the context of environmental conditions expected under current climate variability and could be applicable over a 10-year to 50-year scale.

NOAA and the World Meteorological Organization define "climate normal" as uniform 30-year periods consisting of annual/seasonal, monthly, daily, and hourly averages and statistics of temperature, precipitation, and other climatological variables from almost 15,000 U.S. weather stations (National Centers for Environmental Information n.d.). These periods are used as reference points to detect deviations from long-term averages, which enables trends in departures from the baseline conditions to be tracked. Departures from baseline conditions are being observed with increasing frequency and greater magnitude. Recent extreme events are characteristic of the variability of relevant environmental conditions and are important for representing developing conditions of climate change. An example is the frequency and severity of large marine heatwaves in the Northeast Pacific Ocean increasing over the last four decades, and the tendency for them to persist offshore during summer and autumn. The 2023 event of this nature was the fourth largest by area and fifth longest in duration since satellite observations began in 1982 (Leising et al. 2024). The ecosystem effects of marine heatwaves propagate through the food web and can result in impacts to fisheries (Robertson and Bjorkstedt 2020) and aquaculture (Reid et al. 2019). Climate change is occurring over a long period, and although projections become more uncertain farther into the future, the general trend is toward increasing changes as part of the environmental baseline. Aquaculture is one of the fastest growing food production sectors globally and this growth is recognized as crucial to global food security in the context of climate change.

<u>**Climate Change and the Administrative Environment**</u>

With respect to NEPA, the Council on Environmental Quality issued interim guidance in 2023 (88 FR 1196) to clarify and update the 2016 guidance on greenhouse gas (GHG) emissions. This guidance states that sound analysis of federal actions is crucial and that proposals should be designed in consideration of resilience and adaptation to changing climate. The guidance goes on to state "Given the urgency of the climate crisis and NEPA's important role in providing critical information to decision makers and the public, NEPA reviews should quantify proposed actions' GHG [greenhouse gas] emissions, place GHG emissions in appropriate context and disclose relevant GHG emissions and relevant climate impacts, and identify alternatives and mitigation measures to avoid or reduce GHG emissions." The current programmatic action does not authorize any aquaculture to occur, and given the scope and scale of activities that may occur and changing technologies, it is not possible to quantify GHG emissions for potential aquaculture projects in the potential AOAs at this time; however, aquaculture projects would be permitted under various statutes, including Clean Air Act (CAA) as applicable, which would necessitate GHG quantification and mitigation for projects as they are proposed and permitted if statutory thresholds are reached.

E.O. 13990 states that the administration has a policy of bolstering resilience to the impacts of climate change and advancing environmental justice. Chapter 3, Section D.xi. (Environmental Justice) and Section E. (Cultural and Historic Environment) provide further discussion of Environmental Justice and Tribal considerations that also apply to the context of climate change. The White House released an Ocean Climate Action Plan (Ocean Policy Committee 2023) that focuses on three goals: (1) create a carbon-neutral future, (2) accelerate nature-based solutions, and (3) enhance community resilience to ocean change. In addition to actions from the White House, there are statutes that are applicable to climate change. In the context of AOAs, the CAA directly affects GHG and other emissions, and in the state of California, shoreward of where the AOAs are proposed, the Global Warming Solutions Act, California Environmental Quality Act, and Ocean-Going Vessel Fuel Regulation also regulate activities associated with climate change impacts. In addition, California enacted two climate-related disclosure laws in 2023: (1) the Climate Corporate Data Accountability Act (SB-253), which requires entities with annual revenues over $1 billion to disclose their GHG emissions, and (2) the Greenhouse Gases: Climate-Related Financial Risk law (SB-261), which requires entities with total annual revenues over $500 million to post their climate-related financial risks on their websites with a description of how they plan to reduce or adapt to those risks.

Climate Change and the Physical Environment

Departures from typical climate parameters are mostly driven by anthropogenic activities, including emissions of GHGs from burning of fossil fuels and other activities, such as deforestation, that release GHG from their natural reservoirs (IPCC 2023). GHGs include water vapor, carbon dioxide, methane, nitrous oxide, and ozone; these gasses trap heat within the earth's atmosphere, causing global warming. According to the IPCC CMIP6 climate models, it is "very likely" that the Earth's atmosphere will warm to at least 1.5°C above pre-industrial temperatures between 2021 and 2040. IPCC (2023) reports that ocean temperatures increased 0.93°C from 1850-1900 to 2013-2022. Climate change is expected to lead to substantial changes in physical characteristics and dynamics within the marine environment, with complex and interacting impacts to marine populations, fisheries, and other ecosystem services (Scavia et al. 2002, Harley et al. 2006, and Doney et al. 2012). IPCC (2023) reports that ocean warming has contributed to an overall decrease in maximum catch potential for some fish stocks, and ocean warming and acidification have adversely affected shellfish aquaculture and fisheries in some oceanic regions.

The ocean absorbs approximately one-third of the CO_2 released into the atmosphere every year from industrial and agricultural activities, changing the chemistry of the ocean by decreasing the pH of seawater. CO_2 absorbed by the ocean gets converted to carbonic acid which lowers the pH of seawater over time, resulting in ocean acidification (Andersson et al. 2015). The combined effects of global warming and ocean acidification drive changes in other physical characteristics, such as sea level, salinity (Cullum et al. 2016), dissolved oxygen (Keeling et al. 2010), wind speed and direction, ocean currents (Howard et al. 2020) precipitation, nutrients (Marinov et al. 2010) and sediment loads. These physical changes, in turn, can result in biological effects such as changes in species distribution and abundance (Pecl et al. 2017); organism development and growth (e.g., shell formation in certain invertebrates) (Waldbusser et al. 2015); disease prevalence (Glidden et al. 2022); and occurrence of harmful algal blooms (HABs; Riebesell et al. 2018).

A key indicator of ocean acidification is aragonite saturation state, a measure of the availability of aragonite (a form of calcium carbonate). Aragonite saturation <1.0 indicates relatively acidified, corrosive conditions that are stressful for many California Current Ecosystem (CCE) species, particularly shell-forming invertebrates. Aragonite saturation states tend to be lowest during spring and summer upwelling, and highest in winter in the CCE (Harvey et al. 2023). Ocean acidification affects many shell-forming species, including oysters, mussels, abalone, crabs, and the microscopic plankton that form the base of the oceanic food web (Kroeker et al. 2010, 2013). In addition, significant changes in the behavior and physiology of fish and invertebrates attributable to rising CO_2 and increased acidity have been documented (OPR et al. 2018a). Ocean acidification impacts on these species can propagate through marine food webs and potentially affect fisheries (Marshall et al. 2017).

In addition to these large-scale aspects of climate change, some immediate and localized aspects of climate change are observed in coastal marine ecosystems: intensification of upwelling (Bakun 1990, Schwing and Mendelssohn 1997), changes in phenology (Bograd et al. 2009), and changes in the frequency and intensity of existing interannual and interdecadal climate patterns (Yeh et al. 2009). Substantial changes in weather and precipitation patterns will also affect snowpack, streamflow, river temperatures and other aspects of freshwater habitat, with potential consequences to the future productivity and sustainability of anadromous resources such as salmon (Mantua and Francis 2004, Crozier et al. 2008). As described by Bakun (1990), climate change has led to an intensification of alongshore wind stress, which in turn has led to an intensification of coastal upwelling, as has been documented both around the globe and specifically within the CCE (Schwing and Mendelssohn 1997).

Recent trends over the past 5 years indicate an earlier timing to the start of upwelling in the south, and a later start to upwelling in the north (NMFS 2012), with an earlier start of upwelling likely leading to higher integrated productivity. Changes in the timing of upwelling will also likely have impacts all the way up the food web to the top-level predators and consumers because it is the timing and strength of upwelling that mainly controls primary productivity in the CCE, and thereby overall productivity. Upwelling transports hypoxic, acidified waters from deeper offshore onto the continental shelf, where increased community-level metabolic activity can further exacerbate ocean acidification (Feely et al. 2008). Changes in the timing of upwelling may result in match-mismatch between the availability of predators and their prey, if those timings are somewhat uncoupled (e.g., salmon entering the ocean may have a different timing set by terrestrial forcing, as opposed to the timing of upwelling initiation). Three major aspects of future climate change that will have direct effects on the CCE are: ocean temperature, pH of ocean surface waters, and deep-water oxygen. All three factors show long-term trends and decadal-scale variance similar to changes in the Pacific Decadal Oscillation (Mantua et al. 1997) and North Pacific Gyre Oscillation (Di Lorenzo et al. 2008) climate signals. Within the CCE, deep-water oxygen levels showed a steady and relatively rapid decrease from the mid 1980's into the 2000s (Bograd et al. 2008, McClatchie et al. 2010).

There is increasing evidence that sea-level rise, ocean acidification, and ocean warming associated with climate change are transforming and degrading California's coastal and marine ecosystems (OPR et al. 2018b, CDFW 2022). In the last few years, California has experienced an unprecedented marine heat wave, resulting in closures of fisheries and a significant loss of northern kelp forests. California's ocean supports a vast diversity of marine life, as well as fishing communities that depend on fish and shellfish for their livelihoods and that provide a diverse supply of seafood to the state and for export.

The current projections are for a 0.6°C increase in mean sea surface temperature in the Southern California Bight (SCB) over the next two decades. Sea level is estimated to rise by 0.1 m and 0.2 m for the SCB; ocean surface pH is expected to decrease by 0.1 units. While coastal precipitation is predicted to range from a 2% decrease to a 0.8% increase in precipitation in the SCB (184, 185). Currently available information indicates environmental effects like these are likely to impact the proposed AOAs. Weather events, such as extreme heat, heavy precipitation, drought, and tropical cyclones are also predicted to become more frequent and intense. Dissolved oxygen and salinity are predicted to decrease in many areas/depths within proposed AOAs (Rhodes et al. 2023a).

Climate Change and the Biological Environment

Changes related to climate are likely to affect species' distributions, abundances, interactions with other species, and community structures. Suitable habitat location, quality, timing, and use may also change as climate changes. The SCB undergoes periods of mass warming during El Niño events and Pacific Decadal Oscillation phase (see Chapter 3, Section B (Physical Environment)). Ecosystem productivity and species occurrence is affected greatly during these warming trends, which impacts fisheries, tourism, and other socioeconomics in the region and at the state level. El Niño and Pacific Decadal Oscillation are already a serious conservation concern in the region and shed light on the potential impacts from rising sea surface temperature (SST) due to climate change. Approximately 85% of the marine species in the SCB are at the extreme northern or southern end of their range (Schiff et al. 2000). The ecotone created by the coastline delineates the northern and southern range for many of the seabirds observed in offshore waters as well (USFWS 2005).

Point Conception has been shown to be a major biogeographic boundary for benthic invertebrates and marine fishes (NCCOS 2005). The SCB is less of a barrier for highly mobile, larger predators, but approximately 10 percent of the 132 bird species analyzed in NCCOS (2005) had a range crossover in the SCB. While larger cetaceans and pinnipeds do not seem significantly affected by the range endpoint of Point Conception, many of the smaller species included in the *Delphinidae* family show a range significantly defined by Point Conception and occur primarily north or south of the boundary (NCCOS 2005).

Biological resources described in Chapter 3, Section C. (Biological Environment) of this DPEIS are being affected by climate change as part of the baseline of the biological environment. Some species may be shifting or will shift their ranges; there may be reductions in suitable habitat; temperature and other physical changes to the environment may be affecting prey or predators in ways that will impact populations and their distributions; and habitats may be changing in ways that also affect populations. There is research on some specific taxa and locations that can be applied to future analysis of specific project proposals when permits are sought (e.g., Patrício et al. 2021, Evans and Bjorge 2013, and Sydeman et al. 2015).

Protected Species

All sea turtles, black abalone, and several species of fish are protected under the Endangered Species Act (ESA). Marine mammals are protected under the Marine Mammal Protection Act (MMPA), and some are also protected under ESA. Migratory birds (which is the majority of birds) are protected under the Migratory Bird Treaty Act, and some are also protected under ESA. Climate change constitutes an environmental baseline for all species and habitats, and changes in temperature, salinity, pH, and other ocean conditions may affect the use patterns and distribution of species, in some cases driven by changes in prey distributions and use patterns. The availability of suitable alternative habitats and available prey and conditions for feeding, breeding, and other important life history activities will determine the resilience of species to climate change. Specific discussion of potential effects of climate change on baseline conditions for protected species is described in Appendix 4.

Climate Change and the Socioeconomic Environment

From the perspective of socioeconomics, E.O. 14030 on Climate-Related Financial Risk identified risks that climate change poses to assets and investments, including the risks associated with decarbonization. With respect to aquaculture, risks associated with changing conditions, extreme weather events, and supply chain distributions described in E.O. 14030 are applicable, along with the opportunities described for improving U.S. competitiveness, economic growth, and job creation.

In addition, decreased food security is an issue that may be exacerbated or brought on by climate change impacts to food resources. As a proxy to consider potential effects of change, during the height of the COVID-19 pandemic, the U.S. experienced food shocks and supply chain issues across a multitude of food systems (Galanakis 2020; Laborde et al. 2020; and Love et al. 2021b). Increased food resilience, defined as the "capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances," can buffer against shocks (Love et al. 2021b). A diverse and vibrant aquaculture industry can add resilience to U.S. food systems via select species propagation and responsive production control (Troell et al. 2014).

Despite the changes predicted to occur in the SCB, temperatures are still expected to remain more stable than on land. Along with temperature, drought is, and will continue to be, a major factor of climate change in California. Therefore, marine aquaculture may offer a comparatively stable option for food production on the West Coast (Froehlich et al. 2018). Finfish may be more resilient to climate change than shellfish because of issues with ocean acidification (Froehlich et al. 2018). The potential changes to marine aquaculture production as a result of climate change will likely be considered as California determines what types of aquaculture it will include to support a more climate-resilient food portfolio for the state (Nelson et al. 2019).

Climate Change and the Cultural and Historic Environment

Chapter 3, Section E (Cultural and Historic Environment) describes the cultural and historic baselines in the SCB region where AOAs are proposed. With respect to climate change, California's fourth climate change assessment (Sievanen et al. 2018) reported that climate change impacts like exposure to algal toxins and poor water quality may disproportionately affect tribes and tribal communities and subsistence harvesters of seafood, particularly as California tribes eat more seafood per capita than other groups. This report also notes that tribal economies, cultures, and traditions include marine species that may be affected by climate change, requiring cultural and economic adaptation.

Climate Change and Environmental Justice Considerations

The potential socioeconomic and cultural environmental justice considerations discussed in Chapter 3 of this DPEIS describe the environmental justice baseline in the SCB region where AOAs are proposed. With respect to climate change, California's fourth climate change assessment (Sievanen et al. 2018) reported that climate change is increasing exposure to algal toxins and poor water quality, with a study finding that Asian-American and African-American populations were more likely to consume potentially contaminated seafood. Climate change can have a disproportionate adverse impact on environmental justice communities, and vulnerable coastal communities have increased risk from climate change because of pre-existing socioeconomic inequities that can increase harm or result in displacement (Sievanen et al. 2018).

ii. Other Ocean Uses and Current Events in the Southern California Bight

The baseline of activities to be considered as potentially contributing to cumulative impacts in aggregation with AOAs is described below. The following list is a summary of topics, many of which are addressed in previous sections of this DPEIS, which contribute to the baseline conditions and trends in the SCB and should be considered for potential cumulative impacts associated with aquaculture, should an AOA be identified.

- HAB and domoic acid incidents;
- Marine mammal vessel interactions, vessel restrictions;
- Commercial and recreational fishing;
- Ocean research and ecosystem monitoring;
- Tourism and recreation;
- Commercial shipping;
- Military readiness activities;
- OCS leases;
- Marine debris and water quality;

- Marine aquaculture in the SCB; and
- Marine conservation efforts.

The following current events and trends in the SCB are considered beyond the temporal and spatial scope of this DPEIS. These topics include those that may be considered in a site specific NEPA analysis at the proposed project level for indirect and cumulative impacts when more information about project designs and coastal interactions are known or if other potential large-scale actions become foreseeable and create potential for cumulative impacts at that time.

- Resource extraction (e.g., deepsea mining, dredging);
- Historic and present-day dumping zones (e.g. DDT, spoils, run-off); and
- Historic and present-day spill cleanup efforts (e.g., sewage, oil).

Due to other industries in the area, there is a potential for oil spills, chemical spills, and other pollutants to occur in the broader Santa Barbara Channel and Santa Monica Bay. Notable events, such as oil spills, that have occurred in the last 60 years are summarized on p. 196 of Morris et al. (2021), incorporated by reference. Submarine utilities such as cables and pipelines were incorporated into Morris et al. (2021) modeling as incompatible with aquaculture operations. The AOA alternatives considered in this DPEIS do not currently have any submarine utilities within the areas of analysis. However, it is not possible to predict where new installations may occur in the future. Site specific NEPA analyses would need to consult with local permitting authorities for the potential overlap of specific sites with any new projects for this type of interaction. There are no cumulative impacts for submarine utilities expected at this time.

HAB and Domoic Acid Incidents

Harmful algal blooms, or HABs, occur when a variety of environmental factors cause algae colonies to grow rapidly within a short period of time, which not only consume large amounts of dissolved oxygen as they decay, but also produce high levels of toxins that adversely impact both the ecosystem and human health (NOAA 2016). These toxins bioaccumulate within the food web, which is why they are especially important to consider in aquaculture, as algae is often consumed by shellfish, either directly or indirectly, which is then consumed by humans. One such toxin is domoic acid, a powerful neurotoxin that, in high doses, results in amnesic shellfish poisoning, which causes severe symptoms such as memory loss, heart problems, seizures, and even death. HABs have been known to occur annually along the coast of California, which is why commercially consumed shellfish and finfish are monitored for their levels of toxins; however, recreationally harvested shellfish are not, which poses a great risk to human health (NOAA 2023c). According to NCCOS (2019), NOAA is currently studying the co-occurrence of multiple toxins produced by HABs in Southern California to examine the potential health impacts on the local community. As the global climate changes, incidents of HAB may become more common in shallow, nearshore areas, where the impacts of decreased dissolved oxygen and ocean acidification are more pronounced. The Southern California Coastal Water Research Project monitoring provides general trends in resource health in the region. Significant findings from the published results of 2018 surveys include the following (Smith et al. 2021):

- Domoic acid was widespread in continental shelf sediments of the SCB;
- Domoic acid was detected in 54% of the total shelf habitat area sampled and was most prevalent in the middle shelf strata (67% of mid-shelf area);
- Domoic acid was consistently detected in the sediments during 3 years of field surveys; and
- Domoic acid was consistently detected in benthic infauna tissues on annual and monthly timescales.

Marine Mammal Vessel Interactions

Vessels can attract or repel marine mammals. The main concern around marine mammal/vessel interactions in the SCB is vessel-whale collision. In 2015, NOAA implemented a voluntary vessel speed reduction May 1 through December 15 in the Greater Farallones, Cordell Banks, and Channel Islands

National Marine Sanctuaries, and these zones were extended to include the Monterey Bay National Marine Sanctuary and Santa Barbara Channel Traffic Separation Scheme and Area To Be Avoided in 2023 (NOAA n.d.c). Redfern et al. (2020) found that static spatial management measures like changing shipping lanes and seasonal speed reductions can be effective in mitigating risk from ship traffic variability off California. Rockwood et al. (2021) estimated 8.9 blue whales, 4.6 humpback whales, and 9.7 fin whales were killed in ship collisions each year from Point Conception to San Diego, California based on whale densities and seven years of Automated Information System (vessel location) data. They estimated that if 95% cooperation occurred in the vessel speed reduction lanes, whale deaths there would decrease by 22–26%.

Commercial and Recreational Fishing

Commercial and recreational fishing activity in the SCB is described in Chapter 3, Sections D.i. and D.ii. Fisheries can affect the environment through impacts such as adverse effects to fish stocks, protected species, and habitats, and generally have beneficial socioeconomic effects. Entanglement in fishing gear effects wildlife, and aquaculture infrastructure could potentially contribute additional risk for entanglement (see Chapter 3, Section C (Biological Environment) for entanglement impacts discussion). Fisheries vessels produce emissions and refuse. Commercial, and to the extent practicable recreational, fishing activities have been considered in deconflicting proposed locations for AOAs (Morris et al. 2021). Fisheries may not be able to operate in some areas where aquaculture infrastructure creates navigational hazard for towed gear, and target fish may be repelled from or attracted to aquaculture infrastructure, creating a potential adverse or beneficial interaction for fisheries. The baseline conditions of fisheries for consideration of cumulative impact for the area associated with each alternative are described in Chapter 3, Section D. (Socioeconomic Environment).

Ocean Research and Ecosystem Monitoring

There are a variety of research and monitoring efforts in the region where potential AOAs have been proposed. The Southern California Coastal Water Research Project (SCCWRP 2024) monitoring provides general trends in resource health in the region, conducting regular surveys of sediment, water quality, benthos, and fish. Research grants associated with the State's native fish stock enhancement programs support collaborative projects across a wealth of topics including fish health, physiology, systems design, post-release acoustic tracking, and genetics (e.g., CDFG 2010). NMFS conducts ongoing fishery and protected species research off the California coast, and U.S. Geological Survey and U.S. Fish and Wildlife Service conduct bird studies in the region as well. These ongoing agency projects were considered to the extent practicable in deconflicting proposed locations for AOAs (Morris et al. 2021). The California Cooperative Oceanic Fisheries Investigations project has been ongoing in the CCE since 1949, collecting a variety of physical and biological data (the latest report is Thompson et al. 2022).

Current ocean research and ecosystem monitoring activities may be excluded from aquaculture operations for safety, regulatory, or commercial reasons. This may disrupt long-term data collection and trend analyses. Ocean research and ecosystem monitoring can have adverse impacts on wildlife and habitats, including damaging habitats (e.g., trawl surveys) and creating sound, debris, turbidity, and emissions. At the same time, aquaculture operations may also provide platforms of opportunity to conduct additional research or test and use new technologies for research.

Tourism and Recreation

Within the California Bight, there is a high amount of tourism and recreational activity, most of which occurs nearshore, and includes activities such as sailing, marine mammal watching, scuba diving, and fishing. These activities have been found to be relatively evenly distributed within the Central South Study Area, with no distinct routes, however many recreators were found to favor areas with high biodiversity (Morris et al. 2021). Tourism and recreational activities in the SCB are described in Chapter 3, Section D.v. These activities can affect the environment through impacts such as adverse effects to fish, protected species, and habitats, and generally have beneficial socioeconomic effects. Vessels for tourism and recreation produce emissions and refuse. Tourism and recreational activities have been considered in deconflicting proposed locations for AOAs to the extent practicable (Morris et al. 2021). Tourism and recreation activities may not be able to occur in some areas where aquaculture infrastructure creates safety hazards, and whales or other targets of tourist activities may be repelled from or attracted to aquaculture infrastructure, creating a potential adverse or beneficial interaction for tourism. The baseline conditions of tourism and recreation for consideration of cumulative impact for the area associated with each alternative are described in Chapter 3, Section D.v.

Commercial Shipping

Morris et al. (2021) reports that shipping is considered essential to many industries and should be avoided by aquaculture. While commercial shipping vessels within Santa Monica Bay are rare, the adjacent shipping lanes have a high concentration of tanker traffic, specifically vessels used to offload oil at the Chevron El Segundo terminal (Morris et al. 2021). The proposed potential AOAs are not within shipping channels. Shipping can displace fishing and recreational activities and affect wildlife with potential vessel collision, sound, emissions, and water quality impacts. Shipping routes and types of major vessel patterns near the proposed potential AOAs are described in Morris et al. (2021) and Chapter 3, Section D.vi. (Transportation and Navigation).

Military Readiness Activities

The U.S. Navy's Hawaii-California Training and Testing (HCTT) Study Area consists of the Hawaii Operating Area and the California Operating Area, in addition to a corridor that connects the two. The California Operating Area spans the length of Southern California, including the proposed AOAs located along Santa Barbara and Santa Monica. The HCTT Study Area is used to conduct at-sea military readiness activities, which include active sonar, explosive use, and other sources of underwater sound (U.S. Navy 2018). Military training and testing can displace fishing and recreational activities and affect wildlife with potential vessel collision, sound, emissions, and water quality impacts.

OCS Offshore Wind Leases

Offshore wind leases are described in Chapter 3, Section D.vii. (Offshore Energy and Public Services). Five wind leases have been sold off the coast of Central and Northern California, and on April 24, 2024, the Department of Interior announced a new five-year offshore wind lease schedule that includes another lease sale off the coast of California scheduled for 2028 (BOEM 2024). Potential locations for 2028 lease blocks have not yet been identified by BOEM. Offshore wind farms have the potential to affect the physical and biological environment, as well as the potential to affect fisheries and other commercial activities and cultural resources. BOEM is preparing a PEIS for the five leases currently under development (BOEM n.d.). Offshore wind projects undertake site assessment activities that include deployment of metocean buoys and other scientific devices and conduct geophysical, geotechnical, and biological surveys. Off California, offshore wind will be floating wind, which will include bottom anchored moorings and inter-array cables among potentially hundreds of turbines. Windfarms are subject to permitting and must be in compliance with federal law, including the implementation of a variety of mitigation measures to avoid, minimize, and offset impacts.

Marine Debris and Water Quality

Marine debris and water quality issues affect ecosystem health and are a species conservation concern as discussed in Chapter 3, Section C. (Biological Environment). According to EPA (2011a), ocean-based litter contributes about 11% to all marine debris along the west coast, and 35% is from unknown or unspecified sources. Based on the California Ocean Litter Prevention Strategy (California Ocean Protection Council and NOAA Marine Debris Program [CalOPC 2018]), about 46% of the debris found on California beaches is from ocean-based sources. This debris is concentrated by ocean currents along the same fronts, eddies, and convergences that characterize the SCB and that concentrate marine life in food web interactions (EPA 2011a). Water quality is affected by other activities in the SCB. The SCB Coastal Water Research Project monitoring provides general trends in resource health in the region (SCCWRP 2024). The reports generated by this program provide additional baseline information for future analysis of potential cumulative impacts of marine debris and water quality impairments across ongoing actions in the region and proposed aquaculture projects.

iii. Marine Aquaculture in the Southern California Bight

Statewide, grown or proposed macroalgae species include Ogo (*Gracilaria* spp.), Sea Lettuce (*Ulva* spp.), Dulse (*Palmaria palmata*), Giant Kelp (*Macrocystis pyrifera*), Bladder Wrack (*Fucus* spp.), Nori (*Porphyra lanceolata*), Kombu (*Laminaria farlowii*, *Laminaria setchelii*), and Turkish Towel (*Chondracanthus exasperatus*). Aquaculture farms may sell seaweed that is harvested opportunistically from their shellfish cultivation gear, as regulations allow (CDFW 2020a). The industry is still minimal, with little to no impact on the economy at this point in time (CDFW 2020a). Additional commercial shellfish and seaweed operations located in the SCB but outside the geographic areas associated with the DPEIS alternatives include one mussel farm near Long Beach, a variety of shellfish and algae species near Carlsbad, and seaweed and shellfish near San Diego (Aquarium of the Pacific 2015, CDFW 2020a; and Sea Grant 2024a).

Commercial marine aquaculture development for seaweed, shellfish, and finfish in the SCB is being researched for its economic potential while managing and minimizing significant adverse impacts on the environment (Lester et al. 2018b, Nelson et al. 2019, and CDFW 2022). Ocean-based, commercial aquaculture in California state waters is limited currently to shellfish and seaweed projects (Aquarium of the Pacific 2015, Green Wave 2019, and CDFW 2020a). As of the most recent CDFW report, the Santa Barbara Channel currently has a total of 97 acres (39 ha) leased for commercial aquaculture operations in state waters, with an estimated 25 acres (10 ha) being actively used (CDFW 2020a). Cultivated species include Mediterranean Mussels (*Mytilus galloprovincialis*), Pacific Oysters (*Crassostrea gigas*), and Red Abalone (*Haliotis rufescens*) (CDFW 2020a, 2022; Sea Grant 2024a). There are no commercial marine aquaculture operations in Santa Monica Bay.

Future aquaculture project-specific NEPA analyses would coordinate with USACE on the most up-to-date locations of other proposed or existing aquaculture to sufficiently analyze potential interactions and cumulative impacts among facilities sited in an AOA and other aquaculture operations in the area.

iv. Marine Conservation Efforts

Marine managed areas are described in Chapter 3, Section B.ii. As described in that Section of this DPEIS, there are a variety of state and federal managed areas with differing levels and types of restrictions aimed at conservation and management of resources. A proposed Chumash Heritage National Marine Sanctuary (88 FR 58123) may be added to the network of marine protected areas in the SCB region. Fisheries management also includes conservation practices to meet statutory requirements of Magnuson-Stevens Fishery and Conservation Management Act (MSA), ESA, MMPA, and other laws. Impacts of potential aquaculture operations on marine conservation areas is described in Chapter 3, Section B.ii. (Marine Managed Areas). Aquaculture may be used as a tool for management and conservation with respect to fish harvest, or it may cause impacts that require additional conservation efforts to offset. Cumulatively, marine conservation efforts generally provide benefits to resources and have potential to enhance and be enhanced by aquaculture operations.

B. Potential Cumulative Impacts from Past, Present, and Foreseeable Actions

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact. Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. Baseline conditions for climate change and other ocean uses are described in Chapter 4, Section A. Based on these baselines of past, present, and foreseeable actions, the increment of cumulative effect of the action of identifying AOAs is likely to be very minimal and may result in a lower increment of cumulative impacts compared to aquaculture projects that may be implemented without AOAs due to deconfliction of aquaculture in AOAs. To the extent practicable, the approach to developing alternatives accounts for commercial, recreational, conservation, and military activities, aiming to deconflict the proposed AOAs with these uses through application of the Aquaculture Atlas (Morris et al. 2021). At the stage of individual project proposals, finer-scale consideration for local interactions may result in different localized cumulative effects in space or time. There may be both adverse and beneficial effects, including adverse ecosystem effects in combination with other uses and beneficial and adverse effects to food security. For example, if aquaculture occurs in waters that are far from shore or are subject to high energy conditions, seafood from such facilities may become costly relative to other foods which may affect the food security benefits (Fujita et al. 2023). Diversification can also build food resilience in combination with fisheries and help address food shocks.

A cumulative analysis of climate change on resources that may be impacted by aquaculture facilities would need to be scaled down from global and regional trends to the local scale of a project-specific action area. The following considerations may be used to analyze cumulative effects in association with climate change:

- Changes in the marine physical and chemical condition that could affect biological resources;
- Changes in ocean access and use (habitat use by marine life; commercial or recreational activities for humans);
- Changes in marine ecosystem dynamics, at a population level;
- Changes in fishing community involvement or dependence upon fishery resources; and
- Synergistic effects expected with aspects of climate change.

With respect to cumulative effects with past, present, and foreseeable actions (aside from climate change), the stressors described in Chapters 4(B), (C), (D), and (E) are also applicable to the physical, biological, socioeconomic, and cultural/historic environmental impacts. These stressors may act in synergy or in conflict across actions. The increment of impact associated with the cumulative stressors for these resources is described below for each alternative.

i. Administrative Environment

NEPA regulations state that cumulative effects are effects on the environment that result from the incremental effects of the action when added to the effects of other past, present, and reasonably foreseeable actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative effects can result from actions with individually minor but collectively significant effects taking place over a period of time.

The Regulatory Flexibility Act (RFA; 5 U.S.C. §§ 601-612) is a procedural statute that requires federal agencies to take into account the disproportionate impacts regulations may have on small businesses, and requires agencies consider other alternatives if the impact on small businesses is significant. The RFA does not apply to the AOA NEPA planning process because it is not a regulatory process; however, the impacts of offshore aquaculture interactions with fisheries and fishing communities may change how communities are analyzed in accordance with the RFA and National Standard 8 under MSA (McDevitt 2001).

ii. Climate Change

Climate scientists have concerns about the potential for cumulative and synergistic effects of hypoxia and ocean acidification (PFMC scoping). Ocean acidification, caused by increased anthropogenic CO_2, reduces pH and dissolved carbonate in seawater and is stressful to many marine species (Feely et al. 2008, Busch and McElhany 2016). The main cause of climate change is increasing anthropogenic GHG emissions. Reducing GHG emissions will require national and global efforts. Therefore, any mechanism to consider the impacts of climate change and GHG needs to consider the adequacy and the effectiveness of national and international regulatory mechanisms (NMFS 2023e). It is anticipated that climate change will affect resources in the AOAs, as well as affecting aquaculture viability over time. The value of aquaculture may increase if commercial fish stocks and/or fisheries are adversely affected by climate change.

Aquaculture may have greater impacts in conjunction with climate change. Cultured species unable to move from unfavorable environmental conditions may experience higher physiological stress and changes in their microbiomes, potentially increasing susceptibility to infection and disease. Temperature fluxes, such as marine heat waves, are expected to be a major driver to vulnerability to disease because adjustment and adaptations can be metabolically demanding. Changes in temperature and pH will alter ocean chemistry, such as dissolved oxygen, dissolved nutrients, and bioavailable carbonate for calcification. Lower pH can reduce immune responsiveness in shellfish and finfish, and early life stages are especially vulnerable to negative effects. Climate changes are affecting the distribution of commercial fish species, changing the species composition and the potential for disease transmission near aquaculture facilities. There may be impacts on native pathogens as well. For example, certain ectoparasites can tolerate a wider range of seawater pH than the hosts, possibly resulting in more severe infestations. Ocean acidification in the SCB is already occurring and is expected to persist. (Rhodes et al. 2023a).

The uncertainty associated with the rate and magnitude of climate-related changes and the response of organisms to those changes increases the risk of potential impacts to protected species. The assessment of overall risk to a species, long-term recovery planning, and evaluations of specific actions help to adequately incorporate climate change into the impacts analysis for aquatic species (McClure et al. 2013). Whether climate change is likely to amplify the effects of a particular proposed action depends, in part, on the duration of the action's effects, whether the action's effects on listed species and critical habitat vary in response to any environmental conditions that are likely to change over time (e.g., water temperature, prevalence of invasive species, etc.), and whether the action includes measures to reduce its adverse effects (e.g., through an adaptive management plan) in response to changing environmental conditions. At this point in time, every aquaculture project consultation is so unique that climate change impacts would be considered on a case-by-case basis. To adequately analyze how climate change may exacerbate potential impacts of an action on ESA-listed species, NMFS has developed guidance that would be applied at the project level to ESA consultations (NMFS 2023e). Site specific NEPA analyses from this DPEIS would need to refer back to any local-scale climate change impacts referenced in the environmental baseline section and further assess cumulative effects.

iii. Alternative 1: No Action

For the no action alternative, no AOA would be identified and baselines around past, present, and foreseeable actions would stay the same and interact with ongoing climate change as described in Chapter 4, Section A.

iv. Alternative 2: Santa Barbara Channel

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. Individual project proposals may provide more detail for assessing cumulative effects across regional aquaculture activities.

Climate Change

Climate change introduces substantial risk and uncertainty to ongoing growth and development of aquaculture, as changing oceanographic conditions (e.g., temperature, upwelling, and dissolved oxygen) are expected to impact the environment on which aquaculture depends (FAO 2022). Aquaculture may contribute to climate change through greenhouse gasses (GHGs) produced in pre-installation, installation, and post-installation activities, but may also serve to mitigate effects of climate change in the context of providing improved food security where climate change has affected other food sources. The increment of impact of identification of one to eight AOAs in Santa Barbara Channel is likely to be very minimal in the context of GHGs, climate change, and food security. Quantification of estimated emissions and food production value of specific projects in the context of climate change will be analyzed in future project-specific permitting NEPA analyses.

HAB and Domoic Acid Incidents

HAB and domoic acid incidents affect fish and shellfish supplies for commercial and recreational fisheries. The proposed AOA(s) in Santa Barbara Channel are more than three miles from shore, making them less susceptible to HAB, possibly allowing for the beneficial impact of making more uncontaminated seafood available if aquaculture is undertaken in the AOA(s); however, aquaculture itself can deplete local resources and create conditions for disease and toxic events. In combination with HAB and domoic acid events, the increment of impact of identification of one or more AOAs in Santa Barbara Channel is likely to be very minimal. Localized depletions and disease may be a concern and should be addressed through monitoring and planning that allows for water flow and managed water quality. EPA will review activities as required for National Pollutant Discharge Elimination System permits where discharges are involved in aquaculture activities and require appropriate mitigation and monitoring to meet statutory Clean Water Act (CWA) requirements.

Marine Mammal Vessel Interactions

Relative to the substantial amount of vessel traffic in the Santa Barbara Channel region, the increases in numbers of vessels and time vessels spend on the water is likely to be a very minimal increment of vessel traffic and its associated sound, emissions, and potential for vessel collision with marine mammals and other protected species. Mitigation to avoid vessel collision would be expected to include implementation of NOAA vessel strike avoidance guidance (NMFS 2021d). The voluntary vessel speed reduction program requiring vessels 300 gross tons (gt) and larger to reduce speed to 10 kt maximum in shipping lanes approaching and leaving San Francisco Bay, and 10 kt restrictions May 1 – December 15 in Channel Islands, Greater Farallones, and Cordell Bank National Marine Sanctuaries also reduce general risks to whales. Aquaculture vessels would be much smaller than 300 gt, but cumulatively, this mitigation reduces risks in the region. In 2023, the vessel speed restriction zone was expanded to include Monterey Bay National Marine Sanctuary and the International Maritime Organization modifications to the Santa Barbara Channel Traffic Separation Scheme and Area to be Avoided (NOAA n.d.c), further protecting whales in the region. Thus, impacts of vessel traffic are reduced through regional mitigation measures and the increment of potential to interact with or collide with whales in aquaculture pre-, during- and post-construction is minimal. These restrictions also reduce emissions (NOAA n.d.c).

Commercial and Recreational Fishing

Development of aquaculture in the Santa Barbara Channel region could incrementally increase impacts from commercial and recreational fisheries on habitats, fish stocks, and prey species. Federal fisheries are managed under the MSA to avoid overfishing and minimize impacts to protected species and habitats. Management may be adapted to the presence of aquaculture to avoid cumulative impacts that result in commercial stock depletions. Aquaculture can increase potential for localized disease or escape that result in cumulative adverse impacts to resources affected by fisheries. In combination, fisheries and aquaculture can benefit food security and resilience. Fisheries may not be able to operate within some types of aquaculture facilities, changing the local dynamic of harvest, but the increment of impact to protected resources, commercial or recreational fish stocks, or habitats is likely to be minimal given the small footprint of the proposed AOAs compared to the range of fish and other resources. Morris et al. (2021) was used to minimize conflict of the proposed AOAs with fisheries, and further mitigation may be applied at the project-level by NMFS and USFWS to ensure the effect of aquaculture and fisheries complies with MSA, ESA, MMPA, and other relevant statutes. Individual project proposals may provide more detail for assessing cumulative effects across regional aquaculture activities.

Ocean Research and Ecosystem Monitoring

Ocean research and ecosystem monitoring are common in the SCB, with decades of academic studies and ongoing research in the region for management of fisheries and protected species and habitats. Ocean research and monitoring include deployment of buoys and other scientific equipment platforms and a wide variety of surveys. Morris et al. (2021) was used to minimize conflict of the proposed AOA(s) with areas of ongoing ocean research, particularly for conservation and management purposes, where trend studies may be important. The increment of impact to resources combined with ocean research and ecosystem monitoring is likely to be minimal given the efforts to minimize conflict and the benefits of ocean research and ecosystem monitoring. Aquaculture could result in additional minimal adverse impacts to benthic resources where moorings are installed but may also act to aggregate fish through reef effects and create research opportunities through infrastructure and vessel operations as platforms of opportunity, cumulatively enhancing some research opportunities.

Tourism and Recreation

Tourism and recreation activities are common in the SCB. The increment of impact to resources combined with tourism and recreation is likely to be minimal. The proposed AOA is in federal waters more than 3 nm from shore, reducing the likelihood of synergistic impacts with onshore and nearshore tourism. Combined effects to water quality may be a consideration at the project stage, though requirements of CWA for finfish will result in mitigation at the project level and ongoing monitoring of sediment and water quality in the SCB (SCCWRP 2024) will provide historical and future information to assess potential cumulative impacts related to implementation of aquaculture.

Commercial Shipping

Impacts associated with commercial shipping include emissions, collision risk with protected species, sound, and interruption to fisheries and recreational activities. Although the development of aquaculture would create similar risks, these risks would be in a localized area outside shipping lanes and the increment of additional risk would likely be minimal.

Military Readiness Activities

The military operates in the SCB (US Navy 2018) undertaking a variety of training and testing activities. Morris et al. (2021) was used to minimize conflict of the proposed AOA(s) with military readiness activities. The increment of impact to resources combined with military readiness activity is likely to be minimal. Deconfliction will reduce overlap that could cumulatively stress local resources. Department of Defense will further review any proposed aquaculture operations for mission compatibility.

OCS Offshore Wind Leases

Five offshore wind leases have been sold off the coast of California, and future wind leases are anticipated (BOEM n.d.). The size of offshore wind leases is substantially larger than the proposed AOA (current leases off California range from 63,338 acres to 80,418 acres (25,632 to 32,544 ha); BOEM n.d.). Windfarms would be expected to have substantially more infrastructure than aquaculture, with hundreds of platforms with mooring cables, inter-array cables, substations, and export cables to shore, as well as turbines reaching hundreds of feet into the air. The increment of impact to resources combined with offshore wind projects is likely to be minimal given this substantive difference in footprint and infrastructure. BOEM is preparing a PEIS for the five current leases for their construction and operations authorizations, which will include mitigation to be compliant with applicable statutes.

Marine Debris and Water Quality

As noted in Chapter 4, Section A.ii. (Other Ocean Uses and Current Events), the California Ocean Litter Prevention Strategy (CalOPC 2018) reports that about 46% of the debris found on California beaches is from ocean-based sources. The cumulative effects of marine debris across anthropogenic sources can have serious impacts on wildlife and habitats. The increment of impact to resources from marine debris that may be associated with aquaculture operations, should they be authorized, is likely to be minimal. It is expected that mitigation associated with authorizations for aquaculture projects will include marine debris awareness and prevention, as is the case for offshore wind authorizations (e.g., see NMFS 2022d). This will further reduce the increment of impact.

Water quality is impacted by a variety of activities in the region and is monitored via programs like the SCB Regional Monitoring Program (2024). The increment of impact to resources combined with other actions that affect water quality and produce marine debris is likely to be minimal given the scope and scale of the proposed AOA and the mitigation and monitoring likely to be implemented as a result of permitting and consultations, such as National Pollutant Discharge Elimination System permits and ESA consultations.

Marine Conservation Efforts

The Santa Barbara Channel is adjacent to the Channel Islands National Marine Sanctuary and the proposed Chumash Heritage National Marine Sanctuary. The Santa Barbara Channel also has a network of 19 marine protected areas that include marine reserves, state marine conservation areas, no-take state marine conservation areas, and special closures (Santa Barbara Channel Keeper n.d.). Morris et al. (2021) was used to avoid identifying AOAs in marine conservation areas. In some cases, these areas restrict access or activities, and project specific requirements of future aquaculture operations within AOAs in the region may further restrict access and activities. Monitoring associated with marine conservation efforts may either be adversely affected because of further limits on access or benefited by new platforms of opportunity for collaborative monitoring. The increment of impact to resources as a result of minor access limits or a small number of platforms of opportunity is likely to be minimal compared to the benefits of marine conservation efforts in aggregate.

Marine Aquaculture in the Southern California Bight

In aggregation with other marine aquaculture present or planned in the SCB, development of aquaculture in the potential AOAs could increase the adverse and beneficial effects to resources described in Chapter 3. The increment of impact may be meaningful in the context of aquaculture as a whole given the relative size and scope of potential aquaculture activities in comparison to existing and proposed aquaculture operations described in Chapter 4, Section A.iii. (Marine Aquaculture). Cumulatively, this impact to resources is affected by the type of aquaculture and its extent. Individual project proposals will provide more detail for assessing cumulative effects across regional aquaculture activities.

v. Alternative 3: Santa Monica Bay

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. Individual project proposals may provide more detail for assessing cumulative effects across regional aquaculture activities.

The potential for cumulative impacts and the increment of impact associated with the past, present, and foreseeable actions described for Alternative 2 are not meaningfully different for Alternative 3. The resolution of data and impact potential is generally not sufficient to identify fine-scale difference in potential for increment of cumulative impact between the two potential Alternatives.

Potential Mitigation for Cumulative Impacts

The general discussion of mitigation for Alternative 2 is applicable to Alternative 3 in the context of cumulative impacts.

vi. Alternative 4. Combination of Geographic Areas

Identification of AOAs is a planning effort that does not result in any authorization, permit, or regulatory impact.

Later actions of siting and operating aquaculture facilities may have impacts, which are discussed here. Individual project proposals may provide more detail for assessing cumulative effects across regional aquaculture activities.

A combination of geographic areas has the potential to increase the increment of impact. The larger acreage also contributes to potential for more aquaculture activity, and so more increment of impact in conjunction with past, present, and foreseeable actions. Impacts reflected under Alternative 4 would have similar impacts to those described for Alternatives 2 and 3, with an increased increment of impact on cumulative effects, but the scale of impacts reflected under Alternative 4 is not large enough that a substantive increase in increment of effect would be anticipated. At this stage, identification of AOAs does not authorize any development of aquaculture, so the extent to which aquaculture would occur in the proposed potential AOAs cannot be determined until projects are proposed. Overall, the increment of impact associated with impacts reflected under Alternative 4 is higher than Alternatives 1-3 but would not make up a large component of the cumulative impacts from other activities in the region.

Chapter 5: Compliance with other Laws, Policies, and Regulations

While the proposed action in the EIS is a planning action and does not trigger compliance with the below laws and regulations any potential future aquaculture projects should consider compliance requirements of applicable federal, state, and local laws, regulations, and executive orders. Table 4 summarizes expected (but not necessarily exhaustive) federal environmental compliance requirements for site specific aquaculture facilities, and includes some state requirements that facilities may wish to consider.

Table 4: Laws, Policies, and Regulations

Name	Agency Jurisdiction	Application to Facilities Sited in an AOA
National Environmental Policy Act 42 U.S.C §4321; 40 CFR parts 1500-1508	–	Considers the effects of federal agency actions and alternatives on the human environment.
Endangered Species Act 16 U.S.C. § 1531 et seq. section 7(a)(2)	NMFS, USFWS	Evaluates and ensures that any action is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of the designated critical habitat of listed species.
Marine Mammal Protection Act 16 U.S.C. § 1361 et seq. sections 101, 104	NMFS, USFWS	Evaluates actions for potential impacts on marine mammals and manages the development and implementation of measures to minimize effects.
Migratory Bird Treaty Act 16 U.S.C. § 703 et seq.	USFWS	Evaluates actions for potential impacts on birds and manages the development and implementation of measures to minimize effects.
Rivers and Harbors Act 33 U.S.C. § 403 section 10 33 CFR part 322	USACE	Evaluates proposed structures and work in or affecting navigable waters, including the OCS.
General policies for evaluating permit applications 33 CFR part 320.4(a)	USACE	Public interest factors that must be evaluated in all permit applications.
Clean Water Act 33 U.S.C. § 1251 et seq., sections 318, 402, 403 40 CFR	EPA	Evaluates actions for impacts to waters of the U.S. and aquatic ecosystems, and establishes pollution discharges and water quality standards to avoid adverse impacts.

Name	Agency Jurisdiction	Application to Facilities Sited in an AOA
Outer Continental Shelf Lands Act 43 U.S.C. § 1331 et seq.	BOEM	Considers and manages economic, social, and environmental values of renewable and nonrenewable resources located in submerged lands between the seaward extent of state coastal waters and the seaward extent of the EEZ.
Animal Health Protection Act 7 U.S.C. § 8301 et seq.	USDA	Manages potential diseases in animals and the effects of diseases on animals.
The Food, Drug, and Cosmetic Act 21 U.S.C. § 301 et seq.	FDA	Broad authority to protect public health, primarily through oversight of food and Drugs; includes approving animal drugs, including transgenic fish and therapeutants used in aquaculture, and seafood safety.
National Marine Sanctuaries Act 16 U.S.C. § 1431 et seq.	ONMS	Authorizes the Secretary of Commerce to designate and protect areas of the marine environment with special national significance due to their conservation, recreational, ecological, historical, scientific, cultural, archeological, educational or esthetic qualities as national marine sanctuaries.
Clean Air Act 42 U.S.C. § 7401 et seq.	EPA	Comprehensive law that regulates sources of air emissions. It directs the EPA to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment.
Clean Air Act Section 202 et seq.	EPA	The CAA Section requires a comprehensive approach to reducing pollution from mobile sources, such as cars, trucks, locomotives, ships and planes.
Noise Control Act 42 U.S.C. § 4901 et seq.	EPA	Establishes a national policy to promote an environment for all Americans free from noise that jeopardizes their health and welfare.

Name	Agency Jurisdiction	Application to Facilities Sited in an AOA
Fish and Wildlife Coordination Act 16 U.S.C. § 661 et seq.	NMFS, USFWS, USACE	Directs the Service to investigate and report on proposed Federal actions that affect any stream or other body of water and to provide recommendations to minimize impacts on fish and wildlife resources.
National Historic Preservation Act 54 U.S.C. § 300101 et seq.	ACHP	The act preserves historic and archaeological sites in the United States of America. The act created the National Register of Historic Places, the list of National Historic Landmarks, and the State Historic Preservation Offices.
Lacey Act 16 U.S.C. § 3371 et seq.	NMFS, USFWS (interstate, inter-country)	Prohibits the importation, exportation, transportation, sale, receipt, acquisition, or purchase of any fish or wildlife or plant taken, possessed, transported, or sold in violation of any law, treaty, or regulation of the United States or any Indian tribal law whether in interstate or foreign commerce.
Coastal Zone Management Act 16 U.S.C. § 1451 et seq.	OCM	The act provides for the management of the nation's coastal resources, including the Great Lakes. The goal is to preserve, protect, develop, and where possible, to restore or enhance the resources of the nation's coastal zone, including preserving visual aesthetics.
Magnuson-Stevens Fishery Conservation and Management Act 16 U.S.C. § 1801 et seq.	NMFS, PFMC	The primary law that governs marine fisheries management in U.S. federal waters, it fosters the long-term biological and economic sustainability of marine fisheries, using a transparent and public process of science, management, innovation, and collaboration with the fishing industry.
Unauthorized Aids to Maritime Navigation; Penalty 14 U.S.C. § 83	USCG	No person, or public body, or instrumentality, excluding the armed services, shall establish, erect, or maintain any aid to maritime navigation in or adjacent to the waters subject to the jurisdiction of the United States without first obtaining authority to do so from the Coast Guard.

Name	Agency Jurisdiction	Application to Facilities Sited in an AOA
Navigation and Navigable Waters 33 CFR Chapter 1	USCG	Regulations to safeguard navigation on the high seas and navigable waters of the U.S, including administration of the U.S. Aids to Navigation System.
National Defense 32 CFR 211	DOD Siting Clearinghouse / DHS	Regulations for initiating a formal DoD review of proposed projects to determine if they pose an unacceptable risk to the national security of the United States.
National Aquaculture Act 16 U.S.C. 2801 et seq.	DOI, DOC, USDA	Establishes aquaculture as a national policy priority for the United States.
Concentrated Aquatic Animal Production point source pollution 40 CFR 122.24 and .25 -	EPA	Defines concentrated aquatic animal production facilities for regulation as point sources subject to the CWA NPDES permit program.
Veterinary Feed Directive 21 CFR part 558	FDA	Outlines the process for authorizing use of VFD drugs. Eliminates the use of medically important antibiotics for production purposes (e.g., growth promotion and feed efficiency), use is permitted only under the professional supervision of a licensed veterinarian.
National Shellfish Sanitation Program 21 U.S.C. 372, 42 ; U.S.C. 243	FDA	Promotes and improves the sanitation of shellfish (oysters, clams, mussels and scallops) moving in interstate commerce through federal/state cooperation and uniformity of State shellfish programs.
Ports and Waterways Safety Act 46 U.S.C. §70001 et seq.	USCG	Authorizes the U.S. Coast Guard to establish vessel traffic service/separation schemes for ports, harbors, and other waters subject to congested vessel traffic.
National Invasive Species Act P.L. 104-332	NISC	Provides for ballast water management to prevent the introduction and spread of nonindigenous species into the waters of the United States.
Oil Pollution Act 33 U.S.C. § 2702	USCG, BOEM/BSEE	The Act aims to prevent, prepare, and respond to potential oil spills. Among various requirements, it gives BOEM the authority to oversee industry structures in the OCS.

Name	Agency Jurisdiction	Application to Facilities Sited in an AOA
Ocean Dumping Act 33 U.S.C. § 1401	USACE, EPA, USCG, and NOAA	Prohibits dumping into the ocean material that would unreasonably degrade or endanger human health or the marine environment unless a permit is issued.
Occupational Safety and Health Act 29 U.S.C. § 651	OSHA	Establishes occupational hazards standards, including occupational noise; meeting standards for employees is the responsibility of the employer.
Executive Orders		
Executive Order 12898 - Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	All Federal Agencies	Considers disproportionately high and adverse human health or environmental effects of proposed activities on minority populations and low-income populations.
Executive Order 14096 - Revitalizing our Nation's Commitment to Environmental Justice for All	All Federal Agencies	Supplements the foundational efforts of Executive Order 12898.
Executive Order 13158 - Marine Protected Areas	DOI, DOC, states	Considers impacts on any area of the marine environment that Federal, state, territorial, tribal, or local laws or regulations have reserved to provide lasting protection for part or all of the natural or cultural resource within the protected area.
Executive Order 13112 - Invasive Species	NISC	Implements relevant programs and authorities to prevent, detect, and respond to the spread of invasive species.
Executive Order 13840 - Ocean Policy to Advance the Economic, Security, and Environmental Interests of the United States	OPC	Maintains and enhances benefits to the Nation through improved public access to marine data and information, efficient interagency coordination on ocean-related matters, and engagement with marine industries, the science and technology community, and other ocean stakeholders, recognizes and supports Federal participation in regional ocean partnerships.

Name	Agency Jurisdiction	Application to Facilities Sited in an AOA
Executive Order 13751 - Safeguarding the Nation From the Impacts of Invasive Species	NISC	Amends Executive Order 13112 and directs actions to continue coordinated Federal prevention and control efforts related to invasive species.
Executive Order 13921 – Promoting American Seafood Competitiveness and Economic Growth	Multiple Federal Agencies	Promotes American seafood competitiveness and economic growth, and calls for the expansion of sustainable U.S. seafood production. Also requires the Secretary of Commerce to identify geographic areas containing locations suitable for commercial aquaculture, and complete a PEIS.
Executive Order 13985 - Advancing Racial Equity and Support for Underserved Communities Through the Federal Government	All Federal Agencies	Requires federal agencies to pursue a comprehensive approach to advancing equity for all, including people of color and others who have been historically underserved, marginalized, and adversely affected by persistent poverty and inequality.
Executive Order 14008 - Tackling the Climate Crisis at Home and Abroad	All Federal Agencies	Builds on and reaffirms actions taken to place the climate crisis at the forefront of foreign policy and national security planning.
Executive Order 14091 - Further Advancing Racial Equity and Support for Underserved Communities Through the Federal Government	All Federal Agencies	Builds upon previous equity-related Executive Orders by extending and strengthening equity-advancing requirements for agencies.
Potential State Coordination or Consideration		
Coastal Zone Management Act 16 U.S.C. chapter 33 section 1451 et seq	CCC	Permit applicants shall provide a certification to the permitting agency that proposed activities comply with enforceable policies of the state coastal zone management program.

Name	Agency Jurisdiction	Application to Facilities Sited in an AOA
National Historic Preservation Act 16 U.S.C. chapter 1A subchapter II section 470 and Section 106 of the National Historic Preservation Act of 1966, as amended (26 54 U.S.C. 306108) (36 CFR §§ 800.2(c)(1)]	SHPO	Review process for all projects that may impact eligible sites or resources.
California Ambient Air Quality Standards (CAAQS) est. 1962, last updated 2008; California Air Quality Management Plan (AQMP) under the California Clean Air Act, and Section 328 of the Federal Clean Air Act	CARB	The regulations delegate California the authority to oversee the CAA National standards for California, and develop their own air quality standards. Section 328 requires control of air pollution from OCS sources located within 25 miles of states' seaward boundaries to be comparable to that of onshore areas.
California Ocean Protection Act of 2004 (COPA; Division 26.5 of the CA Public Resources Code Sections 35500-35515)	Cal-OPC, SLC	Establishes the Ocean Protection Council, which helps to coordinate and fund actions to protect and manage California's ocean and coastal resources.
Fish and Game Code (Section 2118)	CDFW	Regulations and permitting for the import, transport, possess, or release alive into CA of certain wild animal species.

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References Cited

Adame, K., F. R. Elorriaga-Verplancken, E. Beier, K. Acevedo-Whitehouse, and M. A. Pardo. 2020. The demographic decline of a sea lion population followed multi-decadal sea surface warming. Scientific Reports 10(1):10499.

Adams, T. P., R. G. Miller, D. Aleynik, and M. T. Burrows. 2014. Offshore marine renewable energy devices as stepping stones across biogeographical boundaries. Journal of Applied Ecology 51(2):330–338.

Aguilar-Manjarrez, J., D. Soto, and R. E. Brummett. 2017. Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture: a handbook. Food and Agriculture Organization of the United Nations ; The World Bank, Rome.

Airamé, S., J. E. Dugan, K. D. Lafferty, H. Leslie, D. A. McArdle, and R. R. Warner. 2003. Applying ecological criteria to marine reserve design: a case study from the California Channel Islands. Ecological Applications 13(sp1):170–184.

Akiona, A. K., B. N. Popp, R. J. Toonen, M. C. Siple, K. Kotubetey, H. Kawelo, and E. C. Franklin. 2022. Predatory fish diets shift towards an invasive mullet in a traditional Hawaiian aquaculture system. Aquaculture, Fish and Fisheries 2(5):307–320.

Akyol, O., and O. Ertosluk. 2010. Fishing near sea-cage farms along the coast of the Turkish Aegean Sea. Journal of Applied Ichthyology 26(1):11–15.

Alberghini, L., A. Truant, S. Santonicola, G. Colavita, and V. Giaccone. 2023. Microplastics in Fish and Fishery Products and Risks for Human Health: A Review. International Journal of Environmental Research and Public Health 20(1):789.

Alexander, K. A., D. Angel, S. Freeman, D. Israel, J. Johansen, D. Kletou, M. Meland, D. Pecorino, C. Rebours, M. Rousou, M. Shorten, and T. Potts. 2016. Improving sustainability of aquaculture in Europe: Stakeholder dialogues on Integrated Multi-trophic Aquaculture (IMTA). Environmental Science & Policy 55:96–106.

Allen, L. 1985. A Habitat Analysis of the Nearshore Marine Fishes from Southern California. Bull. South. Calif. Acad. Sci. 84:133–155.

Allen, L. 2006. Continental shelf and upper slope. pp. 167-202In L.G. Allen, D.J. Pondella, and M. H. Horn (eds.), The Ecology of Marine Fishes: California and Adjacent Waters. University of California Press, Berkeley.

Alleway, H. K., C. L. Gillies, M. J. Bishop, R. R. Gentry, S. J. Theuerkauf, and R. Jones. 2019. The Ecosystem Services of Marine Aquaculture: Valuing Benefits to People and Nature. BioScience 69(1):59–68.

Alsharif, K. A., and N. Miller. 2012. Data Envelopment Analysis to Evaluate the Reliance and Engagement of Florida Communities on Gulf of Mexico Commercial Red Snapper Fisheries. Fisheries 37(1):19–26.

Alston, D., A. Cabarcas, J. Capella, D. Benetti, S. Meltzoff, and R. Cortés. 2005. Environmental and Social Impact of Sustainable Offshore Cage Culture Production in Puerto Rican Waters. Final Report.

Anderson, C. R., R. M. Kudela, C. Benitez-Nelson, E. Sekula-Wood, C. T. Burrell, Y. Chao, G. Langlois, J. Goodman, and D. A. Siegel. 2011. Detecting toxic diatom blooms from ocean color and a regional ocean model: Remote Detection of Toxic Diatom Blooms. Geophysical Research Letters 38(4):n/a-n/a.

Anderson, C. R., D. A. Siegel, R. M. Kudela, and M. A. Brzezinski. 2009. Empirical models of toxigenic Pseudo-nitzschia blooms: Potential use as a remote detection tool in the Santa Barbara Channel. Harmful Algae 8(3):478–492.

Anderson, J., and G. Shamshak. 2008. Future Markets for Aquaculture Products. pp. 231-243 in J.L Anderson, J. Forster, D. Jin, J.E. Kirkley, G. Knapp, C.E. Nash, M. Rubino, G.L. Shamshak, and D. Valderrama, (eds). Offshore Aquaculture in the United States: Economic Considerations, Implications & Opportunities, July 2008 (Pre-Publication Copy). U.S. Dept. of Commerce, NOAA, Silver Spring, MD.

Andersson, A. J., D. I. Kline, P. J. Edmunds, S. D. Archer, N. Bednaršek, R. C. Carpenter, M. Chadsey, P. Goldstein, A. G. Grottoli, and T. P. Hurst. 2015. Understanding ocean acidification impacts on organismal to ecological scales. Oceanography 28(2):16–27.

Andreas, T. Hadibarata, P. Sathishkumar, H. Prasetia, Hikmat, E. D. Pusfitasari, A. N. Tasfiyati, D. Muzdalifah, J. Waluyo, A. Randy, D. P. Ramadhaningtyas, O. Zuas, and A. A. Sari. 2021. Microplastic contamination in the Skipjack Tuna (Euthynnus affinis) collected from Southern Coast of Java, Indonesia. Chemosphere 276:130185.

Aquarium of the Pacific. 2015. Offshore Aquaculture In The Southern California Bight (Sea Grant Workshop Series Part 1). April 28-29, 2015. Available at: https://www.aquariumofpacific.org/downloads/Aquaculture_Workshop_WEB.pdf.

Aquarium of the Pacific. 2016. Offshore Aquaculture in the Southern California Bight (Sea Grant Workshop Series Part 2). July 27-28, 2016. Available at: https://www.aquariumofpacific.org/downloads/Aquaculture_Workshop_2016_WEB.pdf.

Arechavala-Lopez, P., P. Sanchez-Jerez, J. Bayle-Sempere, D. Fernandez-Jover, L. Martinez-Rubio, J. A. Lopez-Jimenez, and F. J. Martinez-Lopez. 2011. Direct interaction between wild fish aggregations at fish farms and fisheries activity at fishing grounds: a case study with Boops boops: Interaction between farm-aggregated fish and fisheries activity. Aquaculture Research 42(7):996–1010.

Arechavala-Lopez, P., K. Toledo-Guedes, D. Izquierdo-Gomez, T. Šegvić-Bubić, and P. Sanchez-Jerez. 2018. Implications of Sea Bream and Sea Bass Escapes for Sustainable Aquaculture Management: A Review of Interactions, Risks and Consequences. Reviews in Fisheries Science & Aquaculture 26(2):214–234.

Argonne National Laboratory. 2019. Environmental Setting of the Southern California OCS Planning Area. US Department of the Interior, Bureau of Ocean Energy Management. OCS Report BOEM 2019-038. 215 p.

Asche, F., T. Bjørndal, and J. A. Young. 2001. Market interactions for aquaculture products. Aquaculture Economics & Management 5(5–6):303–318.

Asche, F., and S. Tveteras. 2005. Market interactions in aquaculture. Page The Economics of Aquaculture with respect to Fisheries. The Economics of Aquaculture with respect to Fisheries. 95th EAAE Seminar. Civitavecchia (Rome).

Atalah, J., and P. Sanchez-Jerez. 2020. Global assessment of ecological risks associated with farmed fish escapes. Global Ecology and Conservation 21:e00842.

Avian Displacement Guidance Committee. 2024. Guidance for Pre- and Post-Construction Monitoring to Detect Changes in Marine Bird Distributions and Habitat Use Related to Offshore Wind Development. Report to the Offshore Wind Environmental Technical Working Group. 100 pp. Available at www.nyetwg.com/avian-displacement-guidance.

Baboolall, D., K. Cook, N. Noel, S. Stewart, and N. Yancy. 2020. Building supportive ecosystems for black-owned US businesses webpage. Accessed June 11, 2024. Available at:

https://www.mckinsey.com/industries/public-sector/our-insights/building-supportive-ecosystems-for-black-owned-us-businesses.

Bacher, K., and A. Gordoa. 2016. Does marine fish farming affect local small-scale fishery catches? A case study in the NW Mediterranean Sea. Aquaculture Research 47(8):2444–2454.

Bacher, K., A. Gordoa, and O. Sagué. 2012. Spatial and temporal extension of wild fish aggregations at Sparus aurata and Thunnus thynnus farms in the north-western Mediterranean. Aquaculture Environment Interactions 2(3):239–252.

Bakun, A. 1990. Global Climate Change and Intensification of Coastal Ocean Upwelling. Science 247(4939):198–201.

Baldridge, A. 1972. Killer Whales Attack and Eat a Gray Whale. Journal of Mammalogy 53(4):898–900.

Baldwin, K., J. Byrne, and B. Brickett. 2012. Taut Vertical Line and North Atlantic Right Whale Flipper Interaction: Experimental Observations. Final Report to the Consortium for Wildlife Bycatch Reduction, under NOAA Award NA09NMF4520413 to the New England Aquarium, Boston. University of New Hampshire, Durham, New Hampshire. 11 pp.

Barker, V. 2016. The Effect of Artificial Light on the Community Structure and Distribution of Reef-Associated Fishes at Oil and Gas Platforms in the Northern Gulf of Mexico. Master of Science, Louisiana State University and Agricultural and Mechanical College.

Barnaby, R. 2006. Growing seafood in the open ocean: offshore aquaculture in the United States. New Hampshire Sea Grant Technical Report UNHMP-TR-SG-06-22.

Barnes, A. C., O. Rudenko, M. Landos, H. T. Dong, A. Lusiastuti, L. H. Phuoc, and J. Delamare-Deboutteville. 2022. Autogenous vaccination in aquaculture: A locally enabled solution towards reduction of the global antimicrobial resistance problem. Reviews in Aquaculture 14(2):907–918.

Barnes, D. 2019. Bird Congregations on Floating Aquaculture Gear: Public Health Issues in New York State. New York Department of Environmental Conservation, Bureau of Shellfisheries. Presentation at Northeast Shellfish Sanitation Association Meeting, April 2019. Plymouth, MA.

Barnes, D. K. A., F. Galgani, R. C. Thompson, and M. Barlaz. 2009. Accumulation and fragmentation of plastic debris in global environments. Philosophical Transactions of the Royal Society B: Biological Sciences 364(1526):1985–1998.

Barrett, L. T., S. J. Theuerkauf, J. M. Rose, H. K. Alleway, S. B. Bricker, M. Parker, D. R. Petrolia, and R. C. Jones. 2022. Sustainable growth of non-fed aquaculture can generate valuable ecosystem benefits. Ecosystem Services 53:101396.

Bart, A. N., J. Clark, J. Young, and Y. Zohar. 2001. Underwater ambient noise measurements in aquaculture systems: a survey. Aquacultural Engineering 25(2):99–110.

Bassi, A., O. P. Love, S. J. Cooke, T. R. Warriner, C. M. Harris, and C. L. Madliger. 2022. Effects of artificial light at night on fishes: A synthesis with future research priorities. Fish and Fisheries 23(3):631–647.

Bath, G. E., C. A. Price, K. L. Riley, and J. A. Morris. 2023. A global review of protected species interactions with marine aquaculture. Reviews in Aquaculture 15(4):1686–1719.

BEA. 2023. U.S. Bureau of Economic Analysis marine economy satellite account, 2021 webpage. Accessed April 30, 2024. Available at: www.bea.gov/news/2023/marine-economy-satellite-account-2021.

Bearzi, M. 2005. Habitat Partitioning by Three Species of Dolphins in Santa Monica Bay, California. Bulletin, Southern California Academy of Sciences 104(3):113–124.

Bearzi, M., C. Saylan, and C. Barroso. 2008. Pinniped Ecology in Santa Monica Bay, California. Acta Zoologica Sinica 54(1):1–11.

Becker, E. A., K. A. Forney, D. L. Miller, P. C. Fiedler, J. Barlow, and J. E. Moore. 2020. Habitat-based density estimates for cetaceans in the California Current Ecosystem based on 1991-2018 survey data. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-638.

Becker, E., K. Forney, D. Foley, R. Smith, T. Moore, and J. Barlow. 2014. Predicting seasonal density patterns of California cetaceans based on habitat models. Endangered Species Research 23(1):1–22.

Bell, T., K. Cavanaugh, V. Saccomanno, K. Cavanaugh, H. Houskeeper, N. Eddy, F. Schuetzenmeister, N. Rindlaub, and M. Gleason. 2023. Kelpwatch: A new visualization and analysis tool to explore kelp canopy dynamics reveals variable response to and recovery from marine heatwaves. PLOS ONE, 18, e0271477.

Bell, T., K. Cavanaugh, and D. Siegel. 2024. SBC LTER: Time series of quarterly NetCDF files of kelp biomass in the canopy from Landsat 5, 7 and 8, since 1984 (ongoing) ver 23. Environmental Data Initiative. https://doi.org/10.6073/pasta/2c1218b7ebe6967da52000adf02f6a8b.

Belle, S. M., and C. E. Nash. 2008. Better management practices for net pen aquaculture. Pages 261–330 in C. S. Tucker and J. Hargreaves, editors. Environmental best management practices for aquaculture. Blackwell Publishing, Ames, Iowa.

Benjamins, S., V. Harnois, H. Smith, L. Johanning, L. Greenhill, C. Carter, and B. Wilson. 2014. Understanding the potential for marine megafauna entanglement risk from renewable marine energy developments. Scottish Natural Heritage Commissioned Report No. 791.

Bennett, N. J., J. J. Alavas, C. E. Ferguson, J. Blythe, E. Morgera, and I. M. Cote. 2022. Environmental Justice in the Ocean. IOF Working Papers 2022 (03), 40 pp., Institute for the Oceans and Fisheries, University of British Columbia.

Benson, S. R., T. Eguchi, D. G. Foley, K. A. Forney, H. Bailey, C. Hitipeuw, B. P. Samber, R. F. Tapilatu, V. Rei, P. Ramohia, J. Pita, and P. H. Dutton. 2011. Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. Ecosphere 2(7):art84.

Beta. 2017. Essential Fish Habitat Assessment: Beta Unit Geophysical Survey Offshore Huntington Beach, California. Project No. 1602-1681. Prepared for Beta Operating Company by Padre Associates, Inc. Ventura, CA.

BIA. 2024. Reforming Federal Funding and Support for Tribal Nations To Better Embrace Our Trust Responsibilities and Promote the Next Era of Tribal Self-Determination. U.S. Dept. of the Interior, Bureau of Indian Affairs. Tribal Leader Engagement Session on Executive Order 14112, January 22, 2024. Washington, D.C.

Bialonski, S., D. A. Caron, J. Schloen, U. Feudel, H. Kantz, and S. D. Moorthi. 2016. Phytoplankton dynamics in the Southern California Bight indicate a complex mixture of transport and biology. Journal of Plankton Research 38(4):1077–1091.

Bianchi, C. 2011. Abundance and Distribution of Megafaunal Invertebrates in Ne Pacific Submarine Canyons and Their Ecological Associations with Demersal Fishes. M.S. Thesis. Washington State University.

Bigelow Laboratory for Ocean Sciences. 2024. Farming Seagrasses and Seaweeds: Responsible Restoration & Revenue Generation. A Report Generated by the Bigelow Laboratory for Ocean Sciences for the Interagency Working Group for the Farming of Seagrasses and Seaweeds. Available at: https://www.bigelow.org/services/seafood-solutions/working-group-seaweed-seagrass.html.

Blackhart, K., D. G. Stanton, and A. M. Shimada. 2006. NOAA Fisheries Glossary. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-F/SPO-69. Available at: https://www.fisheries.noaa.gov/resource/document/noaa-fisheries-glossary.

BLM. 1979. Final Environmental Statement. Proposed 1979 Outer Continental Shelf Oil and Gas Lease Sale Offshore Southern California. U.S. Dept. of the Interior, Bureau of Land Management. OCS Sale No. 48. Volume 3 of 5.

Boehlert, G., C. Braby, A. S. Bull, M. E. Helix, S. Henkel, P. Klarin, and D. Schroeder. 2013. Oregon Marine Renewable Energy Environmental Science Conference Proceedings. U.S. Department of the Interior, Bureau of Ocean Energy Management, Cooperative Agreement with Oregon State University M12AC00012. OCS Report BOEM 2013-0113. 134 pp.

BOEM. 1971. Final Environmental Statement. Proposed installation of Platforms C and Henry on Federal Oil and Gas Leases OCS-P 0241 and 0240 Issued Under the OCS Lands Act, Santa Barbara Channel Area off the Coast of California. U.S. Dept. of the Interior, Bureau of Ocean Energy Management. Available at: https://www.boem.gov/sites/default/files/about-boem/BOEM-Regions/Pacific-Region/DPPs/1971-08-Installation-of-Platforms-Henry-and-C.pdf.

BOEM. 2015. Remotely Operated Vehicle (ROV) Investigations of Unidentified Magnetic Anomalies and/or Sidescan Sonar Targets: Methodological Guidelines. U.S. Dept. of the Interior, Bureau of Ocean Energy Management. Available at: https://www.boem.gov/sites/default/files/environmental-stewardship/Archaeology/ROV_2015_10.pdf.

BOEM. 2018. Beta Unit Geophysical Survey Environmental Assessment - Section 3.8 Commercial and Recreational Fishing. Published by BOEM and Beta Operating Company. Available at: https://www.boem.gov/sites/default/files/about-boem/BOEM-Regions/Pacific-Region/Geological-and-Geophysical-Data/Section-3.8-ComRecRes-111517jll.pdf.

BOEM. 2022. Final Environmental Assessment: Commercial Wind Lease and Grant Issuance and Site Assessment Activities on the Pacific Outer Continental Shelf, Morro Bay Wind Energy Area, California. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Pacific Region. OCS EIS/EA. BOEM 2022-024.

BOEM. 2024. Lease and grant information webpage. Accessed May 31, 2024. Available at: www.boem.gov/renewable-energy/lease-and-grant-information.

BOEM. n.d. California activities webpage. Accessed May 28, 2024. Available at: www.boem.gov/renewable-energy/state-activities/california.

BOEM. 2023b. Selected BOEM-Funded Research Informing Renewable Energy Offshore California, August 2023. U.S. Dept. of the Interior, Bureau of Ocean Energy Management. 15 p. Available at: https://www.boem.gov/sites/default/files/documents/renewable-energy/Selected-BOEM-Research-Renewable-CA_5.pdf.

BOEM. 2023a. Sound Source List: A description of sounds commonly produced during ocean exploration and industrial activity. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Center for Marine Acoustics. Report No.: BOEM OCS 2023-016. 69 p.

Bograd, S. J., C. G. Castro, E. Di Lorenzo, D. M. Palacios, H. Bailey, W. Gilly, and F. P. Chavez. 2008. Oxygen declines and the shoaling of the hypoxic boundary in the California Current. Geophysical Research Letters 35(12):2008GL034185.

Bograd, S. J., I. Schroeder, N. Sarkar, X. Qiu, W. J. Sydeman, and F. B. Schwing. 2009. Phenology of coastal upwelling in the California Current. Geophysical Research Letters 36(1):2008GL035933.

Bograd, S. J., F. B. Schwing, C. G. Castro, and D. A. Timothy. 2002. Bottom water renewal in the Santa Barbara Basin. Journal of Geophysical Research: Oceans 107(C12).

BOM. 2014. Final Environmental Assessment for a Production Capacity Increase at the Existing Open Ocean Mariculture Site off Unualoha Point, Hawaii. Prepared by Blue Ocean Mariculture for Department of Land & Natural Resources, Office of Conservation and Coastal Lands, and the U.S. Army Corps of Engineers.

Bonham, C. H. 2014. Correspondence on shark protections from Charlton Bonham, Director-CDFW to Eileen Sobeck, Assistant Administrator for Fisheries-NOAA. State of California, Natural Resources Agency. Department of Fish and Wildlife. Sacramento, CA. February 3, 2014.

Braaten, B. 2007. Cage culture and environmental impacts. Pages 49-91 in A. Bergheim (ed.). Aquacultural Engineering and Environment. Research Signpost, Kerala, India.

Bright, J. L. 2007. Abundance and Distribution of Structure-Forming Invertebrates and Their Association with Fishes at the Channel Islands “Footprint” Off the Southern Coast of California. M.s. Dissertation. Washington State University, School of Earth and Environmental Science.

Broch, O. J., K. Hancke, and I. H. Ellingsen. 2022. Dispersal and Deposition of Detritus From Kelp Cultivation. Frontiers in Marine Science 9:840531.

Brodeur, R., and O. Yamamura. 2005. Micronekton of the north pacific. PICES scientific report 30(30):1–115.

Brooks, D. K. M., and M. A. Drawbridge. 2005. Benthic Monitoring Program for Growout Facilities Associated with the Ocean Resources Enhancement and Hatchery Program (orehp).

Brooks, K. M. 2004. September 2004 sediment physicochemical monitoring at Hubbs-SeaWorld Research Institute’s enhancement netpens located at Santa Catalina Island, Agua Hedionda Lagoon and San Diego Bay. Page 29 [Technical report prepared for HSWRI, CDFG, and OREAP]. Located at: California Department of Fish and Game, Los Alamitos, CA.

Brooks, K. M. 2006. Sediment physicochemical monitoring at delayed release netpens and raceways for white seabass located in Southern California during 2004 and 2005. Page 97 [Technical report prepared for HSWRI, CDFG and OREAP]. Located at: California Department of Fish and Game, Los Alamitos, CA.

Brooks, K. M. 2007. Sediment physicochemical monitoring at delayed release netpens and raceways for white seabass located in Southern California during the period 2004 through 2006. Report prepared for Hubbs-SeaWorld Research Institute (HSWRI), California Department of Fish and Game (CDFG), and Advisors to the Ocean Resources Enhancement and Hatchery Program (OREHP), 119pp.

Brooks, K. M., and C. V. W. Mahnken. 2003. Interactions of Atlantic salmon in the Pacific Northwest environment. Fisheries Research 62(3):295–305.

Brooks, K. M., A. R. Stierns, C. V. W. Mahnken, and D. B. Blackburn. 2003. Chemical and biological remediation of the benthos near Atlantic salmon farms. Aquaculture 219(1–4):355–377.

Brown, P. E., and W. E. Rainey. 2018. Bats of the California Channel Islands: New Records with New Methods. Western North American Naturalist 78(3):474–495.

Brugère, C., N. B. Ridler, G. Haylor, G. Macfadyen, and N. Hishamunda, editors. 2010. Aquaculture planning: policy formulation and implementation for sustainable development. Food and Agriculture Organization of the United Nations, Rome.

Buchholz, C. M., G. Krause, and B. H. Buck. 2012. Seaweed and Man. Pages 471–493 *in* C. Wiencke and K. Bischof, editors. Seaweed Biology. Springer Berlin Heidelberg, Berlin, Heidelberg.

Buchler, E. R., and S. B. Childs. 1982. Use of the Post-Sunset Glow as an Orientation Cue by Big Brown Bats (Eptesicus fuscus). Journal of Mammalogy 63(2):243–247.

Buck, B. H., and C. M. Buchholz. 2005. Response of offshore cultivated Laminaria saccharina to hydrodynamic forcing in the North Sea. Aquaculture 250(3–4):674–691.

Buck, B. H., M. F. Troell, G. Krause, D. L. Angel, B. Grote, and T. Chopin. 2018. State of the Art and Challenges for Offshore Integrated Multi-Trophic Aquaculture (IMTA). Frontiers in Marine Science 5:165.

Bureau of Safety and Environmental Enforcement (BSEE). 2020. Decommissioning Cost Update for Pacific Outer Continental Shelf Region (POCSR) Facilities Volume 1. Conducted by InterAct PMTI, Inc. Project No. 140E0120P0007. September 2020. Available online at www.bsee.gov/sites/bsee.gov/files/vol-1-a-study-for-the-bureau-of-safety-and-environmental-enforcement-bsee-final-9-10-2020.pdf.

Burella, G., L. Moro, and B. Colbourne. 2019. Noise sources and hazardous noise levels on fishing vessels: The case of Newfoundland and Labrador’s fleet. Ocean Engineering 173:116–130.

Burlingame, B., and S. Dernini. 2010. Sustainable diets and biodiversity: directions and solutions for policy, research and action: proceedings of the intenational scientific symposium Biodiversity and sustainable diets united against hunger, 3-5 November 2010, FAO headquarters, Rome.

Busch, D. S., and P. McElhany. 2016. Estimates of the Direct Effect of Seawater pH on the Survival Rate of Species Groups in the California Current Ecosystem. PLOS ONE 11(8):e0160669.

CA Herps. 2024. Loggerhead sea turtle webpage. Accessed February 15, 2024. Available at: www.californiaherps.com/turtles/page/c.caretta.html.

CAA. 2023. California Aquaculture Association action alert: Lacey Act amendments of 2023 to the House webpage. Accessed April 18, 2024. Available at: https://caaquaculture.org/2023/07/24/action-alert-lacey-act-amendments-of-2023-to-the-house/.

Cabello, F. C., H. P. Godfrey, A. Tomova, L. Ivanova, H. Dölz, A. Millanao, and A. H. Buschmann. 2013. Antimicrobial use in aquaculture re-examined: its relevance to antimicrobial resistance and to animal and human health. Environmental Microbiology 15(7):1917–1942.

Calambokidis, J., M. A. Kratofil, D. M. Palacios, B. A. Lagerquist, G. S. Schorr, M. B. Hanson, R. W. Baird, K. A. Forney, E. A. Becker, R. C. Rockwood, and E. L. Hazen. 2024. Biologically Important Areas II for cetaceans within U.S. and adjacent waters - West Coast Region. Frontiers in Marine Science 11:1283231.

Calhoun, S., F. Conway, and S. Russell. 2016. Acknowledging the voice of women: implications for fisheries management and policy. Marine Policy 74:292–299.

California Sea Grant. 2024. South coast webpage. Accessed June 6, 2024. Available at: www.caseagrant.ucsd.edu/california-commercial-fisheries/regions/south-coast.

Callier, M. D., C. J. Byron, D. A. Bengtson, P. J. Cranford, S. F. Cross, U. Focken, H. M. Jansen, P. Kamermans, A. Kiessling, T. Landry, F. O’Beirn, E. Petersson, R. B. Rheault, Ø. Strand, K. Sundell, T. Svåsand, G. H. Wikfors, and C. W. McKindsey. 2018. Attraction and repulsion of mobile wild organisms to finfish and shellfish aquaculture: a review. Reviews in Aquaculture 10(4):924–949.

CalOPC. 2018. 2018 California Ocean Litter Prevention Strategy: Addressing Marine Debris from Source to Sea. California Ocean Protection Council and National Oceanic and Atmospheric Administration Marine Debris Program.

CARB. 2021. California Air Resources Board CHC fact sheet: commercial passenger fishing (sportfishing) vessel webpage. Accessed April 16, 2024. Available at: https://ww2.arb.ca.gov/resources/fact-sheets/chc-fact-sheet-commercial-passenger-fishing-sportfishing-vessel.

Carballeira Braña, C. B., K. Cerbule, P. Senff, and I. K. Stolz. 2021. Towards Environmental Sustainability in Marine Finfish Aquaculture. Frontiers in Marine Science 8:666662.

Carretta, J. V., E. M. Oleson, K. A. Forney, D. W. Weller, A. R. Lang, J. Baker, A. J. Orr, B. Hanson, J. Barlow, J. E. Moore, M. Wallen, and R. L. Jr. Brownell. 2023. U.S. Pacific marine mammal stock assessments: 2022. U.S. Pacific marine mammal stock assessments: 2022. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-684.

Caselle, J. E., B. P. Kinlan, and R. R. Warner. 2010. Temporal and spatial scales of influence on nearshore fish settlement in the Southern California Bight. Bulletin of Marine Science 86(2).

Cavole, L., A. Demko, R. Diner, A. Giddings, I. Koester, C. Pagniello, M.-L. Paulsen, A. Ramirez-Valdez, S. Schwenck, N. Yen, M. Zill, and P. Franks. 2016. Biological Impacts of the 2013–2015 Warm-Water Anomaly in the Northeast Pacific: Winners, Losers, and the Future. Oceanography 29(2):273–285.

CBD. 2019. Petition to List the Pacific Leatherback Sea Turtle (dermochelys Coriacea) as an Endangered Species Under the California Endangered Species Act. Center for Biological Diversity and Turtle Island Restoration Network. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=177728&inline (13).

CCC. 2014. California Coastal Commission Staff Report and Recommendation Regarding consistency Certification No. CC-035-12 (KZO SeaFarms, Los Angeles County). January 7, 2014.

CCC. 2019. Carlsbad Aquafarms, Inc. Staff Report: Regular Calendar. California Coastal Commission. Application No. 9-18-0163, Th9a. San Francisco, CA. Available at: https://documents.coastal.ca.gov/reports/2019/3/Th9a/Th9a-3-2019-report.pdf.

CDFA. 2022. California Department of Food and Agriculture 2022. 2022-2023 California Agricultural Statistics Review. 163pp. Available online at https://www.cdfa.ca.gov/Statistics/PDFs/2022-2023_california_agricultural_statistics_review.pdf.

CDFG. 2002. Final white seabass fishery management plan. State of CA, Resources Agency, Department of Fish and Game, Marine Region. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=34195&inline.

CDFG. 2010. White Seabass Enhancement Plan. California Dept. of Fish and Game, Marine Region. Available at: https://wildlife.ca.gov/Conservation/Marine/OREHP.

CDFG. 2012. Ocean Resources Enhancement and Hatchery Program Final Negative Declaration. California Dept. of Fish and Game. Los Alamitos, CA. Available at: https://wildlife.ca.gov/Conservation/Marine/OREHP.

CDFG. 2001a. California's Offshore Ecosystem. California's Living Marine Resources: A Status Report. California Dept. of Fish and Game. p. 291-292.

CDFG. 2001b. Culture of Oysters. California's Living Marine Resources: A Status Report. California Dept. of Fish and Game. p. 500-506.

CDFW. 2010. Status of the Fisheries Report an Update Through 2008. Report to the California Fish and Game Commission as directed by the Marine Life Management Act of 1998. California Dept. of Fish and Game, Marine Region. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=34428&inline.

CDFW. 2014. Tribal Communication and Consultation Policy. California Dept. of Fish and Wildlife Departmental Bulletin. No: 2014-07.

CDFW. 2019. Draft Program Environmental Impact Report: Coastal Marine Aquaculture Program. Prepared for California Dept. of Fish and Game by Ascent Environmental, Inc. Sacramento, CA. SCH# 2018032067.

CDFW. 2021. Marine management news: giant kelp and bull kelp enhanced status report now available webpage. Accessed June 26, 2024. Available at: www.cdfwmarine.wordpress.com/2022/01/14/giant-kelp-and-bull-kelp-enhanced-status-report-now-available/.

CDFW. 2022. The California Department of Fish and Wildlife Aquaculture Program Report to the Legislature. CDFW, Aquaculture Program. Available at: https://wildlife.ca.gov/Aquaculture.

CDFW. 2024. Permit guide to aquaculture in California webpage. Accessed January 16, 2024. Available at: https://permits.aquaculturematters.ca.gov/Permit-Guide.

CDFW. 2023b. 2023 California Commercial Fishing Regulations Digest for All Commercial Fishing in California Effective April 1, 2023 Through March 31, 2024. California Department of Fish and Wildlife. Available at: https://nrm.dfg.ca.gov/.

CDFW. 2024b. California Dept. of Fish and Wildlife Pelagic Fisheries webpage. Accessed March 13, 2024. Available at: https://wildlife.ca.gov/Conservation/Marine/Pelagic#52132545-species.

CDFW. 2016a. California Marine Life Protection Act Master Plan for Marine Protected Areas. Appendix F. South Coast: Mpa Background and Priorities. Available at: https://wildlife.ca.gov/Conservation/Marine/MPAs/Master-Plan. California Dept. of Fish and Wildlife.

CDFW. 2016c. California Spiny Lobster Fishery Management Plan. California Department of Fish and Wildlife, Marine Region. Available at: https://wildlife.ca.gov/Conservation/Marine/Lobster-FMP.

CDFW. 2016b. Forage Fish Informative Digest. California Department of Fish and Wildlife. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=142036&inline.

CDFW. 2020b. Marine Species Portal red sea urchin fishery webpage. Accessed February 20, 2024. Available at: https://marinespecies.wildlife.ca.gov/red-sea-urchin/the-fishery/.

CDFW. 2020a. The Status of Commercial Marine Aquaculture in California: Final Report to the California Fish and Game Commission. CDFW, California Commercial Marine Aquaculture Informational Report. Available at: https://wildlife.ca.gov/Aquaculture.

CEA. 2018. Offshore Finfish Aquaculture: Global Review and U.S. Prospects. The David and Lucile Packard Foundation. 34 p. https://www.packard.org/wp-content/uploads/2019/02/Offshore_Aquaculture_Report.pdf.

CEQ. 2023. Instructions to Federal Agencies on Using the Climate and Economic Justice Screening Tool ("CEJST Instructions"). Executive Office of the President of the U.S., Council on Environmental Quality. Available at: https://static-data-screeningtool.geoplatform.gov/data-versions/1.0/data/score/downloadable/CEQ-CEJST-Instructions.pdf.

Chan, F., J. A. Barth, J. Lubchenco, A. Kirincich, H. Weeks, W. T. Peterson, and B. A. Menge. 2008. Emergence of Anoxia in the California Current Large Marine Ecosystem. Science 319(5865):920–920.

Channel Islands National Marine Sanctuary. n.d. Seafloor Mapping webpage. Accessed June 3, 2024. Available at: https://channelislands.noaa.gov/research/seafloor.html.

Chary, K., D. Brigolin, and M. D. Callier. 2022. Farm-scale models in fish aquaculture – An overview of methods and applications. Reviews in Aquaculture 14(4):2122–2157.

Chen, C., R. C. Beardsley, J. Qi, and H. Lin. 2016. Use of Finite-Volume Modeling and the Northeast Coastal Ocean Forecast System in Offshore Wind Energy Resource Planning. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. BOEM 2016-050. 131pp.

Cheng, L., J. Abraham, K. E. Trenberth, J. Fasullo, T. Boyer, M. E. Mann, J. Zhu, F. Wang, R. Locarnini, Y. Li, B. Zhang, F. Yu, L. Wan, X. Chen, L. Feng, X. Song, Y. Liu, F. Reseghetti, S. Simoncelli, V.

Gouretski, G. Chen, A. Mishonov, J. Reagan, and G. Li. 2023. Another Year of Record Heat for the Oceans. Advances in Atmospheric Sciences 40(6):963–974.

Chin, A., P. M. Kyne, T. I. Walker, and R. B. Mcauley. 2010. An integrated risk assessment for climate change: analysing the vulnerability of sharks and rays on Australia's Great Barrier Reef. Global Change Biology 16(7):1936–1953.

Chopin, T., A. Neori, A. Buschmann, S. Pang, and M. Sawhney. 2011. Diversification of the aquaculture sector: Seaweed cultivation, integrated multi-trophic aquaculture, integrated sequential biorefineries. Global Aquaculture Advocate 14:58–60.

Chou, E., B. L. Southall, M. Robards, and H. C. Rosenbaum. 2021. International policy, recommendations, actions and mitigation efforts of anthropogenic underwater noise. Ocean & Coastal Management 202:105427.

Chu, Y. I., C. M. Wang, J. C. Park, and P. F. Lader. 2020. Review of cage and containment tank designs for offshore fish farming. Aquaculture 519:734928.

Cicin-Sain, B., R. W. Knecht, R. Rheault, S. M. Bunsick, R. DeVoe, T. Eichenberg, J. Ewart, and H. Halvorson. 2004. Development of a Policy Framework for Offshore Marine Aquaculture in the 3-200 Mile U.s. Ocean Zone. Center for the Study of Marine Policy University of Delaware.

CINMS. 2010. Water Quality Characterization of the Channel Island National Marine Sanctuary and Surrounding Waters. Prepared by Santa Barbara Channelkeeper and Dr. Diana L. Engle for NOAA's Channel Island National Marine Sanctuary.

Clark, M. R., F. Althaus, T. A. Schlacher, A. Williams, D. A. Bowden, and A. A. Rowden. 2016. The impacts of deep-sea fisheries on benthic communities: a review. ICES Journal of Marine Science 73(suppl_1):i51–i69.

Clavelle, T., S. E. Lester, R. Gentry, and H. E. Froehlich. 2019. Interactions and management for the future of marine aquaculture and capture fisheries. Fish and Fisheries 20(2):368–388.

Clay, P. M., and L. L. Colburn. 2020. A Practitioner's Handbook for Fisheries Social Impact Assessment. NOAA Tech. Memo. NMFS-F/SPO-212, 80 p.

Clay, P. M., and J. Olson. 2008. Defining" fishing communities": vulnerability and the Magnuson-Stevens fishery conservation and management act. Human Ecology Review:143–160.

Clement, D. 2013. Literature Review of Ecological Effects of Aquaculture: Effects on Marine Mammals. Ministry for Primary Industries, New Zealand.

CNAHC. 2024. California Native American Heritage Commission webpage. Accessed June 5, 2024. Available at: https://nahc.ca.gov.

CNDDB. 2024. State and Federally Listed Endangered and Threatened Animals of California, January 2024. State of California, Natural Resources Agency, Department of Fish and Wildlife, Biogeographic Data Branch. California Natural Diversity Database (CNDDB). Available at: https://nrm.dfg.ca.gov.

CNRA. 2008. California Aquatic Invasive Species Management Plan. January 2008. Department of Fish and Game. 153pp. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=3868&inline=1.

Coffin, S., H. Bouwmeester, S. Brander, P. Damdimopoulou, T. Gouin, L. Hermabessiere, E. Khan, A. A. Koelmans, C. L. Lemieux, K. Teerds, M. Wagner, S. B. Weisberg, and S. Wright. 2022. Development and application of a health-based framework for informing regulatory action in relation to exposure of microplastic particles in California drinking water. Microplastics and Nanoplastics 2(1):12.

Connor, W. E. 2000. Importance of n−3 fatty acids in health and disease. The American Journal of Clinical Nutrition 71(1):171S-175S.

Continental Shelf Associates. 2005. Survey of Invertebrate and Algal Communities on Offshore Oil and gas Platforms in Southern California. Final report. Prepared for the U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region, Camarillo, CA. December 2005. OCS Study MMS 2005-070. 232 pp. plus appendices.

Cordero, A., L. I. Waiya, G. Sanchez, S. Diaz, M. Jaimes, M. Moreno, D. Sanchez, D. Valenzuela, V. Vasquez, and J. W. Olmstead. 2016. Chumash Ecosystem Services Assessment. in Channel Islands National Marine Sanctuary 2016 Condition Report.:185–207.

Cornell Lab. 2024. All About Birds California condor life history webpage. Accessed July 3, 2024. Available at: https://www.allaboutbirds.org/guide/California_Condor/lifehistory.

Cornell Lab. 2024b. Cornell Lab of Ornithology, All About Birds, snowy plover webpage Available at: https://www.allaboutbirds.org/guide/Snowy_Plover/overview.

Costello, C., L. Cao, S. Gelcich, M. A. Cisneros, C. M. Free, H. E. Froehlich, C. D. Golden, G. Ishimura, J. Maier, I. Macadam-Somer, T. Mangin, M. C. Melnychuk, M. Miyahara, C. L. de Moor, R. Naylor, L. Nøstbakken, E. Ojea, E. O'Reilly, A. M. Parma, A. J. Plantinga, S. H. Thilsted, and J. Lubchenco. 2020. The Future of Food from the Sea. Nature 588:95–100.

Costello, C., D. Ovando, T. Clavelle, C. K. Strauss, R. Hilborn, M. C. Melnychuk, T. A. Branch, S. D. Gaines, C. S. Szuwalski, R. B. Cabral, D. N. Rader, and A. Leland. 2016. Global fishery prospects under contrasting management regimes. Proceedings of the National Academy of Sciences 113(18):5125–5129.

Costello, M. J. 2009. How sea lice from salmon farms may cause wild salmonid declines in Europe and North America and be a threat to fishes elsewhere. Proceedings of the Royal Society B: Biological Sciences 276(1672):3385–3394.

Cottrell, R. S., J. L. Blanchard, B. S. Halpern, M. Metian, and H. E. Froehlich. 2020. Global adoption of novel aquaculture feeds could substantially reduce forage fish demand by 2030. Nature Food 1:301–308.

Cox, K., L. P. Brennan, T. G. Gerwing, S. E. Dudas, and F. Juanes. 2018. Sound the alarm: A meta-analysis on the effect of aquatic noise on fish behavior and physiology. Global Change Biology 24(7):3105–3116.

Cranford, P. J., R. Anderson, P. Archambault, T. Balch, S. S. Bates, M. D. Callier, C. Carver, L. A. Comeau, B. Hargrave, W. G. Harrison, E. Horne, P. E. Kepkay, W. K. W. Li, A. Mallet, M. Ouellette, and P. Strain. 2006. Indicators and Thresholds for Use in Assessing Shellfish Aquaculture Impacts on Fish Habitat. Canadian Science Advisory Secretariat, Research Document 2006/034. Department of Fisheries and Oceans, Canada. Available at: https://www.dfo-mpo.gc.ca/csas/.

Crear, D., D. Lawson, J. Seminoff, T. Eguchi, R. LeRoux, and C. Lowe. 2016. Seasonal shifts in the movement and distribution of green sea turtles Chelonia mydas in response to anthropogenically altered water temperatures. Marine Ecology Progress Series 548:219–232.

Cromey, C. J., T. D. Nickell, and K. D. Black. 2002. DEPOMOD—modelling the deposition and biological effects of waste solids from marine cage farms. Aquaculture 214(1–4):211–239.

Cromey, C., H. Thetmeyer, N. Lampadariou, K. Black, J. Kögeler, and I. Karakassis. 2012. MERAMOD: predicting the deposition and benthic impact of aquaculture in the eastern Mediterranean Sea. Aquaculture Environment Interactions 2(2):157–176.

Crosson, L., N. Wight, G. VanBlaricom, I. Kiryu, J. Moore, and C. Friedman. 2014. Abalone withering syndrome: distribution, impacts, current diagnostic methods and new findings. Diseases of Aquatic Organisms 108(3):261–270.

Crozier, L. G., A. P. Hendry, P. W. Lawson, T. P. Quinn, N. J. Mantua, J. Battin, R. G. Shaw, and R. B. Huey. 2008. Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. Evolutionary Applications 1(2):252–270.

CRS. 2019. U.S. Offshore Aquaculture Regulation and Development. Congressional Research Service Report, prepared for members and committees of Congress. R45952. Available at: https://crsreports.congress.gov.

CRS. 2022. Clean Air Act: A Summary of the Act and Its Major Requirements. Congressional Research Service Report, prepared for members and committees of Congress. RL30853. Available at: https://crsreports.congress.gov.

CRWQCB. 1997. Santa Monica Bay: State of the Watershed, First Edition. California Regional Water Quality Control Board-Los Angeles Region. http://www.waterboards.ca.gov/losangeles/water_issues/programs/regional_program/wmi/ws_santamonica.shtml.

CSLC. 2015. Cabrillo Power I Llc Encina Marine Oil Terminal Decommissioning Project Marine Wildlife Contingency Plan. Appendix F to the Mitigated Negative Declaration. California State Lands Commission. Sacramento, CA.

CSLC. 2018. Environmental Justice Policy and Implementation Blueprint. California State Lands Commission. Available at: www.slc.ca.gov/wp-content/uploads/2018/11/EJPolicy.pdf.

Cullum, J., D. P. Stevens, and M. M. Joshi. 2016. Importance of ocean salinity for climate and habitability. Proceedings of the National Academy of Sciences 113(16):4278–4283.

Cusato, A. 2021. Slow and Steady Saves the Whales: Preventing Vessel Strikes on Whales in the Santa Barbara Channel. Wm. & Mary Env't L. & Pol'y Rev. 45:911.

Dahlheim, M. E., and P. A. White. 2010. Ecological aspects of transient killer whales Orcinus orca as predators in southeastern Alaska. Wildlife Biology 16(3):308–322.

Dailey, M. D., D. J. Reish, and J. W. Anderson. 1993. Ecology of the Southern California Bight: A Synthesis and Interpretation. University of California Press, Berekley/Los Angeles/London, 926 p.

De Souza Valente, C., and A. H. L. Wan. 2021. Vibrio and major commercially important vibriosis diseases in decapod crustaceans. Journal of Invertebrate Pathology 181:107527.

Deakos, M., J. Baker, and L. Bejder. 2011. Characteristics of a manta ray Manta alfredi -population off Maui, Hawaii, and implications for management. Marine Ecology Progress Series 429:245–260.

Dealy, D. D., J. R. Hilger, and S. M. Stohs. 2024. Economic information for Aquaculture Opportunity Areas off Southern California. U.S. Dept. of Commerce, NOAA Tech. Memo NMFS-SWFSC-697.

Deheyn, D. D., and M. I. Latz. 2006. Bioavailability of metals along a contamination gradient in San Diego Bay (California, USA). Chemosphere 63(5):818–834.

Dekker, D., and L. Bogaert. 1997. Dekker and Bogaert 1997 peregrin falcon ocean forage. Journal of Raptor Research 31(4):381–383.

D'Elia, J., and S. Haig. 2013. California Condors in the Pacific Northwest, 1st edition. Oregon State University Press.

Dempster, T., P. Arechavala-Lopez, L. T. Barrett, I. A. Fleming, P. Sanchez-Jerez, and I. Uglem. 2018. Recapturing escaped fish from marine aquaculture is largely unsuccessful: alternatives to reduce the number of escapees in the wild. Reviews in Aquaculture 10(1):153–167.

Dempster, T., I. Uglem, P. Sanchez-Jerez, D. Fernandez-Jover, J. Bayle-Sempere, R. Nilsen, and P. Bjørn. 2009. Coastal salmon farms attract large and persistent aggregations of wild fish: an ecosystem effect. Marine Ecology Progress Series 385:1–14.

Dewar, H., T. Eguchi, J. Hyde, D. Kinzey, S. Kohin, J. Moore, B. Taylor, and R. Vetter. 2013. Status Review of the Northeastern Pacific Population of White Sharks (Carcharodon carcharias) Under the Endangered Species Act. U.S. Dept. of Commerce, NOAA, SWFSC, La Jolla, CA.

Di Lorenzo, E., N. Schneider, K. M. Cobb, P. J. S. Franks, K. Chhak, A. J. Miller, J. C. McWilliams, S. J. Bograd, H. Arango, E. Curchitser, T. M. Powell, and P. Rivière. 2008. North Pacific Gyre Oscillation links ocean climate and ecosystem change. Geophysical Research Letters 35(8):2007GL032838.

Diana, J. S. 2009. Aquaculture Production and Biodiversity Conservation. BioScience 59(1):27–38.

Dias, M. P., R. Martin, E. J. Pearmain, I. J. Burfield, C. Small, R. A. Phillips, O. Yates, B. Lascelles, P. G. Borboroglu, and J. P. Croxall. 2019. Threats to seabirds: A global assessment. Biological Conservation 237:525–537.

DMR. 2004. Governor's Task Force on the Planning and Development of Marine Aquaculture in Maine Report and Recommendations. Maine DMR. Marine Resources Documents, Paper 9.

Doane, M. 2020. The Nature Conservancy, Beyond sustainable: a food system to restore the planet webpage. Accessed April 1, 2024. Available at: www.nature.org/en-us/what-we-do/our-insights/perspectives/regenerative-agriculture-food-system-restore-planet/.

DOC. 2022. U.S. DOC Strategic Plan, 2022-2026: Innovation, Equity and Resilience. Strengthening American Competitiveness in the 21st Century. U.S. Dept. of Commerce. Washington, D.C. Available at: https://www.commerce.gov/about/strategic-plan.

DOF. 2018. California Department of Finance, E-1 Population Estimates for Cities, Counties, and the State-January 1, 2017 and 2018 webpage. Accessed and cited by California Department of Fish and Wildlife March 12, 2019 (see CDFW 2019). Available at: https://dof.ca.gov/forecasting/demographics/estimates/.

DOI. 1997. American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act. Secretarial Order # 3206. U.S. Department of the Interior. Signed June 5, 1997. Available at: https://www.doi.gov/sites/doi.gov/files/elips/documents/3206_-american_indian_tribal_rights_federal-tribal_trust_responsibilities_and_the_endangered_species_act.pdf.

DOI. 2021. U.S. Dept. of the Interior Invasive Species Strategic Plan, Fiscal Years 2021-2025. Washington, D.C., 54p. Available at: https://www.doi.gov/sites/doi.gov/files/doi-invasive-species-strategic-plan-2021-2025-508.pdf.

Doney, S. C., M. Ruckelshaus, J. Emmett Duffy, J. P. Barry, F. Chan, C. A. English, H. M. Galindo, J. M. Grebmeier, A. B. Hollowed, N. Knowlton, J. Polovina, N. N. Rabalais, W. J. Sydeman, and L. D. Talley. 2012. Climate Change Impacts on Marine Ecosystems. Annual Review of Marine Science 4(1):11–37.

Dooley, J. A., P. B. Sharpe, and D. K. Garcelon. 2005. Movements, foraging, and survival of Bald Eagles reintroduced on the northern Channel Islands, California. Pages 313–321.

Dorval, E., B. J. Macewicz, D. A. Griffith, and Y. Gu. 2018. Spawning Biomass of the Central Stock of Northern Anchovy (Engraulis Mordax) Estimated from the Daily Egg Production Method off California In 2017. U.S. Dept. of Commerce, NOAA Tech. Memo NMFS-SWFSC-607.

Du, B., C. S. Wong, K. McLaughlin, and K. Schiff. 2020. Southern California Bight 2018 Regional Monitoring Program: Volume II. Sediment Chemistry. Southern California Coastal Water Research Project, Costa Mesa, CA. SCCWRP Technical Report 1130.

Duarte, C. M., L. Chapuis, S. P. Collin, D. P. Costa, R. P. Devassy, V. M. Eguiluz, C. Erbe, T. A. C. Gordon, B. S. Halpern, H. R. Harding, M. N. Havlik, M. Meekan, N. D. Merchant, J. L. Miksis-Olds, M. Parsons, M. Predragovic, A. N. Radford, C. A. Radford, S. D. Simpson, H. Slabbekoorn, E. Staaterman, I. C. Van Opzeeland, J. Winderen, X. Zhang, and F. Juanes. 2021. The soundscape of the Anthropocene ocean. Science 371(6529):eaba4658.

Duarte, C. M., M. Holmer, Y. Olsen, D. Soto, N. Marbà, J. Guiu, K. Black, and I. Karakassis. 2009. Will the Oceans Help Feed Humanity? BioScience 59(11):967–976.

Dudek. 2019. Attachment 13: List of Potential Biofouling Organisms for the Ventura Shellfish Enterprise Project. Prepared for Ventura Port Distract. Available online at https://venturaharbor.com/vse-archive/.

Duprey, N. M. T. 2007. Duprey NMT. Dusky Dolphin (Lagenorhynchus obscurus) Behavior and Human Interactions: Implications for Tourism and Aquaculture. Master's thesis. Texas A&M University. Available at: https://oaktrust.library.tamu.edu/server/api/core/bitstreams/5e758e2c-5aed-4104-84e3-04a0e9621218/content.

Ebani, V. V. 2023. Bacterial Infections in Sea Turtles. Veterinary Sciences 10(5):333.

Eguchi, T., S. McClatchie, C. Wilson, S. R. Benson, R. A. LeRoux, and J. A. Seminoff. 2018. Loggerhead Turtles (Caretta caretta) in the California Current: Abundance, Distribution, and Anomalous Warming of the North Pacific. Frontiers in Marine Science 5:452.

Eichhubl, P., H. G. Greene, and N. Maher. 2002. Physiography of an active transpressive margin basin: high-resolution bathymetry of the Santa Barbara basin, Southern California continental borderland. Marine Geology 184(1–2):95–120.

Elliser, C. R., S. Hessing, K. H. MacIver, M. A. Webber, and W. Keener. 2020. Harbor Porpoises (Phocoena phocoena vomerina) Catching and Handling Large Fish on the U.S. West Coast. Aquatic Mammals 46(2):191–199.

Engle, C. R., J. Van Senten, and M. H. Schwarz. 2022. Characterization of supply of marine finfish species with potential for commercial growth in the United States. Journal of the World Aquaculture Society 54(1):54–72.

Enticknap, B., A. Blacow, G. Shester, W. Sheard, J. Warrenchuk, M. LeVine, and S. Murray. 2011. Forage Fish: Feeding the California Current Large Marine Ecosystem. Marine Forage Species Management off the U.S. West Coast. Oceana, Washington, DC.

EPA. 1991. Salmon net pen study summary. U.S. Environmental Protection Agency. Region 10 Dive Team, Seattle, WA. Archived document available at: https://archive.epa.gov/region10/diving/web/pdf/salmon-net-pen-study-91.pdf.

EPA. 2015. EnviroAtlas terms and definitions webpage. U.S. EPA. Accessed March 21, 2024. Available at https://enviroatlas.epa.gov/enviroatlas/glossary/glossary.html.

EPA. 2019. National Pollutant Discharge Elimination System (NPDES) Permit and Rivers and Harbor Act Section 10 Permit for Kampachi Farms – Velella Epsilon (VE) Offshore Aquaculture Project. U.S. Environmental Protection Agency, Region 4. SCREFP No. WP-CRSP-03.

EPA. 2020. Ocean Era - Final Ocean Discharge Criteria Evaluation. NPDES Permit Number FL0A00001. U.S. Environmental Protection Agency. Region 4, Water Division. Atlanta, GA.

EPA. 2022. Interim Environmental Justice and Civil Rights in Permitting: Frequently Asked Questions. U.S. Environmental Protection Agency. Office of General Council, Office of Policy. Washington, D.C.

EPA. 2023. U.S. EPA vessel sewage no-discharge zones webpage. Accessed June 24, 2024. Available at: www.epa.gov/vessels-marinas-and-ports/vessel-sewage-no-discharge-zones.

EPA. 2024b. About the Office of Environmental Justice and External Civil Rights webpage. Accessed June 10, 2024. Available at: www.epa.gov/aboutepa/about-office-environmental-justice-and-external-civil-rights.

EPA. 2011b. Compliance with Executive Order 13166: Improving access to services for persons with limited English proficiency. U.S. EPA Order No. 1000.32. Available at: https://www.epa.gov/sites/default/files/2017-03/documents/epa_order_1000.32_compliance_with_executive_order_13166_02.10.2017.pdf.

EPA. 2024a. EPA orders city of Los Angeles to implement improvements to Hyperion Wastewater Treatment Plant webpage. Accessed August 9, 2024. Available at: www.epa.gov/newsreleases/epa-orders-city-los-angeles-implement-improvements-hyperion-wastewater-treatment-plant.

EPA. 2024c. Glossary from the guide to environmental issues: glossary of terms and acronyms webpage. U.S. EPA. Accessed April 4, 2024. Available at: https://sor.epa.gov/sor_internet/registry/termreg/searchandretrieve/glossariesandkeywordlists/search.do.

EPA. 2015a. Guidance on Considering Environmental Justice During the Development of Regulatory Actions. U.S. Environmental Protection Agency. Available at: https://www.epa.gov/environmentaljustice/guidance-considering-environmental-justice-during-development-action.

EPA. 2011a. Marine Debris in the North Pacific: A Summary of Existing Information and Identification of Data Gaps. U.S. Environmental Protection Agency, Pacific Southwest / Region 9. EPA-909-R-11-006. San Francisco, CA.

ERG. 2021. Input-Output (I-O) Modeling Tools: What's the Difference and When to Use Them? NOAA's Central Library (NCL) and Performance, Risk, and Social Science Office (PRSSO). Presenter: Charles Goodhue, Eastern Research Group, Inc. NOAA webinar presentation, September 20, 2021. Recording available at: www.youtube.com/watch?v=f4RxSFM5jRg.

Erlandson, J. M., T. C. Rick, and C. Peterson. 2005. The Holocene 15,8 (2005) pp. 1227-1235 A geoarchaeological chronology of Holocene dune building on San Miguel Island, California. The Holocene 15(8):1227–1235.

Evans, P. G. H., and A. Bjørge. 2013. Impacts of climate change on marine mammals. MCCIP Science Review 2013:15 pages.

Fabi, G., A. Scarcella, A. Spagnolo, S. A. Bortone, E. Charbonnel, J. J. Goutayer, N. Haddad, A. Lök, and M. Trommelen. 2015. Practical guidelines for the use of artifical reefs in the Mediterranean and the Black Sea. General Fisheries Commission for the Mediterranean. Studies and Reviews No. 96. Food and Agriculture Organization of the United Nations. Rome, Italy. Available at: https://www.fao.org/documents/card/es/c/f55a6cea-b550-435a-ac9d-601ae7870a25/.

Fairey, R., C. Roberts, M. Jacobi, S. Lamerdin, R. Clark, J. Downing, E. Long, J. Hunt, B. Anderson, J. Newman, R. Tjeerdema, M. Stephenson, and C. Wilson. 1998. Assessment of sediment toxicity and chemical concentrations in the San Diego Bay region, California, USA. Environmental Toxicology and Chemistry 17(8):1570–1581.

FAO. 2010. Aquaculture development. 4. Ecosystem approach to aquaculture. FAO Technical Guidelines for Responsible Fisheries No. 5, Suppl. 4. Rome. 53 pp. Available at: https://www.fao.org/documents/card/en?details=983cbbae-237e-54c7-a567-1f5a4adf1003#.

FAO. 2014. FAO, CITES, fisheries and aquaculture The importance of fisheries & aquaculture and what we are doing. Presentation, Cites, FAO. Available at: https://cites.org/sites/default/files/eng/prog/shark/docs/1-fao-cites-fisheries-aquaculture.pdf.

FAO. 2016. Market competition between farmed and wild fish: a literature survey, by Trond Bjorndal and Jordi Guillen. Fisheries and Aquaculture Circular No 1114. Rome, Italy.

FAO. 2018. The global status of seaweed production, trade and utilization. Globefish Research Programme. Volume 124. Rome. 120 pp. Licence: CC BY-NC-SA 3.0 IGO.

FAO. 2022. The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Food and Agriculture Organization of the United Nations. Rome.

FAO. 2020b. FAO term portal, fisheries webpage. Food and Agriculture Organization of the United Nations [online]. Rome, Italy.. Accessed March 26, 2024. Available at: https://www.fao.org/faoterm/collection/fisheries/en/.

FAO. 2020a. The State of World Fisheries and Aquaculture 2020: Sustainability in action. Food and Agriculture Organization of the United Nations. Rome, Italy. Available at: https://doi.org/10.4060/ca9229en.

FAO, IFAD, UNICEF, WFP, and WHO. 2017. The State of Food Security and Nutrition in the World 2017. Building resilience for peace and food security. FAO. Rome, Italy. Available at: https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1107528/.

FDA. 2020. National Shellfish Sanitation Program (NSSP) Guide for the Control of Molluscan Shellfish: 2019 Revision. U.S. Dept. of Health and Human Services, Food and Drug Administration. Available at: https://www.fda.gov/food/federalstate-food-programs/national-shellfish-sanitation-program-nssp.

FDA. 2024. Minor use/minor species webpage. Accessed June 12, 2024. Available at: www.fda.gov/animal-veterinary/development-approval-process/minor-useminor-species.

FDA. 2023b. Agricultural biotechnology webpage. U.S. Food and Drug Administration. Accessed April 1, 2024. Available at: https://www.fda.gov/food/consumers/agricultural-biotechnology.

FDA. 2023a. Aquacultured seafood webpage. Accessed March 9, 2023. Available at: www.fda.gov/food/seafood-guidance-documents-regulatory-information/aquacultured-seafood.

FDA. n.d. FDA Guide for Molluscan Shellfish Aquaculture Harvesting from Federal Waters. U.S. Dept. of Health and Human Services, Food and Drug Administration. Available at: https://www.fda.gov/food/federalstate-food-programs/national-shellfish-sanitation-program-nssp.

Feely, R. A., C. L. Sabine, J. M. Hernandez-Ayon, D. Ianson, and B. Hales. 2008. Evidence for Upwelling of Corrosive "Acidified" Water onto the Continental Shelf. Science 320(5882):1490–1492.

Felando, A., and H. Medina. 2021. The Origins of California's High-Seas Tuna Fleet. The Journal of San Diego History 58.

Fernandes, M., M. Angove, T. Sedawie, and A. Cheshire. 2007. Dissolved nutrient release from solid wastes of southern bluefin tuna (Thunnus maccoyii, Castelnau) aquaculture. Aquaculture Research 38(4):388–397.

Findlay, C. R., L. Rojano-Doñate, J. Tougaard, M. P. Johnson, and P. T. Madsen. 2023. Small reductions in cargo vessel speed substantially reduce noise impacts to marine mammals. Science Advances 9(25):eadf2987.

Fisher, A. M. 2021. A Review of Marine Turtle Orientation and Artificial Lighting Impacts with Novel Results from Florida's Gulf Coast. M.S. Thesis. University of South Florida.

Fisheries and Oceans Canada. 2003. A Scientific Review of the Potential Environmental Effects of Aquaculture in Aquatic Ecosystems, Vol. I. Far-field environmental effects of marine finfish aquaculture (B.T. Hargrave); Ecosystem level effects of marine bivalve aquaculture (P. Cranford, M. Dowd, J. Grant, B. Hargrave and S. McGladdery); Chemical use in marine finfish aquaculture in Canada: a review of current practices and possible environmental effects (L.E. Burridge). Can. Tech. Rep. Fish. Aquat. Sci. 2450: ix + 131 p.

Fissel. 2024. California Retail Market Summary: An Analysis of California Seafood Retail Market for NOAA Fisheries Aquaculture Opportunity Area Development. Unpublished draft in review. U.S. Dept. of Commerce, NMFS.

Fitridge, I., T. Dempster, J. Guenther, and R. De Nys. 2012. The impact and control of biofouling in marine aquaculture: a review. Biofouling 28(7):649–669.

Fleming, I. A., K. Hindar, I. B. Mjølnerød, B. Jonsson, T. Balstad, and A. Lamberg. 2000. Lifetime success and interactions of farm salmon invading a native population. Proceedings of the Royal Society of London. Series B: Biological Sciences 267(1452):1517–1523.

Floerl, O., L. Sunde, and N. Bloecher. 2016. Potential environmental risks associated with biofouling management in salmon aquaculture. Aquaculture Environment Interactions 8:407–417.

Fong, C. R., C. M. Gonzales, M. Rennick, L. D. Gardner, B. S. Halpern, and H. E. Froehlich. 2023. Global yield from aquaculture systems. Reviews in Aquaculture 16(3):1021–1029.

Foreman, M. G. G., M. Guo, K. A. Garver, D. Stucchi, P. Chandler, D. Wan, J. Morrison, and D. Tuele. 2015. Modelling Infectious Hematopoietic Necrosis Virus Dispersion from Marine Salmon Farms in the Discovery Islands, British Columbia, Canada. PLOS ONE 10(6):e0130951.

Forster, J. 2013. A review of opportunities, technical constraints, and future needs of offshore mariculture—Temperate waters. Pages 77–100. FAO Rome, Italy.

Foster, J. W. 2024. CA State Parks California ancient maritime heritage webpage. Accessed: June 6, 2024. Available at: www.parks.ca.gov/?page_id=23712.

Fredriksson, D. W., and J. Beck-Stimpert. 2019. Basis-of-Design Technical Guidance for Offshore Aquaculture Installations In the Gulf of Mexico. U.S. Dept. of Commerce, NOAA. NOAA Technical Memorandum NMFS-SER-9: 27 p.

Fredriksson, D. W., A. T. St. Gelais, T. Dewhurst, S. Coleman, D. C. Brady, and B. A. Costa-Pierce. 2023. Mooring tension assessment of a single line kelp farm with quantified biomass, waves, and currents. Frontiers in Marine Science 10:1178548.

Free, C. M., C. Vargas Poulsen, L. F. Bellquist, S. N. Wassermann, and K. L. Oken. 2022. The CALFISH database: A century of California's non-confidential fisheries landings and participation data. Ecological Informatics 69:101599.

Freeman, S. T. 2015. Minority Exporters: Characteristics and Strategies for New Business and Expansion. U.S. Dept. of Commerce, Minority Business Development Agency. Available at: www.mbda.gov/research-and-data/research/export.

Frieder, C. A., C. Yan, M. Chamecki, D. Dauhajre, J. C. McWilliams, J. Infante, M. L. McPherson, R. M. Kudela, F. Kessouri, M. Sutula, I. B. Arzeno-Soltero, and K. A. Davis. 2022. A Macroalgal Cultivation Modeling System (MACMODS): Evaluating the Role of Physical-Biological Coupling on Nutrients and Farm Yield. Frontiers in Marine Science 9:752951.

Friedland, K. D., M. C. McManus, R. E. Morse, and J. S. Link. 2019. Event scale and persistent drivers of fish and macroinvertebrate distributions on the Northeast US Shelf. ICES Journal of Marine Science:fsy167.

Froehlich, H. E., J. C. Afflerbach, M. Frazier, and B. S. Halpern. 2019. Blue Growth Potential to Mitigate Climate Change through Seaweed Offsetting. Current Biology 29(18):3087-3093.e3.

Froehlich, H. E., J. Couture, L. Falconer, G. Krause, J. A. Morris, M. Perez, G. D. Stentiford, H. Vehviläinen, and B. S. Halpern. 2020. Mind the gap between ICES nations' future seafood consumption and aquaculture production. ICES Journal of Marine Science 78(1):468–477.

Froehlich, H. E., R. R. Gentry, and B. S. Halpern. 2018. Global change in marine aquaculture production potential under climate change. Nature Ecology & Evolution 2(11):1745–1750.

Froehlich, H. E., R. R. Gentry, M. B. Rust, D. Grimm, and B. S. Halpern. 2017b. Public Perceptions of Aquaculture: Evaluating Spatiotemporal Patterns of Sentiment around the World. PLOS ONE 12(1):e0169281.

Froehlich, H. E., A. Smith, R. R. Gentry, and B. S. Halpern. 2017a. Offshore Aquaculture: I Know It When I See It. Frontiers in Marine Science 4:154.

Fudge, T. 2023. KPBS Public Media, Killer whales wow tourists and hunt dolphins off San Diego coast webpage. Accessed March 1, 2024. Available at: www.kpbs.org/news/science-technology/2023/12/27/killer-whales-wow-tourists-and-hunt-dolphins-off-san-diego-coast.

Fujita, R., P. Brittingham, L. Cao, H. Froehlich, M. Thompson, and T. Voorhees. 2023. Toward an environmentally responsible offshore aquaculture industry in the United States: Ecological risks, remedies, and knowledge gaps. Marine Policy 147:105351.

Gabrielino-Tongva Indian Tribe. 2024b. Gabrielino/Tongva culture webpage. Accessed June 2, 2024. Available at: gabrielinotongva.org/culture/.

Gabrielino-Tongva Indian Tribe. 2024c. Gabrielino/Tongva history webpage. Accessed June 3, 2024. Available at: gabrielinotribe.org/history/.

Gabrielino-Tongva Indian Tribe. 2024a. Mapping the Tongva villages of L.A's past webpage. Accessed June 1, 2024. Available at: gabrielinotribe.org/blog-post-title/.

Galanakis, C. M. 2020. The Food Systems in the Era of the Coronavirus (COVID-19) Pandemic Crisis. Foods 9(4):523.

Garlock, T. M., F. Asche, J. L. Anderson, H. Eggert, T. M. Anderson, B. Che, C. A. Chávez, J. Chu, N. Chukwuone, M. M. Dey, K. Fitzsimmons, J. Flores, J. Guillen, G. Kumar, L. Liu, I. Llorente, L. Nguyen, R. Nielsen, R. B. M. Pincinato, P. O. Sudhakaran, B. Tibesigwa, and R. Tveteras. 2024. Environmental, economic, and social sustainability in aquaculture: the aquaculture performance indicators. Nature Communications 15(1):5274.

Gauna, C., and P. C. Sternes. 2024. Novel aerial observations of a possible newborn white shark (Carcharodon carcharias) in Southern California. Environmental Biology of Fishes 107(2):249–254.

Gazeau, F., S. Alliouane, C. Bock, L. Bramanti, M. LÃ³pez Correa, M. Gentile, T. Hirse, H.-O. PÃ¶rtner, and P. Ziveri. 2014. Impact of ocean acidification and warming on the Mediterranean mussel (Mytilus galloprovincialis). Frontiers in Marine Science 1.

Gentry, R. R., H. K. Alleway, M. J. Bishop, C. L. Gillies, T. Waters, and R. Jones. 2020. Exploring the potential for marine aquaculture to contribute to ecosystem services. Reviews in Aquaculture 12(2):499–512.

Gentry, R. R., S. E. Lester, C. V. Kappel, C. White, T. W. Bell, J. Stevens, and S. D. Gaines. 2017. Offshore aquaculture: Spatial planning principles for sustainable development. Ecology and Evolution 7(2):733–743.

Gephart, J. A., L. Deutsch, M. L. Pace, M. Troell, and D. A. Seekell. 2017. Shocks to fish production: Identification, trends, and consequences. Global Environmental Change 42:24–32.

Gephart, J. A., P. J. G. Henriksson, R. W. R. Parker, A. Shepon, K. D. Gorospe, K. Bergman, G. Eshel, C. D. Golden, B. S. Halpern, S. Hornborg, M. Jonell, M. Metian, K. Mifflin, R. Newton, P. Tyedmers, W. Zhang, F. Ziegler, and M. Troell. 2021. Environmental performance of blue foods. Nature 597(7876):360–365.

Gephart, J. A., and M. L. Pace. 2015. Structure and evolution of the global seafood trade network. Environmental Research Letters 10(12):125014.

Gevondyan, E., S. Lajeunesse, R. Lindley, K. Lerner, E. Tanzman, C. Saricks, G. Medley, and P. Reynolds. 2024. Pathways to Reduce Greenhouse Gas Emissions on the U.S. Outer Continental Shelf. Pathways to reduce greenhouse gas emissions on the U.S. Outer Continental Shelf: a detailed analysis of oil and gas extraction emissions and potential emission reductions on the U.S. Outer Continental Shelf. Argonne (IL) and Sterling (VA): U.S. Department of Energy, Argonne National Laboratory and U.S. Department of the Interior, Bureau of Ocean Energy Management. 274 p. Report no.: ANL-23/27 OCS Study BOEM 2024-019.

Gillett, D. J., L. Gilbane, and K. C. Schiff. 2020. Benthic habitat condition of the continental shelf surrounding oil and gas platforms in the Santa Barbara Channel, Southern California. Marine Pollution Bulletin 160:111662.

Gimpel, A., V. Stelzenmüller, S. Töpsch, I. Galparsoro, M. Gubbins, D. Miller, A. Murillas, A. G. Murray, K. Pınarbaşı, G. Roca, and R. Watret. 2018. A GIS-based tool for an integrated assessment of spatial planning trade-offs with aquaculture. Science of The Total Environment 627:1644–1655.

Gladics, A. J., E. F. Melvin, R. M. Suryan, T. P. Good, J. E. Jannot, and T. J. Guy. 2017. Fishery-specific solutions to seabird bycatch in the U.S. West Coast sablefish fishery. Fisheries Research 196:85–95.

Glidden, C. K., L. C. Field, S. Bachhuber, S. M. Hennessey, R. Cates, L. Cohen, E. Crockett, M. Degnin, M. K. Feezell, H. K. Fulton-Bennett, D. Pires, B. N. Poirson, Z. H. Randell, E. White, and S. A. Gravem. 2022. Strategies for managing marine disease. Ecological Applications 32(7):e2643.

Glover, K. A., M. F. Solberg, P. McGinnity, K. Hindar, E. Verspoor, M. W. Coulson, M. M. Hansen, H. Araki, Ø. Skaala, and T. Svåsand. 2017. Half a century of genetic interaction between farmed and wild Atlantic salmon: Status of knowledge and unanswered questions. Fish and Fisheries 18(5):890–927.

Goley, P. D., and J. M. Straley. 1994. Attack on gray whales (Eschrichtius robustus) in Monterey Bay, California, by killer whales (Orcinus orca) previously identified in Glacier Bay, Alaska. Canadian Journal of Zoology 72(8):1528–1530.

Goode, S. L., A. A. Rowden, D. A. Bowden, and M. R. Clark. 2020. Resilience of seamount benthic communities to trawling disturbance. Marine Environmental Research 161:105086.

Gray Whale Count. 2017. GWC Reports webpage. Accessed August 11, 2024. Available at: graywhalescount.org/gwc/GWC_REPORTS.html.

Green, S. J., J. L. Akins, A. Maljković, and I. M. Côté. 2012. Invasive Lionfish Drive Atlantic Coral Reef Fish Declines. PLoS ONE 7(3):e32596.

GreenWave. 2019. Guide to Navigating Lease & Permit Approvals for Ocean Farming in California. Available at: www.greenwave.org/california-guides.

Greer, K., D. Zeller, J. Woroniak, A. Coulter, M. Winchester, M. L. D. Palomares, and D. Pauly. 2019. Global trends in carbon dioxide (CO2) emissions from fuel combustion in marine fisheries from 1950 to 2016. Marine Policy 107:103382.

Gregory, M. R. 2009. Environmental implications of plastic debris in marine settings—entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions. Philosophical Transactions of the Royal Society B: Biological Sciences 364(1526):2013–2025.

Gruenthal, K. M., D. A. Witting, T. Ford, M. J. Neuman, J. P. Williams, D. J. Pondella, A. Bird, N. Caruso, J. R. Hyde, L. W. Seeb, and W. A. Larson. 2014. Development and application of genomic tools to the restoration of green abalone in southern California. Conservation Genetics 15(1):109–121.

GSA. 2023. U.S. General Services Administration, Section 106: National Historic Preservation Act of 1966 webpage. Accessed June 4, 2024. Available at: gsa.gov/real-estate/historic-preservation/historic-preservation-policy-tools/legislation-policy-and-reports/section-106-of-the-national-historic-preservation-act.

Guallar, E., M. I. Sanz-Gallardo, P. van't Veer, P. Bode, A. Aro, J. Gómez-Aracena, J. D. Kark, R. A. Riemersma, J. M. Martín-Moreno, and F. J. Kok. 2002. Mercury, fish oils, and the risk of myocardial infarction. New England Journal of Medicine 347(22):1747–1754.

Guazzo, R. A., T. A. Helble, G. L. D'Spain, D. W. Weller, S. M. Wiggins, and J. A. Hildebrand. 2017. Migratory behavior of eastern North Pacific gray whales tracked using a hydrophone array. PLOS ONE 12(10):e0185585.

Gulland, F. M. D., J. D. Baker, M. Howe, E. LaBrecque, L. Leach, S. E. Moore, R. R. Reeves, and P. O. Thomas. 2022. A review of climate change effects on marine mammals in United States waters: Past predictions, observed impacts, current research and conservation imperatives. Climate Change Ecology 3:100054.

Guragain, P., M. Tkachov, A. S. Båtnes, Y. Olsen, P. Winge, and A. M. Bones. 2021. Principles and Methods of Counteracting Harmful Salmon–Arthropod Interactions in Salmon Farming: Addressing Possibilities, Limitations, and Future Options. Frontiers in Marine Science 8:701793.

Guza, R., and W. O'Reilly. 2001. Wave Prediction in the Santa Barbara Channel. MMS OCS Study 2001055. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Number 14-35-0001-30758. 8 pages.

Haines, H. 1978. Haines 1978 herpes in green sea turtle. Marine Fisheries Review 40(3):33–37.

Hall, K. 2000. Impacts of marine debris and oil: economic and social costs to coastal communities. Kommunenes Internasjonale Miljøorganisasjon, Lerwick.

Halpern, B. S., M. Frazier, J. Potapenko, K. S. Casey, K. Koenig, C. Longo, J. S. Lowndes, R. C. Rockwood, E. R. Selig, K. A. Selkoe, and S. Walbridge. 2015. Spatial and temporal changes in cumulative human impacts on the world's ocean. Nature Communications 6(1):7615.

Hamilton, S., and G. B. Baker. 2019. Technical mitigation to reduce marine mammal bycatch and entanglement in commercial fishing gear: lessons learnt and future directions. Reviews in Fish Biology and Fisheries 29(2):223–247.

Hanna, M. E., E. M. Chandler, B. X. Semmens, T. Eguchi, G. E. Lemons, and J. A. Seminoff. 2021. Citizen-Sourced Sightings and Underwater Photography Reveal Novel Insights About Green Sea Turtle Distribution and Ecology in Southern California. Frontiers in Marine Science 8:671061.

Hannesson, R. 2003. Aquaculture and fisheries. Marine Policy 27(2):169–178.

Hardin, D. D., J. Toal, T. Parr, P. Wilde, and K. Dorsey. 1994. Spatial variation in hard-bottom epifauna in the Santa Maria basin, California: the importance of physical factors. Marine Environmental Research 37(2):165–193.

Harley, C. D. G., A. Randall Hughes, K. M. Hultgren, B. G. Miner, C. J. B. Sorte, C. S. Thornber, L. F. Rodriguez, L. Tomanek, and S. L. Williams. 2006. The impacts of climate change in coastal marine systems. Ecology Letters 9(2):228–241.

Harnish, A. E., R. W. Baird, E. Corsi, A. M. Gorgone, D. Perrine, A. Franco, C. Hankins, and E. Sepeta. 2023. Long-term associations of common bottlenose dolphins with a fish farm in Hawaiʻi and impacts on other protected species. Marine Mammal Science 39(3):794–810.

Hartley, M. L., D. M. Schug, K. F. Wellman, B. Lane, W. T. Fairgrieve, and J. Adam. Luckenbach. 2020. Sablefish Aquaculture: An Assessment of Recent Developments and Their Potential for Enhancing Profitability. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-NWFSC-159.

Hartstein, N. D., and C. L. Stevens. 2005. Deposition beneath long-line mussel farms. Aquacultural Engineering 33(3):192–213.

Harvey, C., A. Leising, N. Tolimieri, and G. Williams. 2023. 2022-2023 California Current Ecosystem Status Report: A report of the NOAA California Current Integrated Ecosystem Assessment Team (CCIEA) to the Pacific Fishery Management Council. Northwest and Southwest Fisheries Science Centers, NOAA. CCIEA Team Report 1.

Hasan, M. R., and M. B. New. 2013. On-farm feeding and feed management in aquaculture. FAO, Rome.

Hawkes, J. 2001. The fourth pillar of sustainability: culture's essential role in public planning. Common Ground Publishing Pty Ltd in association with the Cultural Development Network (Vic)., Australia.

Hawkins, A. D., L. Roberts, and S. Cheesman. 2014. Responses of free-living coastal pelagic fish to impulsive sounds. The Journal of the Acoustical Society of America 135(5):3101–3116.

Heintz, M. B., S. Mau, D. L. Valentine, J. H. Reed, S. J. Hallam, and J. Yang. 2008. Methane Consumption in Waters Overlying a Hydrate- Associated Mound in the Santa Monica Basin: A Project Synopsis. Page Proceedings of the 6th International Conference on Gas Hydrates (ICGH 2008), Vancouver, British Columbia, CANADA, July 2008.

Helsey, C. E. 2000. Hawaii open ocean aquaculture demonstration program. In Proceedings of the 28th US-Japan Natural Resources Aquaculture Panel Joint Meeting on Spawning and Maturation of Aquaculture Species, Technical Report No. 28:15-22.

Helsley, C. E. 2007. Environmental observations around offshore cages in Hawaii. Open ocean aquaculture—moving forward. Oceanic Institute, Waimanalo, HI:41–44.

Helvey, M., C. Pomeroy, N. C. Pradhan, D. Squires, and S. Stohs. 2017. Can the United States have its fish and eat it too? Marine Policy 75:62–67.

Hendershott, M. C., and C. D. Winant. 1996. Surface Circulation in the Santa Barbara Channel. Oceanography 9(2):114–121.

Heredia-Azuaje, H., E. J. Niklitschek, and M. Sepúlveda. 2022. Pinnipeds and salmon farming: Threats, conflicts and challenges to co-existence after 50 years of industrial growth and expansion. Reviews in Aquaculture 14(2):528–546.

HI DLNR. 2014. Conservation District Use Permit (CDUA) HA-3 720, Expansion of Blue Ocean Mariculture Facility. State of Hawaii, Dept. of Land and Natural Resources. Office of Conservation and Coastal Lands. CDUP 1-IA-3720. Available at: https://dlnr.hawaii.gov/occl/files/2013/08/3720-staff-report-and-permit.pdf.

Hickey, B. M. 2000. Basin-to-Basin Water Exchange in the Southern California Bight. Proceedings of the 5th Channel Islands Symposium. U.S. DOI Minerals Management Service, Santa Barbara Museum of Natural History. MMS Pacific OCS Region Document.

Hickey, B. M., and N. S. Banas. 2003. Oceanography of the U.S. Pacific Northwest Coastal Ocean and estuaries with application to coastal ecology. Estuaries 26(4):1010–1031.

Hicks, C. C., P. J. Cohen, N. A. J. Graham, K. L. Nash, E. H. Allison, C. D'Lima, D. J. Mills, M. Roscher, S. H. Thilsted, A. L. Thorne-Lyman, and M. A. MacNeil. 2019. Harnessing global fisheries to tackle micronutrient deficiencies. Nature 574(7776):95–98.

Hildebrand, J. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series 395:5–20.

Hjeltnes, B., B. Bang-Jensen, G. Bornø, A. Haukaas, and C. S. Walde, editors. 2019. The Health Situation in Norwegian Aquaculture 2018. Norwegian Veterinary Institute. Published 14.02.2019 on www.vetinst.no ISSN 1890-3290.

Hoagland, P., Di Jin, and H. Kite-Powell. 2003. The Optimal Allocation of Ocean Space: Aquaculture and Wild-Harvest Fisheries. Marine Resource Economics 18(2):129–147.

Holm, P., B. H. Buck, and R. Langan. 2017. Introduction: New Approaches to Sustainable Offshore Food Production and the Development of Offshore Platforms. Pages 1–20 *in* B. H. Buck and R. Langan, editors. Aquaculture Perspective of Multi-Use Sites in the Open Ocean. Springer International Publishing, Cham.

Holt, C., and N. Mantua. 2009. Defining spring transition: regional indices for the California Current System. Marine Ecology Progress Series 393:285–300.

Horn, M. H., L. G. Allen, and R. N. Lea. 2006. Biogeography. Pages 3–25 in L. G. Allen, D. J. Pondella II, and M. H. Horn (Eds), The Ecology of Marine Fishes, California and Adjacent Waters. University of California Press, Berkeley and Los Angeles, California.

Hourigan, T. F., P. J. Etnoyer, and S. D. Cairns. 2017. The State of Deep-Sea Coral and Sponge Ecosystems of the United States. NOAA Technical Memorandum NMFS-OHC-4. Silver Spring, MD. 467 p.

Howard, E. M., H. Frenzel, F. Kessouri, L. Renault, D. Bianchi, J. C. McWilliams, and C. Deutsch. 2020. Attributing Causes of Future Climate Change in the California Current System With Multimodel Downscaling. Global Biogeochemical Cycles 34(11):e2020GB006646.

Huff, D., M. Yoklavich, M. Love, D. Watters, F. Chai, and S. Lindley. 2013. Environmental factors that influence the distribution, size, and biotic relationships of the Christmas tree coral Antipathes dendrochristos in the Southern California Bight. Marine Ecology Progress Series 494:159–177.

Hughes, S. N., S. Tozzi, L. Harris, S. Harmsen, C. Young, J. Rask, S. Toy-Choutka, K. Clark, M. Cruickshank, H. Fennie, J. Kuo, and J. D. Trent. 2014. Interactions of marine mammals and birds with offshore membrane enclosures for growing algae (OMEGA). Aquatic Biosystems 10(1):3.

Hulot, V., D. Saulnier, C. Lafabrie, and N. Gaertner-Mazouni. 2020. Shellfish culture: a complex driver of planktonic communities. Reviews in Aquaculture 12(1):33–46.

Humboldt Bay District. 2022. Draft Environmental Impact Report for the Humboldt Bay Mariculture Intertidal Pre-Permitting Project. SCH #2017032068. Humboldt Bay Harbor, Recreation and Conservation District. Eureka, CA.

IATTC. 2024. Inter-American Tropical Tuna Commission annual reports webpage. Accessed July 3, 2024. Available at: iattc.org/en-US/publication/commission/Annual-Report.

Inglis, G. J., and J. E. Kross. 2000. Evidence for Systemic Changes in the Benthic Fauna of Tropical Estuaries as a Result of Urbanization. Marine Pollution Bulletin 41(7–12):367–376.

Institute of Medicine. 2006. Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. Washington, DC: The National Academies Press.

IPCC. 2023. IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland.First. Intergovernmental Panel on Climate Change (IPCC).

ISAC. 2006. Invasive Species Definition Clarification and Guidance. U.S. Dept. of the Interior, Office of the Secretary. Invasive Species Advisory Committee White Paper. Available at: https://www.invasivespeciesinfo.gov/invasive-species-definition-clarification-and-guidance.

ISC. 2024. International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean stock assessment reports webpage. Accessed July 2, 2024. Available at: isc.fra.go.jp/reports/stock_assessments.html.

Jackson, D., A. Drumm, S. McEvoy, Ø. Jensen, D. Mendiola, G. Gabiña, J. A. Borg, N. Papageorgiou, Y. Karakassis, and K. D. Black. 2015. A pan-European valuation of the extent, causes and cost of escape events from sea cage fish farming. Aquaculture 436:21–26.

Janasie, C. M. 2023. Federal Food Safety Framework: Where does Seaweed Fit In? JournalofFoodLaw &Policy,18(2). Retrieved from https://scholarworks.uark.edu/jflp/vol18/iss2/6.

Jardine, S. L., M. C. Fisher, S. K. Moore, and J. F. Samhouri. 2020. Inequality in the Economic Impacts from Climate Shocks in Fisheries: The Case of Harmful Algal Blooms. Ecological Economics 176:106691.

Jarvis, E. T., M. J. Allen, and R. W. Smith. 2004. Comparison of recreational fish catch trends to environment-species relationships and fishery-independent data in the southern California bight, 1980-2000. California Cooperative Oceanic Fisheries Investigations Report 45:167.

Jensen, Ø., T. Dempster, E. Thorstad, I. Uglem, and A. Fredheim. 2010. Escapes of fishes from Norwegian sea-cage aquaculture: causes, consequences and prevention. Aquaculture Environment Interactions 1(1):71–83.

Jepson, M., and L. L. Colburn. 2013. Development of Social Indicators of Fishing Community Vulnerability and Resilience in the U.S. Southeast and Northeast Regions. U.S. Dept. of Commerce, NOAA Tech Memo NMFS-F/SPO-129, 64p.

Jiang, X., J. Tu, and D. Fan. 2022. The Influence of a Suspended Cage Aquaculture Farm on the Hydrodynamic Environment in a Semienclosed Bay, SE China. Frontiers in Marine Science 8:779866.

Johansson, M. L., F. Alberto, D. C. Reed, P. T. Raimondi, N. C. Coelho, M. A. Young, P. T. Drake, C. A. Edwards, K. Cavanaugh, J. Assis, L. B. Ladah, T. W. Bell, J. A. Coyer, D. A. Siegel, and E. A. Serrão. 2015. Seascape drivers of Macrocystis pyrifera population genetic structure in the northeast Pacific. Molecular Ecology 24(19):4866–4885.

Johnston, M. A., M. F. Nuttall, E. L. Hickerson, K. O'Connell, R. D. Blakeway, J. A. Embesi, J. MacMillan, D. Peter, and G. P. Schmahl. 2022. Characterizing the Biological Community before and after Partial Removal of an Offshore Gas Platform in the Northwestern Gulf of Mexico. Environmental Management 70(6):1078–1092.

Jones, A., E. Bruce, and D. H. Cato. 2023. Characterising resting patterns of mother-calf humpback whale groups in a semi-enclosed embayment along the Australian east coast migration pathway. Scientific Reports 13(1):14702.

Jones, A. R., H. K. Alleway, D. McAfee, P. Reis-Santos, S. J. Theuerkauf, and R. C. Jones. 2022. Climate-friendly seafood: The potential for emissions reduction and carbon capture in marine aquaculture. BioScience 72(2):123–143.

Journal of College Science Teaching. 2014. Uncovering the world of plastisphere. Journal of College Science Teaching, Abingdon. 43(5):9.

Kalantzi, I., C. Zeri, V.-A. Catsiki, C. Tsangaris, E. Strogyloudi, H. Kaberi, N. Vergopoulos, and M. Tsapakis. 2016. Assessment of the use of copper alloy aquaculture nets: Potential impacts on the marine environment and on the farmed fish. Aquaculture 465:209–222.

Kamal, M., N. Abdel-Raouf, K. Alwutayd, H. AbdElgawad, M. S. Abdelhameed, O. Hammouda, and K. N. M. Elsayed. 2023. Seasonal Changes in the Biochemical Composition of Dominant Macroalgal Species along the Egyptian Red Sea Shore. Biology 12(3):411.

Kapetsky, J. M., J. Aguilar-Manjarrez, and J. Jenness. 2013. A global assessment of offshore mariculture potential from a spatial perspective. FAO fisheries and aquaculture technical paper (549):I.

Karakassis, I., M. Tsapakis, I. Hatziyanni, K.-N. Papadopoulou, and W. Plaiti. 2000. Impact of cage farming of fish on the seabed in three Mediterranean coastal areas. ICES Journal of Marine Science 57(5):1462–1471.

Karakassis, I., M. Tsapakis, C. Smith, and H. Rumohr. 2002. Fish farming impacts in the Mediterranean studied through sediment profiling imagery. Marine Ecology Progress Series 227:125–133.

Katalinas, C. J., J. D. Robinson, A. E. Strand, T. Darden, K. Brenkert, and M. R. Denson. 2019. Forecasting the genetic influences of red drum stock enhancement in South Carolina. Fisheries Management and Ecology 26(3):224–235.

Katsanevakis, S., G. Verriopoulos, A. Nicolaidou, and M. Thessalou-Legaki. 2007. Effect of marine litter on the benthic megafauna of coastal soft bottoms: A manipulative field experiment. Marine Pollution Bulletin 54(6):771–778.

Keeley, N., T. Valdemarsen, S. Woodcock, M. Holmer, V. Husa, and R. Bannister. 2019. Resilience of dynamic coastal benthic ecosystems in response to large-scale finfish farming. Aquaculture Environment Interactions 11:161–179.

Keeling, R. F., A. Körtzinger, and N. Gruber. 2010. Ocean Deoxygenation in a Warming World. Annual Review of Marine Science 2(1):199–229.

Keller, J. M., P. D. McClellan-Green, A. M. Lee, M. D. Arendt, P. P. Maier, A. L. Segars, J. D. Whitaker, D. E. Keil, and M. M. Peden-Adams. 2005. Mitogen-induced lymphocyte proliferation in loggerhead sea turtles: comparison of methods and effects of gender, plasma testosterone concentration, and body condition on immunity. Veterinary Immunology and Immunopathology 103(3–4):269–281.

Kelty, R., and S. Bliven. 2003. Environmental and Aesthetic Impacts of Small Docks and Piers, Workshop Report: Developing a Science-Based Decision Support Tool for Small Dock Management, Phase 1: Status of the Science. NOAA Coastal Ocean Program Decision Analysis Series No. 22. National Centers for Coastal Ocean Science, Silver Spring, MD.:69.

Kemper, C. M., D. Pemberton, M. Cawthorn, S. Heinrich, J. Mann, B. Würsig, P. Shaughnessy, and R. Gales. 2003. AQUACULTURE AND MARINE MAMMALS: CO-EXISTENCE OR CONFLICT? Marine Mammals: Fisheries, Tourism and Management Issues: Fisheries, Tourism and Management Issues:208.

Kennerley, W. 2024. Columbia Basin Bulletin, Researchers document first-ever Hoary bat flying over open ocean in area slated for wind power off northern California coast webpage. Accessed July 1, 2024. Available at: columbiabasinbulletin.org/researchers-document-first-ever-hoary-bat-flying-over-open-ocean-in-area-slated-for-wind-power-off-northern-california-coast/.

Kessouri, F., J. C. McWilliams, D. Bianchi, M. Sutula, L. Renault, C. Deutsch, R. A. Feely, K. McLaughlin, M. Ho, E. M. Howard, N. Bednaršek, P. Damien, J. Molemaker, and S. B. Weisberg. 2021.

Coastal eutrophication drives acidification, oxygen loss, and ecosystem change in a major oceanic upwelling system. Proceedings of the National Academy of Sciences 118(21):e2018856118.

Kgabi, N., and T. Mokgwetsi. 2009. Dilution and dispersion of inhalable particulate matter. WIT Transactions on Ecology and the Environment 127:229–238.

Kiffney, P., J. Thompson, B. Blaud, and L. Hoberecht. 2022. Nonfishing Impacts on Essential Fish Habitat. U.S. Department of Commerce, NOAA White Paper NMFS-NWFSC-WP-2022-01.

Kirchhoff, N. T., K. M. Rough, and B. F. Nowak. 2011. Moving Cages Further Offshore: Effects on Southern Bluefin Tuna, T. maccoyii, Parasites, Health and Performance. PLoS ONE 6(8):e23705.

Kirkley, J. 2009. The NMFS Commercial Fishing & Seafood Industry Input/Output Model (CFSI I/O Model). Prepared for the National Marine Fisheries Service (NMFS). Virginia Institute of Marine Science.

Kite-Powell, H. L., E. Ask, S. Augyte, D. Bailey, J. Decker, C. A. Goudey, G. Grebe, Y. Li, S. Lindell, D. Manganelli, M. Marty-Rivera, C. Ng, L. Roberson, M. Stekoll, S. Umanzor, and C. Yarish. 2022. Estimating production cost for large-scale seaweed farms. Applied Phycology 3(1):435–445.

Kite-Powell, H. L., M. C. Rubino, and B. Morehead. 2013. The future of US seafood supply. Aquaculture Economics & Management 17(3):228–250.

Klasing, S. A., and R. K. Brodberg. 2015. Protocol for Seafood Risk Assessment to Support Fisheries Re-Opening Decisions for Aquatic Oil Spills in California. Pesticide and Environmental Toxicology Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.

Klingbeil, W. H., G. J. Montecinos, and F. Alberto. 2022. Giant kelp genetic monitoring before and after disturbance reveals stable genetic diversity in Southern California. Frontiers in Marine Science 9:947393.

Klinkenberg, B., editor. 2020. E-Flora BC: Electronic Atlas of the Plants of British Columbia [eflora.bc.ca]. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver. Online Database: https://linnet.geog.ubc.ca/Atlas/Atlas.aspx?sciname=Hedera%20helix&noTransfer=0. Accessed October 19, 2023.

Knapp, G., C. Roheim, and J. Anderson. 2007. The Great Salmon: Run Competition Between Wild and Farmed Salmon. TRAFFIC North America. Washington D.C.: World Wildlife Fund.

Knapp, G., and M. C. Rubino. 2016. The Political Economics of Marine Aquaculture in the United States. Reviews in Fisheries Science & Aquaculture 24(3):213–229.

Knoop, J., S. Barrento, R. Lewis, B. Walter, and J. N. Griffin. 2022. Incorporating concepts of biodiversity into modern aquaculture: macroalgal species richness enhances bioremediation efficiency in a lumpfish hatchery. Algae 37(3):213–226.

Knowlton, A. R., and S. D. Kraus. 2001. Mortality and serious injury of northern right whales (Eubalaena glacialis) in the western North Atlantic Ocean. Journal of Cetacean Research and Management (special issue) 2: 193-208.

Knowlton, A. R., J. Robbins, S. Landry, H. A. McKenna, S. D. Kraus, and T. B. Werner. 2016. Effects of fishing rope strength on the severity of large whale entanglements. Conservation Biology 30(2):318–328.

Komoroske, L. M., R. L. Lewison, J. A. Seminoff, D. D. Deheyn, and P. H. Dutton. 2011. Pollutants and the health of green sea turtles resident to an urbanized estuary in San Diego, CA. Chemosphere 84(5):544–552.

Kong, W., S. Huang, Z. Yang, F. Shi, Y. Feng, and Z. Khatoon. 2020. Fish Feed Quality Is a Key Factor in Impacting Aquaculture Water Environment: Evidence from Incubator Experiments. Scientific Reports 10(1):187.

Kramer, S. H., C. D. Hamilton, G. C. Spencer, and H. O. Ogston. 2015. Evaluating the Potential for Marine and Hydrokinetic Devices to Act as Artificial Reefs or Fish Aggregating Devices, Based on Analysis of Surrogates in Tropical, Subtropical, and Temperate U.S. West Coast and Hawaiian Coastal Waters. OCS Study BOEM 2015-021. U.S. Department of Energy, Energy Efficiency and Renewable Energy, Golden, Colorado.

Kraufvelin, P., B. Sinisalo, E. Leppa, and E. Bonsdor. 2001. Changes in zoobenthic community structure after pollution abatement from fish farms in the Archipelago Sea. Marine Environmental Research 51:229–245.

Krause, G., S.-L. Billing, J. Dennis, J. Grant, L. Fanning, R. Filgueira, M. Miller, J. A. Pérez Agúndez, N. Stybel, S. M. Stead, and W. Wawrzynski. 2020. Visualizing the social in aquaculture: How social dimension components illustrate the effects of aquaculture across geographic scales. Marine Policy 118:103985.

Krause, G., C. Brugere, A. Diedrich, M. W. Ebeling, S. C. A. Ferse, E. Mikkelsen, J. A. Pérez Agúndez, S. M. Stead, N. Stybel, and M. Troell. 2015. A revolution without people? Closing the people–policy gap in aquaculture development. Aquaculture 447:44–55.

Kris-Etherton, P. M., W. S. Harris, and L. J. Appel. 2002. Fish Consumption, Fish Oil, Omega-3 Fatty Acids, and Cardiovascular Disease. Circulation 106(21):2747–2757.

Kroeker, K. J., R. L. Kordas, R. N. Crim, and G. G. Singh. 2010. Meta-analysis reveals negative yet variable effects of ocean acidification on marine organisms. Ecology Letters 13(11):1419–1434.

Kroeker, K. J., F. Micheli, and M. C. Gambi. 2013. Ocean acidification causes ecosystem shifts via altered competitive interactions. Nature Climate Change 3(2):156–159.

Kromhout, D., E. B. Bosschieter, and C. de Lezenne Coulander. 1985. The inverse relation between fish consumption and 20-year mortality from coronary heart disease. N Engl J Med. 312(19):1205-1209.

Krumpel, A., A. Rice, K. E. Frasier, F. Reese, J. S. Trickey, A. E. Simonis, J. P. Ryan, S. M. Wiggins, A. Denzinger, H.-U. Schnitzler, and S. Baumann-Pickering. 2021. Long-Term Patterns of Noise From Underwater Explosions and Their Relation to Fisheries in Southern California. Frontiers in Marine Science 8:796849.

Kühn, S., E. L. Bravo Rebolledo, and J. A. Van Franeker. 2015. Deleterious Effects of Litter on Marine Life. Pages 75–116 *in* M. Bergmann, L. Gutow, and M. Klages, editors. Marine Anthropogenic Litter. Springer International Publishing, Cham.

Kuriyama, P. T., J. P. Zwolinski, K. T. Hill, and P. R. Crone. 2020. Assessment of the Pacific Sardine Resource in 2020 for U.S. Management in 2020-2021. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-SWFSC-628.

Laborde, D., W. Martin, J. Swinnen, and R. Vos. 2020. COVID-19 risks to global food security. Science 369(6503):500–502.

Lacoste, É., A. Drouin, A. Weise, P. Archambault, and C. McKindsey. 2018. Low benthic impact of an offshore mussel farm in Îles-de-la-Madeleine, eastern Canada. Aquaculture Environment Interactions 10:473–485.

Lafferty, K. D., and M. T. Tinker. 2014. Sea otters are recolonizing southern California in fits and starts. Ecosphere 5(5):1–11.

Lagerloef, G. S. E., and R. L. Bernstein. 1988. Empirical orthogonal function analysis of advanced very high resolution radiometer surface temperature patterns in Santa Barbara Channel. Journal of Geophysical Research: Oceans 93(C6):6863–6873.

Laist, D. W., A. R. Knowlton, J. G. Mead, A. S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17(1):35–75.

LARWQCB. 2011. State of the Watershed – Report on Water Quality. The Santa Monica Bay Watershed Management Area 2nd edition. California Regional Water Quality Control Board – Los Angeles Region.

Lawson, J. W. 2009. The Use Of Sound Propagation Models To Determine Safe Distances From A Seismic Sound Energy Source. DFO Can. Sci. Advis. Sec. Res. Doc., 2009/060.

Learmonth, J., C. Macleod, M. Santos, G. Pierce, H. Crick, and R. Robinson. 2006. Potential Effects of Climate Change on Marine Mammals. Oceanography and Marine Biology - An Annual Review 44:431–464.

Lee, H., J. Bailey-Brock, and M. McGurr. 2006. Temporal changes in the polychaete infaunal community surrounding a Hawaiian mariculture operation. Marine Ecology Progress Series 307:175–185.

Legrand, E., B. Taormina, J. Grall, P. N. Sævik, Y. Lelièvre, L. Pinsivy, V. Peña, and V. Husa. 2024. Salmon farming alters the structure and functioning of Norwegian maerl bed communities. Aquatic Conservation: Marine and Freshwater Ecosystems 34(4):e4142.

Leising, A., M. Hunsicker, N. Tolimieri, G. Williams, and A. Harley. 2024. 2023-2024 California Current Ecosystem Status Report: A report of the NOAA California Current Integrated Ecosystem Assessment Team (CCIEA) to the Pacific Fishery Management Council. Northwest and Southwest Fisheries Science Centers, NOAA. CCIEA Team Report 1.

Leonard, J., and P. Watson. 2011. Description of the input-output model for Pacific Coast fisheries. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-111, 64 p.

Lepofsky, D., and M. Caldwell. 2013. Indigenous marine resource management on the Northwest Coast of North America. Ecological Processes 2(1):12.

Lester, S. E., R. R. Gentry, C. V. Kappel, C. White, and S. D. Gaines. 2018a. Offshore aquaculture in the United States: Untapped potential in need of smart policy. Proceedings of the National Academy of Sciences 115(28):7162–7165.

Lester, S. E., J. M. Stevens, R. R. Gentry, C. V. Kappel, T. W. Bell, C. J. Costello, S. D. Gaines, D. A. Kiefer, C. C. Maue, J. E. Rensel, R. D. Simons, L. Washburn, and C. White. 2018b. Marine spatial planning makes room for offshore aquaculture in crowded coastal waters. Nature Communications 9(1):945.

Lewanzik, D., and C. C. Voigt. 2014. Artificial light puts ecosystem services of frugivorous bats at risk. Journal of Applied Ecology 51(2):388–394.

Lewitus, A. J., R. A. Horner, D. A. Caron, E. Garcia-Mendoza, B. M. Hickey, M. Hunter, D. D. Huppert, R. M. Kudela, G. W. Langlois, J. L. Largier, E. J. Lessard, R. RaLonde, J. E. Jack Rensel, P. G. Strutton, V. L. Trainer, and J. F. Tweddle. 2012. Harmful algal blooms along the North American west coast region: History, trends, causes, and impacts. Harmful Algae 19:133–159.

Lezama-Ochoa, N., S. Brodie, H. Welch, M. G. Jacox, M. Pozo Buil, J. Fiechter, M. Cimino, B. Muhling, H. Dewar, E. A. Becker, K. A. Forney, D. Costa, S. R. Benson, N. Farchadi, C. Braun, R. Lewison, S. Bograd, and E. L. Hazen. 2024. Divergent responses of highly migratory species to climate change in the California Current. Diversity and Distributions 30(2):e13800.

Liang, Y., G. Zhang, A. Wan, Z. Zhao, S. Wang, and Q. Liu. 2019. Nutrient-limitation induced diatom-dinoflagellate shift of spring phytoplankton community in an offshore shellfish farming area. Marine Pollution Bulletin 141:1–8.

Lin, L., C. C. Chen, X. Zhu, K. Pan, and X. Xu. 2022. Risk of aquaculture-derived microplastics in aquaculture areas: An overlooked issue or a non-issue? Frontiers in Marine Science 9:923471.

Lindell, S., and D. Bailey. 2015. What We Can Learn from Entanglement Cases of Whales and Turtles in Mussel Farming Gear. Presentation at the Northeast Aquaculture Conference & Exposition and the 35th Milford Aquaculture Seminar. January, 2015. Portland, ME.

Liu, O. R., E. J. Ward, S. C. Anderson, K. S. Andrews, L. A. K. Barnett, S. Brodie, G. Carroll, J. Fiechter, M. A. Haltuch, C. J. Harvey, E. L. Hazen, P.-Y. Hernvann, M. Jacox, I. C. Kaplan, S. Matson, K. Norman, M. P. Buil, R. L. Selden, A. Shelton, and J. F. Samhouri. 2023. Species redistribution creates unequal outcomes for multispecies fisheries under projected climate change. SCIENCE ADVANCES 9(eadg5468).

Lloyd, B. 2003. Potential effects of mussel farming on New Zealand's marine mammals and seabirds: A discussion paper. Department of Conservation. Wellington, New Zealand.

Lluch-Belda, D., D. B. Lluch-Cota, and S. E. Lluch-Cota. 2003. Scales of Interannual Variability in the California Current System: Associated Physical Mechanisms and Likely Ecological Impacts. CalCOFI Rep. 44.

Logerwell, E. A., and P. E. Smith. 2001. Mesoscale eddies and survival of late stage Pacific sardine (*Sardinops sagax*) larvae. Fisheries Oceanography 10(1):13–25.

Lorenzen, K., M. C. M. Beveridge, and M. Mangel. 2012. Cultured fish: integrative biology and management of domestication and interactions with wild fish. Biological Reviews 87(3):639–660.

Los Angeles City Planning. 2017. Draft Environmental Impact Report: Tribal Cultural Resources Analysis for the Proposed 668 South Alameda Project. LA City Planning. Available at: https://planning.lacity.gov/eir/668SoAlamedaStreet/deir/4.3.2%20Tribal%20Cultural%20Resources.pdf.

Love, D. C., E. H. Allison, F. Asche, B. Belton, R. S. Cottrell, H. E. Froehlich, J. A. Gephart, C. C. Hicks, D. C. Little, E. M. Nussbaumer, P. Pinto Da Silva, F. Poulain, A. Rubio, J. S. Stoll, M. F. Tlusty, A. L. Thorne-Lyman, M. Troell, and W. Zhang. 2021b. Emerging COVID-19 impacts, responses, and lessons for building resilience in the seafood system. Global Food Security 28:100494.

Love, D. C., E. M. Nussbaumer, J. Harding, J. A. Gephart, J. L. Anderson, F. Asche, J. S. Stoll, A. L. Thorne-Lyman, and M. W. Bloem. 2021a. Risks shift along seafood supply chains. Global Food Security 28:100476.

Lovell, S. J., J. Hilger, S. Steinback, and C. Hutt. 2016. The Economic Contribution of Marine Angler Expenditures on Durable Goods in the United States, 2014. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/SPO-165, 72 p.

Lovett. 2022. Lovett 2022. "Economic Guidance for Coastal Management Professionals." NOAA National Ocean Service (NOS). Presenter: Beth Lovett, NOAA Affiliate. NOAA webinar presentation, October 19, 2022.

Lynn, R. J., S. J. Bograd, T. K. Chereskin, and A. Huyer. 2003. Seasonal renewal of the California Current: The spring transition off California. Journal of Geophysical Research: Oceans 108(C8):2003JC001787.

Lyon, G. S., and E. D. Stein. 2010. Effluent discharges from offshore oil platforms to the outer continental shelf of southern California in 2005. pp. 29–43 in: Southern California Coastal Water

Research Project 2010 Annual Report, S.B. Weisberg and K. Miller (eds.), Costa Mesa, CA, Southern California Coastal Water Research Project.

Ma, J., T. J. Bruce, E. M. Jones, and K. D. Cain. 2019. A Review of Fish Vaccine Development Strategies: Conventional Methods and Modern Biotechnological Approaches. Microorganisms 7(11):569.

Macfadyen, G., T. Huntington, and R. Cappel. 2009. Abandoned, lost or otherwise discarded fishing gear. UNEP Regional Seas Reports and Studies, No. 185; FAO Fisheries and Aquaculture Technical Paper, No. 523. Rome, UNEP/FAO. 2009. 115p.

MacLeod, M. J., M. R. Hasan, D. H. F. Robb, and M. Mamun-Ur-Rashid. 2020. Quantifying greenhouse gas emissions from global aquaculture. Scientific Reports 10(1):11679.

MacNamara, R., M. Shane, and M. Drawbridge. 2022. Understanding the long-term movement patterns of hatchery-reared white seabass. Environmental Biology of Fishes 105(12):1797–1808.

Mangion, M., J. A. Borg, R. Thompson, and P. J. Schembri. 2014. Influence of tuna penning activities on soft bottom macrobenthic assemblages. Marine Pollution Bulletin 79(1–2):164–174.

Mantua, N., and R. Francis. 2004. Natural Climate Insurance for Pacific Northwest Salmon and Salmon Fisheries: Finding Our Way through the Entangled Bank. American Fisheries Society Symposium 43.

Mantua, N., S. Hare, Y. Zhang, J. Wallace, and R. Francis. 1997. A Pacific Interdecadal Climate Oscillation With Impacts on Salmon Production. Bulletin of the American Meteorological Society 78(6).

Marangoni, L. F. B., T. Davies, T. Smyth, A. Rodríguez, M. Hamann, C. Duarte, K. Pendoley, J. Berge, E. Maggi, and O. Levy. 2022. Impacts of artificial light at night in marine ecosystems—A review. Global Change Biology 28(18):5346–5367.

Marcus, J. 2022. Boston Globe, On both coasts, oyster tours are the new wine tours webpage. Accessed September 16, 2022. Available at: bostonglobe.com/2022/09/15/lifestyle/both-coasts-oyster-tours-are-new-wine-tours/.

Marinov, I., S. C. Doney, and I. D. Lima. 2010. Response of ocean phytoplankton community structure to climate change over the 21st century: partitioning the effects of nutrients, temperature and light. Biogeosciences 7(12):3941–3959.

Marshak, A. R., and J. S. Link. 2021. Primary production ultimately limits fisheries economic performance. Scientific Reports 11(1):12154.

Marshall, K. N., I. C. Kaplan, E. E. Hodgson, A. Hermann, D. S. Busch, P. McElhany, T. E. Essington, C. J. Harvey, and E. A. Fulton. 2017. Risks of ocean acidification in the California Current food web and fisheries: ecosystem model projections. Global Change Biology 23(4):1525–1539.

Mascorda Cabre, L., P. Hosegood, M. J. Attrill, D. Bridger, and E. V. Sheehan. 2021. Offshore longline mussel farms: a review of oceanographic and ecological interactions to inform future research needs, policy and management. Reviews in Aquaculture 13(4):1864–1887.

Mascorda-Cabre, L., E. V. Sheehan, M. J. Attrill, and P. Hosegood. 2024. Assessing the impact of an offshore longline mussel farm on local water circulation in a highly hydrodynamic energetic bay. Aquaculture 585:740697.

Mashkour, N., K. Jones, S. Kophamel, T. Hipolito, S. Ahasan, G. Walker, R. Jakob-Hoff, M. Whittaker, M. Hamann, I. Bell, J. Elliman, L. Owens, C. Saladin, J. L. Crespo-Picazo, B. Gardner, A. L. Loganathan, R. Bowater, E. Young, D. Robinson, W. Baverstock, D. Blyde, D. March, M. Eghbali, M. Mohammadi, D. Freggi, J. Giliam, M. Hale, N. Nicolle, K. Spiby, D. Wrobel, M. Parga, A. Mobaraki, R. Rajakaruna, K. P. Hyland, M. Read, and E. Ariel. 2020. Disease risk analysis in sea turtles: A baseline study to inform conservation efforts. PLOS ONE 15(10):e0230760.

McBride, S., and F. S. Conte. 1996. California abalone aquaculture. California Aquaculture. University of California, Davis. Dept. of Animal Science. ASAQ-A10, 5 pp.

McClatchie, S., R. Goericke, G. Auad, and K. Hill. 2010. Re-assessment of the stock–recruit and temperature–recruit relationships for Pacific sardine (Sardinops sagax). Canadian Journal of Fisheries and Aquatic Sciences 67(11):1782–1790.

McClure, M. M., M. Alexander, D. Borggaard, D. Boughton, L. Crozier, R. Griffis, J. C. Jorgensen, S. T. Lindley, J. Nye, M. J. Rowland, E. E. Seney, A. Snover, C. Toole, and K. Van Houtan. 2013. Incorporating Climate Science in Applications of the U.S. Endangered Species Act for Aquatic Species. Conservation Biology 27(6):1222–1233.

McClure, M. M., M. A. Haltuch, E. Willis-Norton, D. D. Huff, E. L. Hazen, L. G. Crozier, M. G. Jacox, M. W. Nelson, K. S. Andrews, L. A. K. Barnett, A. M. Berger, S. Beyer, J. Bizzarro, D. Boughton, J. M. Cope, M. Carr, H. Dewar, E. Dick, E. Dorval, J. Dunham, V. Gertseva, C. M. Greene, R. G. Gustafson, O. S. Hamel, C. J. Harvey, M. J. Henderson, C. E. Jordan, I. C. Kaplan, S. T. Lindley, N. J. Mantua, S. E. Matson, M. H. Monk, P. Moyle, C. Nicol, J. Pohl, R. R. Rykaczewski, J. F. Samhouri, S. Sogard, N. Tolimieri, J. Wallace, C. Wetzel, and S. J. Bograd. 2023. Vulnerability to climate change of managed stocks in the California Current large marine ecosystem. Frontiers in Marine Science 10:1103767.

McDermott, D. J., T. C. Heesen, and D. R. Young. 1974. DDT in bottom sediments around five southern California outfall systems. TM 217, Southern California Coastal Water Research Project. El Segundo, CA. 54 pp.

McDevitt, M. J. 2001. Impact Of The Regulation Flexibility Act On The Implementation And Judicial Review Provisions Of The Magnuson-Stevens Fishery Conservation And Management Act. Ocean and Coastal Law Journal 6(2).

McGinnis, M. V. 2006. Negotiating ecology: Marine bioregions and the destruction of the Southern California Bight. Futures 38(4):382–405.

McGinnity, P., P. Prodöhl, A. Ferguson, R. Hynes, N. Ó. Maoiléidigh, N. Baker, D. Cotter, B. O'Hea, D. Cooke, G. Rogan, J. Taggart, and T. Cross. 2003. Fitness reduction and potential extinction of wild populations of Atlantic salmon, *Salmo salar* , as a result of interactions with escaped farm salmon. Proceedings of the Royal Society of London. Series B: Biological Sciences 270(1532):2443–2450.

McIntosh, P., L. T. Barrett, F. Warren-Myers, A. Coates, G. Macaulay, A. Szetey, N. Robinson, C. White, F. Samsing, F. Oppedal, O. Folkedal, P. Klebert, and T. Dempster. 2022. Supersizing salmon farms in the coastal zone: A global analysis of changes in farm technology and location from 2005 to 2020. Aquaculture 553:738046.

McKibben, S. M., W. Peterson, A. M. Wood, V. L. Trainer, M. Hunter, and A. E. White. 2017. Climatic regulation of the neurotoxin domoic acid. Proceedings of the National Academy of Sciences 114(2):239–244.

McKindsey, C. W., P. Archambault, M. D. Callier, and F. Olivier. 2011. Influence of suspended and off-bottom mussel culture on the sea bottom and benthic habitats: a review. Canadian Journal of Zoology 89(7):622–646.

McLaughlin, K., J. Davis, A. Bonnema, B. Du, G. Ichikawa, W. Jakl, W. Heim, and K. Schiff. 2021. Regional assessment of contaminant bioaccumulation in sport fish tissue in the Southern California Bight, USA. Marine Pollution Bulletin 172:112798.

McLaughlin, K., R. Mazor, M. Sutula, and K. Schiff. 2023. Regional assessment of trash in Southern California coastal watersheds, United States. Frontiers in Environmental Science 11:1210201.

McLaughlin, K., K. Schiff, B. Du, J. Davis, A. Bonnema, G. Ichikawa, B. Jakl, and W. Heim. 2020. Southern California Bight 2018 Regional Monitoring Program: Volume V. Contaminant Bioaccumulation in Edible Sport Fish Tissue. Technical Report 1155. Southern California Coastal Water Research Project. Costa Mesa, CA.

McLean, D. L., L. C. Ferreira, J. A. Benthuysen, K. J. Miller, M. Schläppy, M. J. Ajemian, O. Berry, S. N. R. Birchenough, T. Bond, F. Boschetti, A. S. Bull, J. T. Claisse, S. A. Condie, P. Consoli, J. W. P. Coolen, M. Elliott, I. S. Fortune, A. M. Fowler, B. M. Gillanders, H. B. Harrison, K. M. Hart, L. Henry, C. L. Hewitt, N. Hicks, K. Hock, K. Hyder, M. Love, P. I. Macreadie, R. J. Miller, W. A. Montevecchi, M. M. Nishimoto, H. M. Page, D. M. Paterson, C. B. Pattiaratchi, G. T. Pecl, J. S. Porter, D. B. Reeves, C. Riginos, S. Rouse, D. J. F. Russell, C. D. H. Sherman, J. Teilmann, V. L. G. Todd, E. A. Treml, D. H. Williamson, and M. Thums. 2022. Influence of offshore oil and gas structures on seascape ecological connectivity. Global Change Biology 28(11):3515–3536.

Mearns, A., M. Matta, G. Shigenaka, D. MacDonald, M. Buchman, H. Harris, J. Golas, and G. Lauenstein. 1991. Contaminant Trends in the Southern California Bight: Inventory and Assessment. NOAA Technical Memorandum NOS ORCA 62. 441 pp.

Meichssner, R., P. Krost, and R. Schulz. 2021. Experimental testing of density- and season-dependent growth in vegetative Fucus aquaculture and modelling of growth over one year for different cultivation scenarios. Journal of Applied Phycology 33(6):3939–3950.

Mercader, M., C. Blazy, J. Di Pane, C. Devissi, A. Mercière, A. Cheminée, P. Thiriet, J. Pastor, R. Crec'hriou, M. Verdoit-Jarraya, and P. Lenfant. 2019. Is artificial habitat diversity a key to restoring nurseries for juvenile coastal fish? Ex situ experiments on habitat selection and survival of juvenile seabreams. Restoration Ecology 27(5):1155–1165.

Mercader, M., A. Mercière, G. Saragoni, A. Cheminée, R. Crec'hriou, J. Pastor, M. Rider, R. Dubas, G. Lecaillon, P. Boissery, and P. Lenfant. 2017. Small artificial habitats to enhance the nursery function for juvenile fish in a large commercial port of the Mediterranean. Ecological Engineering 105:78–86.

MESC. 2015. Environmental Baseline of LA/LB Harbors. Appendix H to the Harbor Safety Plan for the Ports of Los Angeles and Long Beach. Marine Exchange of Southern California. Prepared for the Los Angeles / Long Beach Harbor Safety Committee. Available at: https://mxsocal.org/hsc-safety-plan/.

MESC. 2023. Harbor Safety Plan for the Ports of Los Angeles and Long Beach: Mandated by California Oil Spill Prevention and Response Act of 1990. Marine Exchange of Southern California. Prepared for the Los Angeles / Long Beach Harbor Safety Committee. Available at: https://mxsocal.org/hsc-safety-plan/.

Methot, R. 1989. Synthetic Estimates of Historical Abundance and Mortality for Northern Anchovy. American Fisheries Society Symposium 6: 66-82.

Meynecke, J.-O., and H. Kela. 2023. What's at Play: Humpback Whale Interaction with Seaweed Is a Global Phenomenon. Journal of Marine Science and Engineering 11(9):1802.

Michaelis, A. K. 2024. Southern California Bight Aquaculture Opportunity Area Site Selected Options: Community Social Vulnerability Profiles. Unpublished draft currently in review. U.S. Dept. of Commerce, NMFS, SEFSC.

Mikkelsen, E. 2007. Aquaculture-Fisheries Interactions. Marine Resource Economics 22(3):287–303.

Miller, M., J. Carlson, P. Cooper, D. Kobayashi, and J. Wilson. 2014b. Status Review Report: Scalloped Hammerhead Shark (Sphyrna lewini). Final Report to National Marine Fisheries Service, Office of Protected Resources. March 2014.133 pp.

Miller, M., C. Steele, D. Horn, and C. Hanna. 2018. Marine Debris Trends: 30 Years of Change on Ventura County and Channel Island Beaches. Western North American Naturalist 78(3):328–340.

Miller, R. R., J. C. Field, J. A. Santora, I. D. Schroeder, D. D. Huff, M. Key, D. E. Pearson, and A. D. MacCall. 2014a. A Spatially Distinct History of the Development of California Groundfish Fisheries. PLoS ONE 9(6):e99758.

Milne, M. H., H. De Frond, C. M. Rochman, N. J. Mallos, G. H. Leonard, and B. R. Baechler. 2024. Exposure of U.S. adults to microplastics from commonly-consumed proteins. Environmental Pollution 343:123233.

Mitarai, S., D. A. Siegel, J. R. Watson, C. Dong, and J. C. McWilliams. 2009. Quantifying connectivity in the coastal ocean with application to the Southern California Bight. Journal of Geophysical Research: Oceans 114(C10):2008JC005166.

Mooney, T. A., L. Di Iorio, M. Lammers, T.-H. Lin, S. L. Nedelec, M. Parsons, C. Radford, E. Urban, and J. Stanley. 2020. Listening forward: approaching marine biodiversity assessments using acoustic methods. Royal Society Open Science 7(8):201287.

Mooney-McAuley, K. M., M. D. Edwards, J. Champenois, and E. Gorman. 2016. Best Practice Guidelines for Seaweed Cultivation and Analysis. Public output report of the EnAlgae project, Swansea. 36pp. Available online at www.enalgae.eu.

Moore, J. D., S. N. Byron, B. C. Marshman, and J. P. Snider. 2019. An oxytetracycline bath protocol to eliminate the agent of withering syndrome, Candidatus Xenohaliotis californiensis, in captive abalone populations. Aquaculture 503:267–274.

Moore, K. M., E. H. Allison, S. J. Dreyer, J. A. Ekstrom, S. L. Jardine, T. Klinger, S. K. Moore, and K. C. Norman. 2020. Harmful Algal Blooms: Identifying Effective Adaptive Actions Used in Fishery-Dependent Communities in Response to a Protracted Event. Frontiers in Marine Science 6:803.

Moore, K., and D. Wieting. 1999. Marine Aquaculture, Marine Mammals, and Marine Turtles Interaction Workshop 12-13 January 1999, Silver Spring, Maryland. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-16, 60 p.

Morash, A. J., and K. Alter. 2015. Effects of environmental and farm stress on abalone physiology: perspectives for abalone aquaculture in the face of global climate change. Reviews in Aquaculture 8(4):342–368.

Mordecai, G. J., K. M. Miller, A. L. Bass, A. W. Bateman, A. K. Teffer, J. M. Caleta, E. Di Cicco, A. D. Schulze, K. H. Kaukinen, S. Li, A. Tabata, B. R. Jones, T. J. Ming, and J. B. Joy. 2021. Aquaculture mediates global transmission of a viral pathogen to wild salmon. Science Advances 7(22):eabe2592.

Morgan, L. E., and R. Chuenpagdee. 2003. Shifting gears: addressing the collateral impacts of fishing methods in U.S. waters. Island Press, Washington, D.C.

Mori, C., and M. Riley. 2021. Framework for ESA Section 7 Evaluation of Aquaculture Projects in the Greater Atlantic Region. Greater Atlantic Region Policy Series [21-02]. NOAA Fisheries Greater Atlantic Regional Fisheries Office www.greateratlantic.fisheries.noaa.gov/policyseries/. 183pp.

Morris, J., J. MacKay, J. Jossart, L. Wickliffe, A. Randall, G. Bath, M. Balling, B. Jensen, and K. Riley. 2021. An Aquaculture Opportunity Area Atlas for the Southern California Bight. NOAA Technical Memorandum NOS NCCOS 298. Beaufort, NC. 485 pp. https://doi.org/10.25923/tmx9-ex26.

Mouat, J., R. L. Lozano, and H. Bateson. 2010. Economic impacts of marine litter. Kommunenes Internasjonale Miljøorganisasjon.

Mount, J., B. Gray, K. Bork, J. E. Cloern, F. W. Davis, T. Grantham, L. Grenier, J. Harder, Y. Kuwayama, P. Moyle, M. W. Schwartz, A. Whipple, and S. Yarnell. 2019. A Path Forward for California's Freshwater Ecosystems. Public Policy Institute of California. Available at: https://www.ppic.org/publication/a-path-forward-for-californias-freshwater-ecosystems/.

Mozaffarian, D., and E. B. Rimm. 2006. Fish Intake, Contaminants, and Human Health: Evaluating the Risks and the Benefits. JAMA 296(15):1885.

Murray, G., and L. D'Anna. 2015. Seeing shellfish from the seashore: The importance of values and place in perceptions of aquaculture and marine social–ecological system interactions. Marine Policy 62:125–133.

Nafpaktitis, B. G., R. H. Backus, J. E. Craddock, R. L. Haedrich, B. Robison, and C. Karnella. 1977. The families Neoscopelidae and Myctophidae. Pp. 1-265 in Part 7 of the Monograph Series, Fishes of the Western North Atlantic. Sears Foundation for Marine Research, New Haven: Yale University 1977.

NARA. 2019. About controlled unclassified information (CUI) webpage. U.S. National Archives and Records Administration. Accessed March 21, 2024. Available at https://www.archives.gov/cui/about.

Nash, C. E. 2004. Achieving policy objectives to increase the value of the seafood industry in the United States: the technical feasibility and associated constraints. Food Policy 29(6):621–641.

Nash, C. E., P. R. Burbridge, and J. K. Volkman. 2005. Guidelines for ecological risk assessment of marine fish aquaculture. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-71, 90 p.

National Centers for Environmental Information. n.d. NCEI U.S. climate normals webpage. Accessed May 30, 2024. Available at: ncei.noaa.gov/products/land-based-station/us-climate-normals.

National Marine Protected Areas Center. 2008. De facto marine protected areas webpage. Accessed March 21, 2024. Available at: https://marineprotectedareas.noaa.gov/dataanalysis/defacto/.

National Oceanography Centre. 2010. Global sea-level rise at the end of the last ice age webpage. Accessed June 6, 2024. Available at: https://noc.ac.uk/news/global-sea-level-rise-end-last-ice-age.

Naylor, R. L., R. J. Goldburg, J. H. Primavera, N. Kautsky, M. C. Beveridge, J. Clay, C. Folke, J. Lubchenco, H. Mooney, and M. Troell. 2000. Effect of aquaculture on world fish supplies. Nature 405(6790):1017–1024.

Naylor, R. L., R. W. Hardy, D. P. Bureau, A. Chiu, M. Elliott, A. P. Farrell, I. Forster, D. M. Gatlin, R. J. Goldburg, K. Hua, and P. D. Nichols. 2009. Feeding aquaculture in an era of finite resources. Proceedings of the National Academy of Sciences 106(36):15103–15110.

Naylor, R. L., A. Kishore, U. R. Sumaila, I. Issifu, B. P. Hunter, B. Belton, S. R. Bush, L. Cao, S. Gelcich, J. A. Gephart, C. D. Golden, M. Jonell, J. Z. Koehn, D. C. Little, S. H. Thilsted, M. Tigchelaar, and B. Crona. 2021. Blue food demand across geographic and temporal scales. Nature Communications 12(1):5413.

NCCOS. 2005. A Biogeographic Assessment of the Channel Islands National Marine Sanctuary: A Review of Boundary Expansion Concepts for NOAA's National Marine Sanctuary Program. Prepared by NOAA National Centers for Coastal Ocean Science's Biogeography Team in cooperation with the National Marine Sanctuary Program. Silver Spring, MD. NOAA Technical Memorandum NOS NCCOS 21. 215 pp.

NCCOS. 2019. National Centers for Coastal Ocean Science, Co-occurrence of different HAB toxins detected in coastal southern california waters webpage. Accessed May 31, 2024. Available at: coastalscience.noaa.gov/news/co-occurring-hab-toxins-found-in-coastal-southern-california-waters/.

NCCOS. 2022. National Centers for Coastal Ocean Science, Evaluating socioeconomic indicators of coastal communities for increased understanding of aquaculture siting webpage. Accessed May 29, 2024. Available at: https://coastalscience.noaa.gov/project/evaluating-socioeconomic-indicators-of-coastal-communities-for-increased-understanding-of-aquaculture-siting/.

Nederlof, M. A. J., M. C. J. Verdegem, A. C. Smaal, and H. M. Jansen. 2022. Nutrient retention efficiencies in integrated multi-trophic aquaculture. Reviews in Aquaculture 14(3):1194–1212.

Neira, C., L. A. Levin, G. Mendoza, and A. Zirino. 2014. Alteration of benthic communities associated with copper contamination linked to boat moorings. Marine Ecology 35(1):46–66.

Nelson, M., J. Schubel, and K. Thompson. 2019. Frequently Asked Questions: Marine Aquaculture in California and the U.s. Seafood for the Future, Aquarium of the Pacific.

Nemtzov, S. C., and L. Olsvig-Whittaker. 2003. The Use of Netting Over Fishponds as a Hazard to Waterbirds. Waterbirds 26(4):416.

Nightingale, B., T. Longcore, and C. A. Simenstad. 2006. Artificial night lighting and fishes. Ecological consequences of artificial night lighting:257–276.

Ning, Z., S. Liu, G. Zhang, X. Ning, R. Li, Z. Jiang, J. Fang, and J. Zhang. 2016. Impacts of an integrated multi-trophic aquaculture system on benthic nutrient fluxes: a case study in Sanggou Bay, China. Aquaculture Environment Interactions 8:221–232.

NISC. 2016. Management Plan: 2016-2018. National Invasive Species Council. Washington, D.C. Available at: www.doi.gov/invasivespecies/management-plan.

Nishimoto, M. M., R. D. Simons, and M. S. Love. 2019. Offshore oil production platforms as potential sources of larvae to coastal shelf regions off southern California. Bulletin of Marine Science 95(4):535–558.

NMFS. 2001. Final United States National Plan of Action for the Conservation and Management of Sharks. U.S. Dept. of Commerce, NOAA. Available at: https://media.fisheries.noaa.gov/dam-migration/npoa_sharks_2001.pdf.

NMFS. 2002. A Code of Conduct for Responsible Aquaculture Development in the U.s. Exclusive Economic Zone. U.S. Dept. of Commerce, NOAA.

NMFS. 2008. White Abalone Recovery Plan (Haliotis sorenseni). U.S. Dept. of Commerce, NOAA. Available at: https://www.fisheries.noaa.gov/action/recovery-plan-white-abalone.

NMFS. 2010. Fixed Gear Guide: California, Oregon, and Washington Commercial Fisheries Trap/pot, gillnet, and longline/set line. U.S. Dept. of Commerce, NOAA. Available at: https://media.fisheries.noaa.gov/dam-migration/fixed_gear_guide_final_121411.pdf.

NMFS. 2012. Final Rule to Revise the Critical Habitat Designation for Leatherback sea turtles. U.S. Dept. of Commerce, NOAA, Southwest Fisheries Science Center. Available at: https://media.fisheries.noaa.gov/dam-migration/leatherback_criticalhabitat_biological-508.pdf.

NMFS. 2014. Olive Ridley Sea Turtle (lepidochelys Olivacea) 5-Year Review: Summary and Evaluation. U.S. Dept. of Commerce, NMFS. Office of Protected Resources, Silver Spring, MD. and USFWS, Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, FL.

NMFS. 2016a. Biological Programmatic Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Shellfish Aquaculture Activities in Washington State. U.S. Dept. of Commerce, NOAA, West Coast Region. NMFS Consultation No. WCR-2014-1502.

NMFS. 2016b. Ecosystem-Based Fisheries Management Policy of the National Marine Fisheries Service National Oceanic and Atmospheric Administration. NMFS Policy 01-120. Available at: https://www.fisheries.noaa.gov/national/laws-policies/fisheries-management-policy-directives.

NMFS. 2018. 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commerce. NOAA Technical Memorandum NMFS-OPR-59, 167 p.

NMFS. 2020a. Fisheries of the United States, 2018. U.S. Dept. of Commerce. NOAA Current Fishery Statistics No. 2018 Available at: https://www.fisheries.noaa.gov/ national/commercial-fishing/fisheries-united-states-2018.

NMFS. 2020b. Status of Stocks 2019: Annual Report to Congress on the Status of U.S. Fisheries. U.S. Dept. of Commerce, NOAA. Available at: https://www.fisheries.noaa.gov/national/sustainable-fisheries/status-stocks-reports.

NMFS. 2020c. Final Endangered Species Act Recovery Plan for Black Abalone (Haliotis cracherodii). U.S. Dept. of Commerce, NOAA, West Coast Region, Protected Resources Division. Available at: https://www.fisheries.noaa.gov/resource/document/final-black-abalone-recovery-plan-haliotis-cracherodii.

NMFS. 2020d. Scalloped Hammerhead Shark (Sphyrna lewini) 5-Year Review: Summary and Evaluation. U.S. Dept. of Commerce, NOAA, Office of Protected Resources. Available at: https://media.fisheries.noaa.gov/dam-migration/scalloped_hammerhead_5-year_review.pdf.

NMFS. 2020e. Loggerhead Sea Turtle (Caretta caretta) North Pacific Ocean DPS 5-Year Review: Summary and Evaluation. U.S. Dept. of Commerce, NMFS, Office of Protected Resources Silver Spring, MD. and USFWS, Southeast Region, North Florida Ecological Services Office, Jacksonville, FL.

NMFS. 2021a. Pacific Islands Aquaculture Management Program, Draft Programmatic Environmental Impact Statement. U.S. Dept. of Commerce, NOAA, Pacific Islands Regional Office. RTID 0648-XA867. Available at: https://media.fisheries.noaa.gov/2022-09/NOAA-NMFS-2021-0044-0158_content.pdf.

NMFS. 2021b. SPECIES in the SPOTLIGHT Priority Actions 2021–2025: Pacific Leatherback Turtles (Dermochelys coriacea). U.S. Dept. of Commerce, NOAA, Office of Protected Resources. Available at: https://www.fisheries.noaa.gov/resource/document/species-spotlight-priority-actions-2021-2025-pacific-leatherback-turtle.

NMFS. 2021c. Report to Congress: National Marine Fisheries Service: Response to National Academies of Sciences, Engineering, and Medicine 2021 Recommendations. U.S. Dept. of Commerce, NOAA. Available at: https://www.fisheries.noaa.gov/resource/document/noaa-fisheries-response-national-academies-sciences-engineering-and-medicine-2021.

NMFS. 2021d. Vessel Strike Avoidance Measures. U.S. Dept. of Commerce, NOAA, Southeast Regional Office. Available at: https://media.fisheries.noaa.gov/2021-06/Vessel_Strike_Avoidance_Measures.pdf.

NMFS. 2021e. West Coast Highly Migratory Species Fisheries and Gear webpage. Accessed March 13, 2024. Available at: https://www.fisheries.noaa.gov/west-coast/sustainable-fisheries/west-coast-highly-migratory-species-fisheries-and-gear.

NMFS. 2022a. Fisheries of the United States, 2020. U.S. Dept. of Commerce. NOAA Current Fishery Statistics No. 2020. Available at: https://www.fisheries.noaa.gov/ national/sustainable-fisheries/fisheries-united-states.

NMFS. 2022b. Guide to Permitting Marine Aquaculture in the United States (2022). U.S. Dept. of Commerce, NOAA. Available at: https://www.fisheries.noaa.gov/resource/document/guide-permitting-marine-aquaculture-united-states-2022.

NMFS. 2022c. NOAA Aquaculture Strategic Plan (2023-2028). U.S. Dept. of Commerce, NOAA Aquaculture Program. Available at: https://www.fisheries.noaa.gov/resource/document/noaa-aquaculture-strategic-plan-2023-2028.

NMFS. 2022d. Concurrence Letter and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Bureau of Ocean Energy Management's Offshore Wind Lease Issuance, Site Characterization and Assessment for the Morro Bay and Humboldt Wind Energy Areas. U.S. Dept. of Commerce, NOAA, West Coast Region. WCRO-2022-01796.

NMFS. 2022e. National Saltwater Recreational Fisheries Summit Report 2022. U.S. Dept. of Commerce. Prepared by Tidal Bay Consulting and AECOM for NMFS. Available at: https://media.fisheries.noaa.gov/2022-07/2022_RecSummitReport_Public_508.pdf.

NMFS. 2022f. NOAA Fisheries Fishing gear and risks to protected species webpage. Accessed February 20, 2024. Available at: www.fisheries.noaa.gov/national/bycatch/fishing-gear-and-risks-protected-species.

NMFS. 2022g. Aquaculture literacy at NOAA webpage. Accessed April 3, 2024. Available at: https://www.fisheries.noaa.gov/national/aquaculture/aquaculture-literacy-noaa.

NMFS. 2022h. NOAA Fisheries Southern california steelhead webpage. Accessed March 14, 2024. U.S. Dept. of Commerce, NMFS. Available at: https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/southern-california-steelhead.

NMFS. 2022i. NOAA Fisheries Loggerhead turtle research webpage. Accessed March 14, 2024. U.S. Dept. of Commerce, NMFS. Available at: https://www.fisheries.noaa.gov/west-coast/science-data/loggerhead-turtle-research.

NMFS. 2022j. NOAA Fisheries Species in the Spotlight: Priority Actions 2021-2025, Pacific Leatherback Turtle webpage. Accessed March 14, 2024. U.S. Dept. of Commerce, NMFS. Available at: https://www.fisheries.noaa.gov/resource/document/species-spotlight-priority-actions-2021-2025-pacific-leatherback-turtle.

NMFS. 2023a. Public Scoping Report for the Southern California Aquaculture Opportunity Areas Programmatic Environmental Impact Statement. U.S. Dept. of Commerce, NOAA, West Coast Regional Office. Available at: https://www.fisheries.noaa.gov/resource/document/public-scoping-report-southern-california-aquaculture-opportunity-areas.

NMFS. 2023b. NOAA Fisheries Steller sea lion webpage. Accessed February 16, 2024. Available at: fisheries.noaa.gov/species/steller-sea-lion.

NMFS. 2023c. NOAA Fisheries List of Fisheries summary table webpage. Accessed February 7, 2024. Available at: fisheries.noaa.gov/national/marine-mammal-protection/list-fisheries-summary-tables.

NMFS. 2023d. NMFS 2023d large whale entanglement report.

NMFS. 2023e. Guidance for Treatment of Climate Change in NMFS Endangered Species Act Decisions. U.S. Dept. of Commerce, NOAA. Procedure 02-110-18. Available at: https://www.fisheries.noaa.gov/s3/2023-05/02-110-18-renewal-kdr.pdf.

NMFS. 2023f. International Agreements Concerning Living Marine Resources of Interest to Noaa Fisheries. U.S. Dept. of Commerce, NOAA, Office of International Affairs, Trade, and Commerce. Available at: https://www.fisheries.noaa.gov/resource/document/2023-fisheries-international-agreement-book.

NMFS. 2023g. NOAA Fisheries Status of Stocks 2022 webpage. Accessed April 8, 2024. Available at: fisheries.noaa.gov/sustainable-fisheries/status-stocks-2022.

NMFS. 2023g(tables). NOAA Fisheries Status of Stocks 2022 webpage. Accessed April 8, 2024. Available at: fisheries.noaa.gov/s3/2023-04/2022-SOS-Stock-Status-Tables.pdf.

NMFS. 2023h. Fisheries Economics of the United States, 2020. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-F/SPO-236B, 231 p.

NMFS. 2023i. NOAA Fisheries West Coast Region saltwater recreational fisheries implementation plan webpage. Accessed April 16, 2024. Available at: fisheries.noaa.gov/west-coast/recreational-fishing/west-coast-region-saltwater-recreational-fisheries-implementation.

NMFS. 2023j. NOAA Fisheries off west coast states: west coast salmon fisheries; 2023 specifications and management measures webpage. Accessed July 2, 2024. Available at: fisheries.noaa.gov/action/fisheries-west-coast-states-west-coast-salmon-fisheries-2023-specifications-and-management.

NMFS. 2023k. NOAA Fisheries, Equity and Environmental Justice Strategy. U.S. Dept. of Commerce, NOAA. Available at: https://www.fisheries.noaa.gov/national/about-us/equity-and-environmental-justice-strategy.

NMFS. 2023l. National Saltwater Recreation Fisheries Policy. U.S. Dept. of Commerce, NOAA. Policy Directive 01-118. Available at: https://www.fisheries.noaa.gov/s3/2023-09/Final-PDS-Entry-8-30-23-508-Compliant-JC-Signature.pdf.

NMFS. 2023m. West Coast Groundfish webpage. Accessed: March 13, 2024. Available at: https://www.fisheries.noaa.gov/species/west-coast-groundfish/overview.

NMFS. 2023n. West Coast Highly Migratory Species webpage. Accessed March 13, 2024. Available at: https://www.fisheries.noaa.gov/west-coast/sustainable-fisheries/west-coast-highly-migratory-species.

2023o. NOAA Fisheries Green Turtle Research and Conservation in Southern California webpage. Accessed March 14, 2024. U.S. Dept. of Commerce, NMFS. Available at: https://www.fisheries.noaa.gov/west-coast/science-data/green-turtle-research-and-conservation-southern-california.

NMFS. 2023p. NOAA Fisheries Leatherback Turtle Research webpage. Accessed March 14, 2024. U.S. Dept. of Commerce, NMFS. Available at: https://www.fisheries.noaa.gov/west-coast/science-data/leatherback-turtle-research.

NMFS. 2023q. NOAA Fisheries Seabirds webpage. Accessed March 14, 2024. U.S. Dept. of Commerce, NMFS. Available at: https://www.fisheries.noaa.gov/national/science-data/seabirds.

NMFS. 2023r. 2023 5-Year Review: Summary & Evaluation of Southern California Steelhead. U.S. Dept. of Commerce, NMFS, West Coast Region. Available at: https://repository.library.noaa.gov/view/noaa/55493.

NMFS. 2024a. NOAA Fisheries Understanding marine wildlife stranding and response webpage. Accessed February 13, 2024. Available at: fisheries.noaa.gov/insight/understanding-marine-wildlife-stranding-and-response.

NMFS. 2024b. NOAA Fisheries Marine mammal unusual mortality events webpage. Accessed February 13, 2024. Available at: fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-unusual-mortality-events.

NMFS. 2024c. NOAA Fisheries Marine Mammal Protection Act section 120 pinniped removal program webpage. Accessed June 4, 2024. Available at: fisheries.noaa.gov/west-coast/marine-mammal-protection/marine-mammal-protection-act-section-120-pinniped-removal.

NMFS. 2024d. Fisheries Economics of the United States, 2022. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-F/SPO-248, 28 p.

NMFS. 2024e. NOAA Fisheries West coast highly migratory species and gear webpage. Accessed April 16, 2024. Available at: fisheries.noaa.gov/west-coast/sustainable-fisheries/west-coast-highly-migratory-species-fisheries-and-gear.

NMFS. 2024f. Critical habitat webpage. Accessed April 3, 2024. Available at: https://www.fisheries.noaa.gov/national/endangered-species-conservation/critical-habitat.

NMFS. 2024g. Incidental take authorizations under the marine mammal protection act webpage. Accessed April 3, 2024. Available at: https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act.

NMFS. 2024h. Endangered Species Act Recovery Plan for the Oceanic Whitetip Shark (Carcharhinus longimanus). U.S. Dept. Commerce, NOAA, Office of Protected Resources. Available at: https://www.fisheries.noaa.gov/resource/document/recovery-plan-oceanic-whitetip-shark.

NMFS. 2024i. West Coast Coastal Pelagic Species webpage. Accessed March 13, 2024. Available at: https://www.fisheries.noaa.gov/species/west-coast-coastal-pelagic-species.

NMFS. 2024j. NOAA Fisheries List of Fisheries Summary Tables webpage. Accessed March 13, 2024. U.S. Dept. of Commerce, NMFS. Available at: https://www.fisheries.noaa.gov/national/marine-mammal-protection/list-fisheries-summary-tables.

NMFS. n.d.a. NOAA Fisheries Species Directory Database. Accessed individual species profile pages November 2023. U.S. Dept. of Commerce, NOAA. Available at: https://www.fisheries.noaa.gov/species-directory/.

NMFS. n.d.b. NOAA Marine Mammal Stock Assessment Reports by Species/Stock Database. Accessed individual species stock assessments November 2023. U.S. Dept. of Commerce, NOAA. Available at: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock.

NOAA. 2009a. Introduction to Economics for Coastal Managers. U.S. Dept. of Commerce, NOAA Coastal Services Center. Available at: https://coast.noaa.gov/data/digitalcoast/pdf/economics-for-coastal-managers.pdf.

NOAA. 2009b. National Weather Service - glossary webpage. Accessed March 25, 2024. Available at: https://forecast.weather.gov/glossary.php.

NOAA. 2011. Marine Aquaculture Policy. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration. Available at: fisheries.noaa.gov/resource/document/noaa-marine-aquaculture-policy-2011.

NOAA. 2013. National Coastal Population Report: Population Trends from 1970 to 2020. U.S. Department of Commerce, NOAA, developed in partnership with the U.S. Census Bureau. Available at: https://cdn.oceanservice.noaa.gov/oceanserviceprod/facts/coastal-population-report.pdf.

NOAA. 2016. What is a harmful algal bloom? webpage. Accessed May 31, 2024. Available at: noaa.gov/what-is-harmful-algal-bloom.

NOAA. 2017. Policy and Procedures for Compliance with the National Environmental Policy Act and Related Authorities. Companion Manual for NOAA Administrative Order 216-6A. U.S. Dept.of Commerce. Available at: https://www.noaa.gov/sites/default/files/2021-10/NOAA-NAO-216-6A-Companion-Manual-03012018%20%281%29.pdf.

NOAA. 2019. NOAA Fisheries and National Ocean Service guidance and best practices for engaging and incorporating traditional ecological knowledge in decision-making. Available at: https://www.noaa.gov/sites/default/files/2021-11/19-065933-Traditional-Knowledge-in-Decision-Making-Document-Signed.pdf.

NOAA. 2021. ENOW Explorer webpage (search Santa Barbara and Ventura Counties). Accessed May 1, 2024. Available at: coast.noaa.gov/enowexplorer/.

NOAA. 2021b. Blue Economy Strategic Plan 2021-2025. U.S. Dept. of Commerce, NOAA. Available at: https://cdn.oceanservice.noaa.gov/oceanserviceprod/economy/Blue-Economy%20Strategic-Plan.pdf.

NOAA. 2022a. Story map: our dynamic marine economy webpage. Accessed April 5, 2024. Available at: noaa.gov/stories/story-map-our-dynamic-marine-economy.

NOAA. 2022b. Building a climate ready nation. FY 2022-2026 Strategic Plan. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration. Available at: https://www.noaa.gov/sites/default/files/2022-06/NOAA_FY2226_Strategic_Plan.pdf.

NOAA. 2023a. Sovereign relations on the west coast webpage. Accessed June 1, 2024. Available at: fisheries.noaa.gov/west-coast/partners/sovereign-relations-west-coast.

NOAA. 2023b. NOAA Procedures for Government-to-Government Consultation with Federally Recognized Indian Tribal Governments. U.S. Dept. of Commerce, NOAA. Available at: https://www.noaa.gov/organization/administration/nao-218-8A-policy-on-G2G-consultation-with-federally-Recognized-Tribal-Governments.

NOAA. 2023c. West coast/Alaska: harmful algal blooms webpage. Accessed May 31, 2024. Available at: oceanservice.noaa.gov/hazards/hab/west-coast.html.

NOAA. 2023d. National Ocean Service - What is the EEZ? webpage. Accessed March 22, 2024. Available at: https://oceanservice.noaa.gov/facts/eez.html.

NOAA. 2023e. National Ocean Service - What is upwelling? webpage. Accessed March 26, 2024. Available at: https://oceanservice.noaa.gov/facts/upwelling.html.

NOAA. 2024a. CoastWatch-West coast, Loggerhead background webpage. Accessed February 15, 2024. Available at: coastwatch.pfeg.noaa.gov/loggerheads/loggerhead_background.html.

NOAA. 2024b. Office for Coastal Management economics and demographics webpage. Accessed April 5 2024. Available at: coast.noaa.gov/states/fast-facts/economics-and-demographics.html.

NOAA. 2024c. Discover an Ocean of Business Opportunity. NOAA and the Marine Economy. Top Ten Things to Know Series. U.S. Dept. of Commerce, Office for Coastal Management. Available at: coast.noaa.gov/data/nationalfacts/pdf/hand-out-marine-economy.pdf.

NOAA. 2024d. Federal agencies release joint U.S. strategy for combating illegal, unreported, and unregulated fishing webpage. Accessed May 2, 2024. Available at: fisheries.noaa.gov/agency-statement/federal-agencies-release-joint-us-strategy-combating-illegal-unreported-and.

NOAA. 2024e. National Ocean Service -What is seaweed? webpage. Accessed March 26, 2024. Available at: https://oceanservice.noaa.gov/facts/seaweed.html.

NOAA. n.d.a. NOAA Archaelogical Resources Protection Act Summary of Information. U.S. Dept. of Commerce, NOAA.

NOAA. n.d.b. Office of Coast Survey wrecks and obstructions database webpage. Wrecks identified in Santa Monica Bay and Santa Barbara Channel. Available at: https://www.fisheries.noaa.gov/inport/item/39988.

NOAA. n.d.c. Greater Farallones National Marine Sanctuary, Vessel speed reduction to protect whales webpage. Accessed May 28, 2024. Available at: farallones.noaa.gov/eco/whales/vessel-speed-reduction.html.

NOAA NOS. 2022. Final Programmatic Environmental Impact Statement for Surveying and Mapping Projects in U.S. Waters for Coastal and Marine Data Acquisition. U.S. Dept. of Commerce, NOAA, National Ocean Service.

NOAA OCM. 2023. NOAA Regional and State Report on the U.S. Marine Economy. U.S. Dept. of Commerce, NOAA, Office for Coastal Management.

NOAA OCM. 2024. NOAA Regional and State Report on the U.S. Marine Economy. U.S. Dept. of Commerce, NOAA, Office for Coastal Management. Available at: https://coast.noaa.gov/data/digitalcoast/pdf/econ-report-regional-state.pdf.

NOAA ONMS. 2023. Proposed Chumash Heritage National Marine Sanctuary Draft Environmental Impact Statement. U.S. Dept. of Commerce, NOAA, Office of National Marine Sanctuaries, Silver Spring, MD.

Norman, K., J. Sepez, H. Lazrus, N. Milne, C. Package, S. Russell, K. Grant, R. P. Lewis, J. Primo, E. Springer, M. Styles, B. Tilt, and I. Vaccaro. 2007. Community Profiles for West Coast and North Pacific Fisheries Washington, Oregon, California, and other U.S. States. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-85, 602 p.

Northridge, S., A. Coram, and J. Gordon. 2013. Investigations on Seal Depredation at Scottish Fish Farms. Edinburgh: Scottish Government.

NPS. 2012. Final Environmental Impact Statement Drakes Bay Oyster Company Special Use Permit. U.S. Dept. of the Interior, National Park Service. Available at: https://parkplanning.nps.gov/document.cfm?documentID=50651.

NPS. 2016. U.S. National Park Service, Western snowy plover - Channel Islands National Park webpage. Accessed June 4, 2024. Available at: nps.gov/chis/learn/nature/snowy-plover.htm.

NPS. 2020. U.S. National Park Service, Townsend's Big-eared bat - Channel Islands National Park webpage. Accessed February 22, 2024. Available at: nps.gov/chis/learn/nature/townsends-bat.htm.

NPS. 2021. Channel Islands National Park, Northern Elephant Seal webpage. Accessed March 14, 2024. U.S. Fish and Wildlife Service. Available at: https://www.nps.gov/places/northern-elephant-seal.htm.

NPS. 2022. Channel Islands National Park, Marine animals webpage. Accessed March 14, 2024. U.S. Fish and Wildlife Service. Available at: https://www.nps.gov/chis/learn/nature/marine-animals.htm.

NPS. 2024a. U.S. National Park Service, Bald eagle - Channel Islands National Park webpage. Accessed February 16, 2024. Available at: nps.gov/chis/learn/nature/bald-eagles.htm.

NPS. 2024b. U.S. National Park Service, Peregrine falcon - Channel Islands National Park webpage. Accessed February 16, 2024. Available at: nps.gov/chis/learn/nature/peregrine-falcon.htm.

NSGLC. 2023. Seaweed Food Safety: Comparing Compliance with Preventive Controls for Human Foods and Seafood HACCP. National Sea Grant Law Center. NSGLC-23-05-02. Available at: https://nsglc.olemiss.edu/projects/regulatingseaweed/files/seaweedfoodsafety.pdf.

NSTC. 2022a. A National Strategic Plan for Aquaculture Research. National Science and Technology Council, Subcommittee on Aquaculture. Available at: https://www.ars.usda.gov/SCA/.

NSTC. 2022b. A Strategic Plan to Enhance Regulatory Efficiency in Aquaculture. National Science and Technology Council, Subcommittee on Aquaculture. Available at: https://www.ars.usda.gov/SCA/.

Oakes, C. T., and D. J. Pondella. 2009. The Value of a Net-Cage as a Fish Aggregating Device in Southern California. Journal of the World Aquaculture Society 40(1):1–21.

Ocean Era. 2021. Preliminary Environmental Review for the Ocean Era Offshore Aquaculture Farm Off ʻEwa Beach, Oʻahu, Hawaiʻi. Ocean Era, Inc., Kailua-Kona, HI. Available at: ocean-era.squarespace.com.

Ocean Policy Committee. 2023. Ocean Climate Action Plan. Ocean Policy Committee. Available at: https://www.whitehouse.gov/wp-content/uploads/2023/03/Ocean-Climate-Action-Plan_Final.pdf.

Ocean Spaces. 2014. California Fisheries Data Explorer: Interactive Fisheries Data Explorer. Accessed: April 2024. California Ocean Science Trust, Oakland, CA. Available online: http://tools.oceanspaces.org/fisheriesdataexplorer.

Oceana. 2021. Automatic identification systems essential to maintaining safe and sustainable fisheries webpage. Accessed April 9, 2024. Available at: usa.oceana.org/blog/automatic-identification-systems-essential-to-maintaining-safe-and-sustainable-fisheries.

OCM. 2024. InPort - Military operating areas webpage. NOAA National Centers for Environmental Information, Office for Coastal Management. Accessed April 3, 2024. Available at: https://www.fisheries.noaa.gov/inport/item/55364.

O'Connor, S., S. Campbell, H. Cortez, and T. Knowles. 2009. Whale Watching Worldwide: tourism numbers, expenditures and expanding economic benefits, a special report from the International Fund for Animal Welfare, Yarmouth MA, USA, prepared by Economists at Large.

OEHHA. 2022. Indicators of Climate Change in California, Fourth Edition. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment.

OIMB. 2011. Oregon Institute of Marine Biology, The Fish Project - forage fish fisheries webpage. Accessed March 11, 2024. Available at: https://thefishproject.weebly.com/forage-fish-fisheries.html.

Olesiuk, P. F., J. W. Lawson, and E. A. Trippel. 2012. Pathways of effects of noise associated with aquaculture on natural marine ecosystems in Canada. Canadian Science Advisory Secretariat, Research Document 2010/025. Department of Fisheries and Oceans, Canada.

ONMS. 2009. Channel Islands National Marine Sanctuary Condition Report 2009. U.S. Dept. of Commerce, NOAA, Office of National Marine Sanctuaries, Silver Spring, MD. 60pp.

ONMS. 2019. Channel Islands National Marine Sanctuary 2016 Condition Report. U.S. Dept. of Commerce, NOAA, Office of National Marine Sanctuaries, Silver Spring, MD. 482 pp.

Ono, K., C. A. Simenstad, J. D. Toft, S. L. Southard, K. L. Sobocinski, and A. Borde. 2010. Assessing and mitigating dock shading impacts on the behavior of juvenile pacific salmon (Oncorhynchus spp.): can artificial light mitigate the effects? Washington (State). Dept. of Transportation. Office of Research and Library ….

OPC. 2020. Strategic Plan to Protect California's Coast and Ocean 2020–2025. California Ocean Protection Council. Available at: https://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20200226/OPC-2020-2025-Strategic-Plan-FINAL-20200228.pdf.

OPC. 2021. Guiding Principles for Sustainable Marine Aquaculture in California. California Ocean Protection Council. Available at: https://opc.ca.gov/wp-content/uploads/2021/06/Aquaculture-Principles-Public-20210604.pdf.

Owen, K., R. Dunlop, and D. Donnelly. 2012. Seaweed interactions by humpback whales (Megaptera novaeangliae): A form of object play? Aquatic mammals 38(4).

Oyabu, A., L. Wu, T. Matsumoto, N. Kihara, H. Yamanaka, and T. Minamoto. 2024. The effect of artificial light at night on wild fish community: manipulative field experiment and species composition analysis using environmental DNA. Environmental Advances 15:100457.

Pacific Northwest Laboratories. 1969. Review of the Santa Barbara Channel Oil Pollution Incident. PNL, Battelle Memorial Institute. Richland, WA.

Papastamatiou, Y. P., D. G. Itano, J. J. Dale, C. G. Meyer, and K. N. Holland. 2010. Site fidelity and movements of sharks associated with ocean-farming cages in Hawaii. Marine and Freshwater Research 61(12):1366.

Parker, M., and S. Bricker. 2020. Sustainable Oyster Aquaculture, Water Quality Improvement, and Ecosystem Service Value Potential in Maryland Chesapeake Bay. Journal of Shellfish Research 39(2):269.

Parrish, K., and M. Karp. 2024. Wild Species Analysis in Support of Marine Aquaculture in the Gulf of Mexico and the Southern California Bight. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-NWFSC-196.

Patrício, A., L. Hawkes, J. Monsinjon, B. Godley, and M. Fuentes. 2021. Climate change and marine turtles: recent advances and future directions. Endangered Species Research 44:363–395.

Peabody, B., and J. Toft. 2021. Puget Sound Restoration Fund Grant Proposal Abstract. Project Title: From nuisance to profit: Monetizing seaweeds and cockles that foul shellfish aquaculture farms. Proposal No. 21WCR016-026. Available at: https://media.fisheries.noaa.gov/2021-05/FY21%20S-K%20Summary%20of%20All%20Proposals.pdf.

Pearse, J. S., and A. H. Hines. 1979. Expansion of a central California kelp forest following the mass mortality of sea urchins. Marine Biology 51(1):83–91.

Peavey, L. E., B. N. Popp, R. L. Pitman, S. D. Gaines, K. E. Arthur, S. Kelez, and J. A. Seminoff. 2017. Opportunism on the High Seas: Foraging Ecology of Olive Ridley Turtles in the Eastern Pacific Ocean. Frontiers in Marine Science 4:348.

Pecl, G. T., M. B. Araújo, J. D. Bell, J. Blanchard, T. C. Bonebrake, I.-C. Chen, T. D. Clark, R. K. Colwell, F. Danielsen, B. Evengård, L. Falconi, S. Ferrier, S. Frusher, R. A. Garcia, R. B. Griffis, A. J. Hobday, C. Janion-Scheepers, M. A. Jarzyna, S. Jennings, J. Lenoir, H. I. Linnetved, V. Y. Martin, P. C. McCormack, J. McDonald, N. J. Mitchell, T. Mustonen, J. M. Pandolfi, N. Pettorelli, E. Popova, S. A. Robinson, B. R. Scheffers, J. D. Shaw, C. J. B. Sorte, J. M. Strugnell, J. M. Sunday, M.-N. Tuanmu, A. Vergés, C. Villanueva, T. Wernberg, E. Wapstra, and S. E. Williams. 2017. Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. Science 355(6332):1–9.

Peng, X., D. J. Yousavich, A. Bourbonnais, F. Wenzhöfer, F. Janssen, T. Treude, and D. L. Valentine. 2024. The fate of fixed nitrogen in Santa Barbara Basin sediments during seasonal anoxia. Biogeosciences 21(12):3041–3052.

Petton, B., D. Destoumieux-Garzón, F. Pernet, E. Toulza, J. De Lorgeril, L. Degremont, and G. Mitta. 2021. The Pacific Oyster Mortality Syndrome, a Polymicrobial and Multifactorial Disease: State of Knowledge and Future Directions. Frontiers in Immunology 12:630343.

PFMC. 2013. Pacific Coast Fishery Ecosystem Plan for the U.S. Portion of the California Current Large Marine Ecosystem. Pacific Fishery Management Council. Portland, OR. Available at: https://swfsc-publications.fisheries.noaa.gov/publications/CR/2013/2013Pacific5.pdf.

PFMC. 2016. Comprehensive Ecosystem-Based Amendment 1: Protecting Unfished and Unmanaged Forage Fish Species of the U.S. Portion of the California Current Ecosystem. Pacific Fishery Management Council. Portland, OR. Available at: https://repository.library.noaa.gov/view/noaa/15444.

PFMC. 2019. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery. Appendix C, Part 2: the Effects of Fishing on Groundfish Habitat: West Coast Perspective. Pacific Fishery Management Council. Portland, OR.

PFMC. 2024. Pacific Fishery Management Council Commercial fisheries descriptions webpage. Accessed March 13, 2024. Available at: https://www.pcouncil.org/hms-commercial-fisheries-descriptions/.

PFMC. 2023b. Coastal Pelagic Species Fishery Management Plan as Amended Through Amendment 20. Published June 2023. Pacific Fishery Management Council. Portland, OR. Available at: https://www.pcouncil.org/fishery-management-plan-and-amendments/.

PFMC. 2023d. Fishery Management Plan for U.S. West Coast Fisheries for Highly Migratory Species: Amended Through Amendment 7. Published March 2023. Pacific Fishery Management Council.

Portland, OR. Available at: https://www.pcouncil.org/documents/2023/04/fishery-management-plan-for-west-coast-fisheries-for-highly-migratory-species-through-amendment-5.pdf/.

PFMC. 2022a. July 2022 Letter to NMFS on NOAA Aquaculture Opportunity Areas. Pacific Fishery Management Council. Portland, OR. Available at: https://www.pcouncil.org/documents/2022/07/july-2022-letter-to-nmfs-on-noaa-aquaculture-opportunity-areas.pdf/.

PFMC. 2022b. Pacific Coast Fishery Ecosystem Plan for the U.S. Portion of the California Current Large Marine Ecosystem (Revised and Updated). Pacific Fishery Management Council. Portland, OR. Available at: https://www.pcouncil.org/documents/2022/04/pacific-coast-fishery-ecosystem-plan-march-2022.pdf/.

PFMC. 2023c. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery. Published December 2023. Pacific Fishery Management Council. Portland, OR. Available at: https://www.pcouncil.org/documents/2022/08/pacific-coast-groundfish-fishery-management-plan.pdf/.

PFMC. 2021c. Pacific Fishery Management Council Fact Sheet: Coastal pelagic species webpage. Accessed March 13, 2024. Available at: https://www.pcouncil.org/fact-sheet-coastal-pelagic-species/.

PFMC. 2021b. Pacific Fishery Management Council Fact Sheet: Groundfish webpage. Accessed March 13, 2024. Available at: https://www.pcouncil.org/fact-sheet-groundfish/.

PFMC. 2021a. Pacific Fishery Management Council Fact Sheet: Highly migratory species webpage. Accessed March 13, 2024. Available at: https://www.pcouncil.org/fact-sheet-highly-migratory-species/.

PFMC. n.d. Pacific Fishery Management Council HMS stock assessment and fishery evaluation (SAFE) documents webpage. Accessed July 2, 2024. Available at: pcouncil.org/safe-documents-2/.

PFMC. 2022c. Status of the Pacific Coast Coastal Pelagic Species Fishery and Recommended Acceptable Biological Catches: Stock Assessment and Fishery Evaluation 2021 Including Information Through June 2021. Published September 2022. Pacific Fishery Management Council. Portland, OR. Available at: https://www.pcouncil.org/documents/2022/10/2021-cps-safe-september-2022.pdf/.

PFMC. 2022d. Status of the Pacific Coast Groundfish Fishery: Stock Assessment and Fishery Evaluation Description of the Fishery. Published July 2022. Pacific Fishery Management Council. Portland, OR. Available at: https://www.pcouncil.org/documents/2022/09/status-of-the-pacific-coast-groundfish-fishery-stock-assessment-and-fishery-evaluation-july-2022.pdf/.

PFMC. 2023a. Status of the U.S. West Coast Fisheries for Highly Migratory Species Through 2022. Published November 2023. Pacific Fishery Management Council. Portland, OR. Available at: https://www.pcouncil.org/documents/2023/11/2022-hms-safe-november-2023.pdf/.

Pitman, R. L., J. A. Totterdell, H. Fearnbach, L. T. Ballance, J. W. Durban, and H. Kemps. 2015. Whale killers: Prevalence and ecological implications of killer whale predation on humpback whale calves off Western Australia. Marine Mammal Science 31(2):629–657.

Pitta, P., M. Tsapakis, E. Apostolaki, T. Tsagaraki, M. Holmer, and I. Karakassis. 2009. 'Ghost nutrients' from fish farms are transferred up the food web by phytoplankton grazers. Marine Ecology Progress Series 374:1–6.

Porrello, S., M. Lenzi, G. Ferrari, E. Persia, F. Savelli, and P. Tomassetti. 2005. Loading of nutrient from a land-based fish farm(Orbetello, Italy) at different times. Aquaculture International 13(1–2):97–108.

Poti, M., S. Henkel, J. Bizzarro, T. Hourigan, M. Clarke, C. Whitmire, A. Powell, M. Yoklavich, L. Bauer, and A. Winship. 2020. Cross-Shelf Habitat Suitability Modeling: Characterizing Potential Distributions of Deep-Sea Corals, Sponges, and Macrofauna Offshore of the US West Coast. Camarillo (CA): US Department of the Interior, Bureau of Ocean Energy Management. OCS Study. BOEM 21:267.

Préat, N., M. De Troch, S. Van Leeuwen, S. E. Taelman, S. De Meester, F. Allais, and J. Dewulf. 2018. Development of potential yield loss indicators to assess the effect of seaweed farming on fish landings. Algal Research 35:194–205.

Price, C., K. Black, B. Hargrave, and J. Morris. 2015. Marine cage culture and the environment: effects on water quality and primary production. Aquaculture Environment Interactions 6(2):151–174.

Price, C. S., and J. A. J. Morris. 2013. Marine cage culture and the environment: Twenty-first century science informing a sustainable industry. NOAA Technical Memorandum NOS NCCOS 164. 158 pp.

Price, C. S., J. A. Jr. Morris, E. P. Keane, D. M. Morin, C. Vaccaro, and D. W. W. Bean. 2017. Protected Species & Marine Aquaculture Interactions. NOAA Technical Memorandum NOS NCCOS 211. 85 pp.

Protected Seas. 2022. CA Kelp Protections, kelp proximity estimates webpage. Accessed March 12, 2024. Available at: https://protectedseas.maps.arcgis.com/home/index.html.

Purcell, C., J. Volk, and G. Blair. 2023. Science Advice for Genetic Effects from Offshore Aquaculture in Southern California and the Gulf of Mexico. Unpublished draft(s) currently in review. U.S. Dept. of Commerce, NMFS.

Rajkumar, R., Z. Yaakob, and M. S. Takriff. 2014. Potential of the Micro and Macro Algae for Biofuel Production: A Brief Review. BioResources 9(1):1606–1633.

Ramasamy, R., and R. B. Subramanian. 2021. Synthetic textile and microfiber pollution: a review on mitigation strategies. Environmental Science and Pollution Research 28(31):41596–41611.

Ramos, J., P. G. Lino, M. Caetano, F. Pereira, M. Gaspar, and M. N. Dos Santos. 2015. Perceived impact of offshore aquaculture area on small-scale fisheries: A fuzzy logic model approach. Fisheries Research 170:217–227.

Ramsay, A., J. Davidson, T. Landry, and H. Stryhn. 2008. The effect of mussel seed density on tunicate settlement and growth for the cultured mussel, Mytilus edulis. Aquaculture 275(1–4):194–200.

Ratcliff, J., A. Wan, M. Edwards, A. Soler-Vila, M. Johnson, M. H. Abreu, and L. Morrison. 2016. Metal content of kelp (Laminaria digitata) co-cultivated with Atlantic salmon in an Integrated Multi-Trophic Aquaculture system. Aquaculture 450:234–243.

Raul, C., S. S. Pattanaik, S. Prakash, K. Sreedharan, and S. Bharti. 2020. Greenhouse gas emissions from aquaculture systems. World Aquac 57:57–61.

Ray, N. E., T. J. Maguire, A. N. Al-Haj, M. C. Henning, and R. W. Fulweiler. 2019. Low greenhouse gas emissions from oyster aquaculture. Environmental Science & Technology 53(15):9118–9127.

Redfern, J., L. Hatch, C. Caldow, M. DeAngelis, J. Gedamke, S. Hastings, L. Henderson, M. McKenna, T. Moore, and M. Porter. 2017. Assessing the risk of chronic shipping noise to baleen whales off Southern California, USA. Endangered Species Research 32:153–167.

Redfern, J. V., E. A. Becker, and T. J. Moore. 2020. Effects of Variability in Ship Traffic and Whale Distributions on the Risk of Ships Striking Whales. Frontiers in Marine Science 6:793.

Redmond, S., L. Green, C. Yarish, J. Kim, and C. Neefus. 2014. New England Seaweed Culture Handbook. Seaweed Cultivation (Paper 1).

Reid, G., H. Gurney-Smith, M. Flaherty, A. Garber, I. Forster, K. Brewer-Dalton, D. Knowler, D. Marcogliese, T. Chopin, R. Moccia, C. Smith, and S. De Silva. 2019. Climate change and aquaculture: considering adaptation potential. Aquaculture Environment Interactions 11:603–624.

Relano, V., and D. Pauly. 2022. Philopatry as a Tool to Define Tentative Closed Migration Cycles and Conservation Areas for Large Pelagic Fishes in the Pacific. Sustainability 14(9):5577.

Rensel, J. E., and J. R. M. Forster. 2007. Beneficial Environmental Effects of Marine Finfish Mariculture. Final report to the National Oceanic and Atmospheric Administration, NOAA Award #NA040AR4170130, Washington, D.C.

Rhodes, L. D., K. L. Parrish, and M. W. Rub. 2023a. Scientific Support for Health Management and Biosecurity for Marine Aquaculture in the United States. U.S. Dept. of Commerce. NOAA Tech Memo NMFS-NWFSC-186.

Rhodes, L. D., K. L. Parrish, and M. L. Willis. 2023b. Review of Best Practices for Biosecurity and Disease Management for Marine Aquaculture in U.S. Waters. U.S. Dept. of Commerce. NOAA Tech Memo NMFS-NWFSC-180.

Riebesell, U., N. Aberle-Malzahn, E. P. Achterberg, M. Algueró-Muñiz, S. Alvarez-Fernandez, J. Arístegui, L. T. Bach, M. Boersma, T. Boxhammer, W. Guan, M. Haunost, H. G. Horn, C. R. Löscher, A. Ludwig, C. Spisla, M. Sswat, P. Stange, and J. Taucher. 2018. Toxic algal bloom induced by ocean acidification disrupts the pelagic food web. Nature Climate Change 8(12):1082–1086.

Ritter, F. 2012. Collisions of sailing vessels with cetaceans worldwide: First insights into a seemingly growing problem. J. Cetacean Res. Manage. 12(1):119–127.

Ritzman, J., A. Brodbeck, S. Brostrom, S. McGrew, S. Dreyer, T. Klinger, and S. K. Moore. 2018. Economic and sociocultural impacts of fisheries closures in two fishing-dependent communities following the massive 2015 U.S. West Coast harmful algal bloom. Harmful Algae 80:35–45.

Robb, D. H. F., M. MacLeod, M. R. Hasan, and D. Soto. 2017. Greenhouse gas emissions from aquaculture: a life cycle assessment of three Asian systems. FAO Fisheries and Aquaculture Technical Paper No. 609. Rome, FAO. 110 pp.

Robertson, R. R., and E. P. Bjorkstedt. 2020. Climate-driven variability in Euphausia pacifica size distributions off northern California. Progress in Oceanography 188:102412.

Rockwood et al. 2021a. Rockwood et al. 2021 vessel strike model in SBC.

Rockwood, R. C., J. D. Adams, S. Hastings, J. Morten, and J. Jahncke. 2021b. Modeling Whale Deaths From Vessel Strikes to Reduce the Risk of Fatality to Endangered Whales. Frontiers in Marine Science 8:649890.

Rockwood, R. C., J. Calambokidis, and J. Jahncke. 2017. High mortality of blue, humpback and fin whales from modeling of vessel collisions on the U.S. West Coast suggests population impacts and insufficient protection. PLOS ONE 12(8):e0183052.

Rubino, M., editor. 2008. Offshore Aquaculture in the United States: Economic Considerations, Implications & Opportunities. U.S. Dept. of Commerce; Silver Spring, MD; USA. NOAA Tech. Memo. NMFS F/SPO-103. 263 pp.

Rubino, M. C. 2022. Policy Considerations for Marine Aquaculture in the United States. Reviews in Fisheries Science & Aquaculture 31(1):86–102.

Rumley, E. R. 2010. An Agricultural Law Research Project: Aquaculture and the Lacey Act. The National Agricultural Law Center. Available at: https://nationalaglawcenter.org/publication/download/springsteen-aquaculture-and-the-lacey-act-national-aglaw-center-publication-2010/.

Russell, S. M., A. Arias-Arthur, K. Sparks, and A. Varney. 2016. West Coast Communities and Catch Shares: The Early Years of Social Change. Coastal Management 44(5):441–451.

Russell, T. M., A. R. Szesciorka, T. W. Joyce, D. G. Ainley, and L. T. Ballance. 2023. National Marine Sanctuaries capture enhanced abundance and diversity of the California Current Ecosystem avifauna. Journal of Marine Systems 240:103887.

Russo, T., L. D'Andrea, A. Parisi, M. Martinelli, A. Belardinelli, F. Boccoli, I. Cignini, M. Tordoni, and S. Cataudella. 2016. Assessing the fishing footprint using data integrated from different tracking devices: Issues and opportunities. Ecological Indicators 69:818–827.

Rust, M. B., K. H. Amos, A. L. Bagwill, W. W. Dickhoff, L. M. Juarez, C. S. Price, J. A. Morris, and M. C. Rubino. 2014. Environmental Performance of Marine Net-Pen Aquaculture in the United States. Fisheries 39(11):508–524.

Rydell, J. 2006. Bats and their insect prey at streetlights. In Ecological Consequences of Artificial Night Lighting, edited by C. Rich and T. Longcore, pp. 43-60. Washington, D.C.: Island Press.

Saba, G. K., and D. K. Steinberg. 2012. Abundance, Composition and Sinking Rates of Fish Fecal Pellets in the Santa Barbara Channel. Scientific Reports 2(1):716.

Saez, L. E., D. Lawson, and M. DeAngelis. 2021. Large whale entanglements off the U.S. West Coast, from 1982-2017. NOAA Tech. Memo. NMFS-OPR-63A, 50 p.

San Diego Audubon. 2024. Save the endangered California Least Tern webpage. Accessed: March 13, 2024. Available at: https://www.sandiegoaudubon.org/what-we-do/conservation-1/habitat-restoration.html.

Santa Barbara Channelkeeper. n.d. Marine Protected Areas webpage. Accessed May 28, 2024. Available at: sbck.org/our-work/advocacy/marine-protected-areas/.

Santa Ynez Band of Chumash Indians. n.d.c. Chumash culture webpage. Accessed June 6, 2024. Available at: chumash.gov/culture.

Santa Ynez Band of Chumash Indians. n.d.a. Our history webpage. Accessed June 2, 2024. Available at: chumash.gov/chumash-history.

Santa Ynez Band of Chumash Indians. n.d.b. The Santa Ynez Reservation webpage. Accessed June 6, 2024. Available at: chumash.gov/the-santa-ynez-reservation.

Santora, J. A., J. C. Field, I. D. Schroeder, K. M. Sakuma, B. K. Wells, and W. J. Sydeman. 2012. Spatial ecology of krill, micronekton and top predators in the central California Current: Implications for defining ecologically important areas. Progress in Oceanography 106:154–174.

Santora, J. A., N. J. Mantua, I. D. Schroeder, J. C. Field, E. L. Hazen, S. J. Bograd, W. J. Sydeman, B. K. Wells, J. Calambokidis, L. Saez, D. Lawson, and K. A. Forney. 2020. Habitat compression and ecosystem shifts as potential links between marine heatwave and record whale entanglements. Nature Communications 11(1):536.

Sapkota, A., A. R. Sapkota, M. Kucharski, J. Burke, S. McKenzie, P. Walker, and R. Lawrence. 2008. Aquaculture practices and potential human health risks: Current knowledge and future priorities. Environment International 34(8):1215–1226.

Scavia, D., J. C. Field, D. F. Boesch, R. W. Buddemeier, V. Burkett, D. R. Cayan, M. Fogarty, M. A. Harwell, R. W. Howarth, C. Mason, D. J. Reed, T. C. Royer, A. H. Sallenger, and J. G. Titus. 2002. Climate change impacts on U.S. Coastal and Marine Ecosystems. Estuaries 25(2):149–164.

SCB 2018 Regional Monitoring Program Sediment Quality Assessment Planning Committee. 2022. Southern California Bight 2018 Regional Monitoring Program Sediment Quality Executive Synthesis Report. Technical Report 1248. Southern California Coastal Water Research Project. Costa Mesa, CA.

SCCWRP. 2024. Southern California Bight Regional Monitoring Program - Southern California Coastal Water Research Project webpage. Accessed May 28, 2024. Available at: www.sccwrp.org/about/research-areas/regional-monitoring/southern-california-bight-regional-monitoring-program/.

Schiff, K., M. J. Allen, E. Zeng, and S. Bay. 2000. Southern California. Marine Pollution Bulletin 41(1–6):76–93.

Schlosberg, D., L. B. Collins, and S. Niemeyer. 2017. Adaptation policy and community discourse: risk, vulnerability, and just transformation. Environmental Politics 26(3):413–437.

Schroeder, D. M., and M. S. Love. 2002. Recreational Fishing and Marine Fish Populations in California. CalCOFI Rep. 43.

Schwing, F. B., and R. Mendelssohn. 1997. Increased coastal upwelling in the California Current System. Journal of Geophysical Research: Oceans 102(C2):3421–3438.

Scripps. 2019. Research Highlight: Scientists Find Key Changes in Gray Whale Migration Routes Off Southern California webpage. Accessed March 14, 2024. Available at: https://scripps.ucsd.edu/news/research-highlight-scientists-find-key-changes-gray-whale-migration-routes-southern-california.

Sea Grant. 2016. 10-Year NOAA Sea Grant Aquaculture Vision. Sea Grant Association. MASGP-16-015.

Sea Grant. 2022. Seaweed Farming in the United States webinar, August 26, 2022. Available at: https://www.youtube.com/watch?v=k9oP-K50KK8.

Sea Grant. 2023. Programmatic Environmental Assessment for Funding Aquaculture Research and Development Projects. U.S. Dept. of Commerce, NOAA, Office of Oceanic and Atmospheric Research (OAR), National Sea Grant Office.

Sea Grant. 2024a. California Sea Grant, Aquaculture in California webpage. Accessed Nov 1, 2024. Available at: caseagrant.ucsd.edu/our-work/discover-california-seafood/aquaculture-california.

Sea Grant. 2024c. California Sea Grant, California sea cucumber webpage. Accessed October 22, 2024. Available at: https://caseagrant.ucsd.edu/seafood-profiles/california-sea-cucumber.

Sea Grant. 2024b. California Sea Grant, Discover California commercial fisheries webpage. Accessed April 9, 2024. Available at: https://caseagrant.ucsd.edu/california-commercial-fisheries.

Sea Grant. 2024e. California Sea Grant, Santa Barbara Channel webpage. Accessed March 13, 2024. Available at: https://caseagrant.ucsd.edu/california-commercial-fisheries/regions/santa-barbara-channel.

SeaVeg. n.d. Maine Coast Sea Vegetables, California warning on seaweed (Prop 65) webpage. Accessed June 6, 2024. Available at: https://seaveg.com/pages/seaweed-prop-65.

SEER. 2021. SEER Webinar #1: Underwater Noise & Entanglement Considerations for Offshore Wind Farms. November 30, 2021. Recording available online at: https://tethys.pnnl.gov/events/seer-webinar-1-underwater-noise-entanglementconsiderations-offshore-wind-farms.

SEER. 2022. Bat and Bird Interactions with Offshore Wind Farms. U.S. Offshore Wind Synthesis of Environmental Effects Research. Available at: https://tethys.pnnl.gov/summaries/bat-bird-interactions-offshore-wind-energy-development.

Seierstad, S. L., I. Seljeflot, O. Johansen, R. Hansen, M. Haugen, G. Rosenlund, L. Frøyland, and H. Arnesen. 2005. Dietary intake of differently fed salmon; the influence on markers of human atherosclerosis. European Journal of Clinical Investigation 35(1):52–59.

Sekula-Wood, E., C. Benitez-Nelson, S. Morton, C. Anderson, C. Burrell, and R. Thunell. 2011. Pseudo-nitzschia and domoic acid fluxes in Santa Barbara Basin (CA) from 1993 to 2008. Harmful Algae 10(6):567–575.

Seminoff, J., C. Allen, G. Balazs, P. Dutton, T. Eguchi, H. Haas, S. Hargrove, M. Jensen, D. Klemm, A. Lauritsen, S. MacPherson, P. Opay, E. Possardt, S. Pultz, E. Seney, K. Van Houtan, and R. Waples. 2015.

Status Review of the Green Turtle (Chelonia mydas) Under the U.S. Endangered Species Act. NOAA Technical Memorandum, NOAANMFS-SWFSC-539. 571pp.

Sepez, J. 2007. A Quantitative Model for Ranking and Selecting Communities Most Involved in Commercial Fisheries. NAPA Bulletin 28(1):43–56.

Seung, C. K., and E. C. Waters. 2005. A Review of Regional Economic Models for Alaska Fisheries. U.s. Dept. of Commerce, Noaa, Alaska Fisheries Science Center. AFSC Processed Report 2005-01. 129 pp.

Shamshak, G. L., J. L. Anderson, F. Asche, T. Garlock, and D. C. Love. 2019. U.S. seafood consumption. Journal of the World Aquaculture Society 50(4):715–727.

Shapiro, A. D., J. Tougaard, P. B. Jørgensen, L. A. Kyhn, J. D. Balle, C. Bernardez, A. Fjälling, J. Karlsen, and M. Wahlberg. 2009. Transmission loss patterns from acoustic harassment and deterrent devices do not always follow geometrical spreading predictions. Marine Mammal Science 25(1):53–67.

Shepperson, J. L., N. T. Hintzen, C. L. Szostek, E. Bell, L. G. Murray, and M. J. Kaiser. 2018. A comparison of VMS and AIS data: the effect of data coverage and vessel position recording frequency on estimates of fishing footprints. ICES Journal of Marine Science 75(3):988–998.

Sherr, E. B., B. F. Sherr, and P. A. Wheeler. 2005. Distribution of coccoid cyanobacteria and small eukaryotic phytoplankton in the upwelling ecosystem off the Oregon coast during 2001 and 2002. Deep Sea Research Part II: Topical Studies in Oceanography 52(1–2):317–330.

Siegel, J., and L. Crozier. 2020. Impacts of Climate Change on Salmon of the Pacific Northwest: A review of the scientific literature published in 2019. U.S. National Marine Fisheries Service, Northwest Region. Available at: https://doi.org/10.25923/jke5-c307.

Sievanen, L., J. Phillips, C. Colgan, G. Griggs, J. Finzi Hart, E. Hartge, T. Hill, R. Kudela, N. Mantua, K. Nielsen, and L. Whiteman. 2018. California's Coast and Ocean Summary Report. California's Fourth Climate Change Assessment. Publication number: SUMCCC4A-2018-011.

Sim, B.-R., H. C. Kim, S. Kang, S.-P. Yoon, D. I. Lee, and W.-C. Lee. 2024. Chemical recovery of a fish farm in Jinju Bay of South Korea after cessation of long-term fish farming. Ocean & Coastal Management 251:107083.

SiMoN. 2024. SIMoN Species Database Red sea urchin webpage. Accessed January 29, 2024. Available at: https://www.sanctuarysimon.org/dbtools/species-database/id/187/Mesocentrotus/franciscanus/red-sea-urchin/.

Simons, A. L., K. L. M. Martin, and T. Longcore. 2021. Determining the Effects of Artificial Light at Night on the Distributions of Western Snowy Plovers (Charadrius nivosus nivosus) and California Grunion (Leuresthes tenuis) in Southern California. Journal of Coastal Research 38(2).

Sims, N. A. 2013. Kona Blue Water Farms case study: permiting, operations, marketing, environmental impacts, and impediments to expansion of global open ocean mariculture. In A. Lovatelli, J. Aguilar-Manjarrez & D. Soto, eds. Expanding mariculture farther offshore: Technical, environmental, spatial and governance challenges. FAO Technical Workshop, 22–25 March 2010, Orbetello, Italy. FAO Fisheries and Aquaculture Proceedings No. 24. Rome, FAO. pp. 263–296.

Širovic, A., A. Rice, E. Chou, J. Hildebrand, S. Wiggins, and M. Roch. 2015. Seven years of blue and fin whale call abundance in the Southern California Bight. Endangered Species Research 28(1):61–76.

Skirtun, M., M. Sandra, W. J. Strietman, S. W. K. Van Den Burg, F. De Raedemaecker, and L. I. Devriese. 2022. Plastic pollution pathways from marine aquaculture practices and potential solutions for the North-East Atlantic region. Marine Pollution Bulletin 174:113178.

Smith, G. S., and R. J. Jr. Thorpe. 2020. Gentrification: A Priority for Environmental Justice and Health Equity Research. Ethnicity & Disease 30(3):509–512.

Smith, J., D. Shultz, M. D. A. Howard, G. Robertson, V. Phonsiri, V. Renick, D. A. Caron, R. Kudela, and K. McLaughlin. 2021. Southern California Bight 2018 Regional Monitoring Program: Volume VIII. Harmful Algal Blooms. SCCWRP Technical Report #1170.

Smith, K. F., D. F. Sax, and K. D. Lafferty. 2006. Evidence for the Role of Infectious Disease in Species Extinction and Endangerment. Conservation Biology 20(5):1349–1357.

Smith, M. D., C. A. Roheim, L. B. Crowder, B. S. Halpern, M. Turnipseed, J. L. Anderson, F. Asche, L. Bourillón, A. G. Guttormsen, A. Khan, L. A. Liguori, A. McNevin, M. I. O'Connor, D. Squires, P. Tyedmers, C. Brownstein, K. Carden, D. H. Klinger, R. Sagarin, and K. A. Selkoe. 2010. Sustainability and Global Seafood. Science 327(5967):784–786.

Smith, M., D. C. Love, C. M. Rochman, and R. A. Neff. 2018. Microplastics in Seafood and the Implications for Human Health. Current Environmental Health Reports 5(3):375–386.

Smith, P. 1985. Year-class strength and survival of O-group clupeioids. Canadian Journal of Fisheries and Aquatic Sciences. 42(Suppl. 1):69–82.

Smith, S. C., and H. Whitehead. 1993. Variations in the feeding success and behaviour of galápagos sperm whales (Physeter macrocephalus) as they relate to oceanographie conditions. Canadian Journal of Zoology 71(10):1991–1996.

Smultea, M., D. Fertl, C. Bacon, M. Moore, V. James, and B. Wursig. 2017. Cetacean mother-calf behavior observed from a small aircraft off Southern California. Animal Behavior and Cognition 4(1):1–23.

Sneeringer, S. 2015. Restrictions on antibiotic use for production purposes in U.S. livestock industries likely to have small effets on prices and quantities, U.S. Dept. of Agriculture Economic Research Service webpage. Available at: https://www.ers.usda.gov/amber-waves/2015/november/restrictions-on-antibiotic-use-for-production-purposes-in-u-s-livestock-industries-likely-to-have-small-effects-on-prices-and-quantities/.

Solick, D. I., and C. M. Newman. 2021. Oceanic records of North American bats and implications for offshore wind energy development in the United States. Ecology and Evolution 11(21):14433–14447.

Spyrka, A. 2017. Change in Marine Debris in the Santa Barbara Channel: An Environmental Science and Resource Management Capstone Project. B.S. Thesis. California State University Channel Islands.

Stallinga, P. 2018. Signal Analysis of the Climate: Correlation, Delay and Feedback. Journal of Data Analysis and Information Processing 06(02):30–45.

Starcrest Consulting Group. 2023. Air Emissions Benefit of Vessel Speed Reduction During Enhancing Cetacean Habitat and Observation (ECHO) Program. Prepared for Vancouver Fraser Port Authority, March 2023.

Steele, C. L. W., and M. R. Miller. 2022. Temporal trends in anthropogenic marine macro-debris and micro-debris accumulation on the California Channel Islands. Frontiers in Marine Science 9:905969.

Steinberger, J., S. R. Daniels, N. Hagberg, C. R. Isasi, A. S. Kelly, D. Lloyd-Jones, R. R. Pate, C. Pratt, C. M. Shay, J. A. Towbin, E. Urbina, L. V. Van Horn, and J. P. Zachariah. 2016. Cardiovascular Health Promotion in Children: Challenges and Opportunities for 2020 and Beyond: A Scientific Statement From the American Heart Association. Circulation 134(12).

Stelzenmüller, V., A. Gimpel, M. Gopnik, and K. Gee. 2017. Aquaculture site-selection and marine spatial planning: the roles of GIS-based tools and models. In: Buck B, Langan R, editors. Aquaculture perspective of multi-use sites in the open ocean. Cham (Switzlerland): Springer. p. 131-148.

Stenton-Dozey, J., and N. Broekhuizen. 2019. Provision of Ecological and Ecosystem Services by Mussel Farming in the Marlborough Sounds: A Literature Review in Context of the State of the Environment

Pre-and Post-Mussel Farming. Prepared for Marine Farming Association, National Institute of Water & Atmospheric Research, Christchurch.

Sternfield, M. 2024. KTLA News, Experts stunned by Southern California's new killer whales webpage. Accessed January 24, 2024. Available at: ktla.com/news/local-news/a-month-later-southern-californias-killer-whales-are-still-hanging-around/.

Stevens, C., D. Plew, N. Hartstein, and D. Fredriksson. 2008. The physics of open-water shellfish aquaculture. Aquacultural Engineering 38(3):145–160.

Stierhoff, K. L., J. P. Zwolinski, and D. A. Demer. 2019. Distribution, biomass, and demography of coastal pelagic fishes in the California Current Ecosystem during summer 2018 based on acoustic-trawl sampling. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-SWFSC-613. 83 pp.

Stone, J. K., and L. Moro. 2022. Occupational noise exposure in Canada's salmonid aquaculture industry. Aquaculture 550:737831.

Strange, E. L. 2016. Assessing Southern Resident Killer Whale (Orcinus orca) Prey Abundance: The Effects of Chinook Salmon (Oncorhynchus tshawystcha) Ocean Fishery Reductions and Related Hatchery Production. M.S. Thesis. California State University, Sacramento, CA. Retrieved from: http://hdl.handle.net/10211.3/171230.

Straughan, D., D. Dalby, D. Crisp, J. Baker, A. Southward, A. McIntyre, and J. Vandermeulen. 1982. Observations on the Effects of Natural Oil Seeps in the Coal Oil Point Area [and Discussion]. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences. 297(1087):269–283.

Sudirman, H. Halide, J. Jompa, Zulfikar, Iswahyudin, and A. D. McKinnon. 2009. Wild fish associated with tropical sea cage aquaculture in South Sulawesi, Indonesia. Aquaculture 286(3–4):233–239.

Sultana, F., M. A. Wahab, M. Nahiduzzaman, M. Mohiuddin, M. Z. Iqbal, A. Shakil, A.-A. Mamun, M. S. R. Khan, L. Wong, and M. Asaduzzaman. 2023. Seaweed farming for food and nutritional security, climate change mitigation and adaptation, and women empowerment: A review. Aquaculture and Fisheries 8(5):463–480.

Sun, K., J. Zhang, F. Lin, J. S. Ren, Y. Zhao, W. Wu, and Y. Liu. 2020. Evaluating the influences of integrated culture on pelagic ecosystem by a numerical approach: A case study of Sungo Bay, China. Ecological Modelling 415:108860.

Sun, X., R. Filgueira, N. Wang, T. Guyondet, J. Dong, and X. Zhang. 2023. Assessing shellfish farming-mediated benthic impacts based on organic carbon flux simulation and composition of macrofaunal community. Science of The Total Environment 861:160598.

Sunny, R. C., D. W. Fredriksson, I. Tsukrov, L. Zhu, M. Bowden, M. Chambers, and B. Silkes. 2023. Design considerations for a continuous mussel farm in New England Offshore waters. Part II: Using validated numerical models to estimate the probability of failure. Unpublished Draft.

Sunny, R. C., D. W. Fredriksson, I. Tsukrov, L. Zhu, M. Bowden, M. Chambers, and B. Silkes. 2024. Design considerations for a continuous mussel farm in New England Offshore waters. Part I: Development of environmental conditions for engineering design. Aquacultural Engineering 107:102476.

Suter, J., R. Ames, B. Holycross, and J. Watson. 2021. Observing unobserved fishing characteristics in the drift gillnet fishery for swordfish. U.S. Dept. of Commerce, NMFS, Agenda Item F.1.a., NMFS Report 2. Available at: https://www.pcouncil.org/documents/2021/06/f-1-a-nmfs-report-2-observing-unobserved-fishing-characteristics-in-the-drift-gillnet-fishery-for-swordfish.pdf/.

Swartz, S. L. 1986. Gray Whale Migratory, Social and Breeding Behavior. Rep. Int. Whal. Commn. Special Issue 8.:207-229.

Swartz, S. L., and M. L. Jones. 2016. Gray Whale (Eschrichtius robustus, Lilljeborg 1861). Marine Mammal Encyclopedia 3rd Edition Published by Academic Press, Inc. Laguna San Ignacio Ecosystem Science Program, Darnestown, Maryland, USA.

SWRCB. 2017. California State Water Resources Control board - Public water supply systems webpage. Accessed March 26, . Available at https://www.waterboards.ca.gov/about_us/performance_report_1516/regulate/25111_ddw_comm_inspections.shtml.

SWRCB. 2021. State Water Resources Control Board, Areas of Special Biologicial Significance webpage. Accessed February 15, 2024. Available at: waterboards.ca.gov/water_issues/programs/ocean/asbs.html.

SWRCB. 2024. State Water Resources Control Board, 2024 California Integrated Report webpage. Accessed February 15, 2024. Available at: waterboards.ca.gov/water_issues/programs/water_quality_assessment/2024_integrated_report.html.

Sydeman, W. J., S. A. Thompson, J. A. Santora, J. A. Koslow, R. Goericke, and M. D. Ohman. 2015. Climate–ecosystem change off southern California: Time-dependent seabird predator–prey numerical responses. Deep Sea Research Part II: Topical Studies in Oceanography 112:158–170.

Syed, Z. 2023. Sierra Club, New restrictions seek to separate ships from whales webpage. Accessed March 4, 2024. Available at: sierraclub.org/sierra/new-restrictions-seek-separate-ships-whales.

Szymkowiak, M., and M. Rhodes-Reese. 2020. Addressing the Gender Gap: Using Quantitative and Qualitative Methods to Illuminate Women's Fisheries Participation. Frontiers in Marine Science 7:299.

Tajalli Bakhsh, T., K. Simpson, T. LaPierre, K. Ware, and M. Spaulding. 2023. Geohazard Analysis and Suitability Update for Offshore California Wind Farms. Kingstown, RI: U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2023-040. 71 p. Contract No: 140M0121F0009.

Talsness, C. E., A. J. M. Andrade, S. N. Kuriyama, J. A. Taylor, and F. S. Vom Saal. 2009. Components of plastic: experimental studies in animals and relevance for human health. Philosophical Transactions of the Royal Society B: Biological Sciences 364(1526):2079–2096.

Tan, K., P. Xu, L. Huang, C. Luo, J. Huang, H. Fazhan, and K. Y. Kwan. 2024. Effects of bivalve aquaculture on plankton and benthic community. Science of The Total Environment 914:169892.

Tang, Y., Y. Kang, D. L. Berry, and C. J. Gobler. 2014. The ability of the red macroalga, Porphyra purpurea (Rhodophyceae) to inhibit the proliferation of seven common harmful microalgae. J. Appl. Phycol. 27 (1), 531–544. https://doi.org/10.1007/ s10811-014-0338-y.

Tegner, M. J., and P. K. Dayton. 2000. Ecosystem effects of fishing in kelp forest communities. ICES Journal of Marine Science 57(3):579–589.

Tendall, D. M., J. Joerin, B. Kopainsky, P. Edwards, A. Shreck, Q. B. Le, P. Kruetli, M. Grant, and J. Six. 2015. Food system resilience: Defining the concept. Global Food Security 6:17–23.

Theuerkauf, S. J., L. T. Barrett, H. K. Alleway, B. A. Costa-Pierce, A. St. Gelais, and R. C. Jones. 2021. Habitat value of bivalve shellfish and seaweed aquaculture for fish and invertebrates: Pathways, synthesis and next steps. Reviews in Aquaculture 14(1):54–72.

Theuerkauf, S. J., V. Crothers, and J. A. Jr. Morris. 2019. Ventura Shellfish Enterprise: Aquaculture Siting Analysis Results. U.S. Dept. of Commerce, NCCOS, National Ocean Service. Coastal Aquaculture Siting and Sustainability Technical Report, Revised Feb. 2019.

Thompson, A. R., E. P. Bjorkstedt, S. J. Bograd, J. L. Fisher, E. L. Hazen, A. Leising, J. A. Santora, E. V. Satterthwaite, W. J. Sydeman, M. Alksne, T. D. Auth, S. Baumann-Pickering, N. M. Bowlin, B. J. Burke,

E. A. Daly, H. Dewar, J. C. Field, N. T. Garfield, A. Giddings, R. Goericke, J. Hildebrand, C. A. Horton, K. C. Jacobson, M. G. Jacox, J. Jahncke, M. Johns, J. Jones, R. M. Kudela, S. R. Melin, C. A. Morgan, C. F. Nickels, R. A. Orben, J. M. Porquez, E. J. Portner, A. Preti, R. R. Robertson, D. L. Rudnick, K. M. Sakuma, I. D. Schroeder, O. E. Snodgrass, S. A. Thompson, J. S. Trickey, P. Warzybok, W. Watson, and E. D. Weber. 2022. State of the California Current Ecosystem in 2021: Winter is coming? Frontiers in Marine Science 9:958727.

Thompson, P. L., J. Nephin, S. C. Davies, A. E. Park, D. A. Lyons, C. N. Rooper, M. A. Peña, J. R. Christian, K. L. Hunter, E. Rubidge, and A. M. Holdsworth. 2023. Groundfish biodiversity change in northeastern Pacific waters under projected warming and deoxygenation. Philosophical Transactions of the Royal Society B: Biological Sciences 378(20220191).

Thorstad, E., C. Todd, I. Uglem, P. Bjørn, P. Gargan, K. Vollset, E. Halttunen, S. Kålås, M. Berg, and B. Finstad. 2015. Effects of salmon lice Lepeophtheirus salmonis on wild sea trout Salmo trutta—a literature review. Aquaculture Environment Interactions 7(2):91–113.

Thums, M., S. D. Whiting, J. Reisser, K. L. Pendoley, C. B. Pattiaratchi, M. Proietti, Y. Hetzel, R. Fisher, and M. G. Meekan. 2016. Artificial light on water attracts turtle hatchlings during their near shore transit. Royal Society Open Science 3(5):160142.

Tičina, V., I. Katavić, and L. Grubišić. 2020. Marine Aquaculture Impacts on Marine Biota in Oligotrophic Environments of the Mediterranean Sea – A Review. Frontiers in Marine Science 7:217.

Tirado, M. C., R. Clarke, L. A. Jaykus, A. McQuatters-Gollop, and J. M. Frank. 2010. Climate change and food safety: A review. Food Research International 43(7):1745–1765.

Tissot, B. N., M. M. Yoklavich, M. S. Love, K. York, and M. Amend. 2006. Benthic invertebrates that form habitat on deep banks off southern California, with special reference to deep sea coral. Fishery Bulletin 104:167–181.

Tlusty, M. F., D. R. Fiore, and J. S. Goldstein. 2005. Use of formulated diets as replacements for Artemia in the rearing of juvenile American lobsters (Homarus americanus). Aquaculture 250(3–4):781–795.

TNC. 2021. Global Perspectives of Restorative Aquaculture. The Nature Conservancy. Arlington, VA.

TNC. 2022. Assessment of the Environmental Footprint of Forever Oceans Operations in Panama. Prepared by Global Aquaculture Program, The Nature Conservancy, and Tucker Consulting Services.

Tringali, M. D., and T. M. Bert. 1998. Risk to Genetic Effective Population Size should be an Important Consideration in Fish Stock-Enhancement Programs. Bulletin of Marine Science 62(2):641–659.

Troell, M., R. L. Naylor, M. Metian, M. Beveridge, P. H. Tyedmers, C. Folke, K. J. Arrow, S. Barrett, A.-S. Crépin, P. R. Ehrlich, Å. Gren, N. Kautsky, S. A. Levin, K. Nyborg, H. Österblom, S. Polasky, M. Scheffer, B. H. Walker, T. Xepapadeas, and A. De Zeeuw. 2014. Does aquaculture add resilience to the global food system? Proceedings of the National Academy of Sciences 111(37):13257–13263.

Troell, Max., C. Halling, A. Nilsson, A. H. Buschmann, N. Kautsky, and L. Kautsky. 1997. Integrated marine cultivation of Gracilaria chilensis (Gracilariales, Rhodophyta) and salmon cages for reduced environmental impact and increased economic output. Aquaculture 156(1–2):45–61.

Tubau, X., C. K. Paull, G. Lastras, D. W. Caress, M. Canals, E. Lundsten, K. Anderson, R. Gwiazda, and D. Amblas. 2015. Submarine canyons of Santa Monica Bay, Southern California: Variability in morphology and sedimentary processes. Marine Geology 365:61–79.

Tyner, M., L. J. Burnett, and M. M. Stake. 2013. California Condor Foraging on a Live California Sea Lion Pup. Western Birds 44:151–154.

UBC. 2009b. University of British Columbia. Indigenous Foundations - Global actions webpage. Accessed April 4, 2024. Available at: https://indigenousfoundations.arts.ubc.ca/global_actions/.

UBC. 2009a. University of British Columbia. Indigenous Foundations - Terminology webpage. Accessed April 4, 2024. Available at: https://indigenousfoundations.arts.ubc.ca/terminology/.

Underwood, L., and A. Jeffs. 2023. Settlement and recruitment of fish in mussel farms. Aquaculture Environment Interactions 15:85–100.

UNEP. 2009. Marine litter: a global challenge. Regional Seas, United Nations Environment Programme, Nairobi, Kenya.

UNEP. 2019. Frontiers 2018/19: Emerging issues of environmental concern. United Nations Environment Programme. Nairobi, Kenya.

UNESCO. 2024. State of the Ocean Report. Paris, IOC-UNESCO. (IOC Technical Series, 190). https://doi.org/10.25607/4wbg-d349.

Unuofin, J. O., and A. Igwaran. 2023. Microplastics in seafood: Implications for food security, safety, and human health. Journal of Sea Research 194:102410.

Upite, C., K. Murray, B. Stacy, L. Stokes, and S. Weeks. 2019. Mortality Rate Estimates for Sea Turtles in Mid-Atlantic and Northeast Fishing Gear, 2012-2017. Greater Atlantic Region Policy Series 19-03. NOAA Fisheries Greater Atlantic Regional Fisheries Office www.greateratlantic.fisheries.noaa.gov/policyseries/. 15p.

U.S. Census Bureau. 2022. Annual Estimates of the Resident Population for the United States, Regions, States, District of Columbia, and Puerto Rico: April 1, 2020 to July 1, 2022. U.S. Census Bureau, Polulation Division. Released December 2022. Available at: https://www.census.gov/data/tables/time-series/demo/popest/2020s-state-total.html.

U.S. Commission on Ocean Policy. 2004b. An Ocean Blueprint for the 21st Century. U.S. Commission on Ocean Policy, Final Report. Washington, DC. ISBN#0–9759462–0–X.

U.S. Commission on Ocean Policy. 2004a. Review of U.S. Ocean and Coastal Law: The Evolution of Ocean Governance Over Three Decades. U.S. Commission on Ocean Policy. Appendix 6 to An Ocean Blueprint for the 21st Century Final Report of the U.S. Commission on Ocean Policy Washington, D.C. ISBN#0–9759462–7–7.

U.S. Navy. 2013. Hawaii-Southern California Training and Testing Activities Final Environmental Impact Statement/ Overseas Environmental Impact Statement. U.S. Dept. of the Navy, HSTT EIS/OEIS Project Manager Naval Facilities Engineering Command, Pacific/EV21.CS. Pearl Harbor, HI. 1.

U.S. Navy. 2018. Hawaii-Southern California Training and Testing Activities Final Environmental Impact Statement/ Overseas Environmental Impact Statement. U.S. Dept. of the Navy. Final October 2018, Volume 1. Available at: https://www.nepa.navy.mil/hstt/.

U.S. Ocean Policy Committee. 2023. Ocean Justice Strategy: A report by the Ocean Policy Committee. Washington, D.C. Available at: https://www.whitehouse.gov/wp-content/uploads/2023/12/Ocean-Justice-Strategy.pdf?cb=1701982354.

USACE. 2012. Memorandum for Record, KZO Sea Farms. Department of the Army Environmental Assessment and Statement of Finding. CESPL-RG. Application: SPL-2012-00042-DPS.

USCG. 2012. Coast Guard-AWO Safety Partnership Quality Action Team On Reducing Fall-Overboard Crew Fatalities. U.S. Coast Guard partnered with The American Waterways Operators, April 2012. Available at: https://www.americanwaterways.com/sites/default/files/falloverboardqatreportapril2012.pdf.

USCG. 2015. Vessel biofouling prevention and management options report. U.S. Coast Guard Acquisition Directorate, Research and Development Center. Report No. CG-D-15-15. Published March 2015. Available at: https://apps.dtic.mil/sti/tr/pdf/ADA626612.pdf.

USCG. 2016. National Search and Rescue Plan of the United States. U.S. Dept. of Homeland Security, U.S. Coast Guard. Available at: https://www.dco.uscg.mil/portals/9/cg-5r/manuals/national_sar_plan_2016.pdf.

USCG. 2018. Ballast Water Management for Control of Non-indigenous Species in Waters of the United States. U.S. Dept. of Homeland Security, U.S. Coast Guard. COMDTPUB P16700.4, NVIC 01-18. Available at: https://www.dco.uscg.mil/Portals/9/DCO%20Documents/5p/5ps/NVIC/2018/NVIC-01_18.pdf.

USCG. 2020. Standards of Training, Certification, and Watchkeeping (STCW): History, Implementation, and Structure. U.S. Dept. of Homeland Security, U.S. Coast Guard. National Maritime Center. Available at: https://www.dco.uscg.mil/Portals/9/NMC/pdfs/stcw/stcw_history_implementation_and_structure.pdf.

USCG. 2023. Pacific Coast Port Access Route Study. U.S. Dept. of Homeland Security, U.S. Coast Guard. PAC-PARS Workgroup. Docket Number USCG-2021-0345. Available at: https://www.navcen.uscg.gov/port-access-route-study-reports.

USCG. 2024. Local Notice to Mariners. U.S. Dept. of Homeland Security, U.S. Coast Guard. LNM District 11, Week: 22/24.

USDA. 2014. 2012 Census of Agriculture: Census of Aquaculture (2013). Volume 3. Special Studies, Part 2. AC-12-SS-2. U.S. Department of Agriculture.

USDA. 2019. 2017 Census of Agriculture Highlights: Aquaculture - Results from the 2018 Census of Aquaculture. U.S. Dept. of Agriculture, National Agriculture Statistics Service. Available at: https://www.nass.usda.gov/Publications/Highlights/2019/2017Census_Aquaculture_in_2018.pdf.

USDA. 2020. Aquaculture is Agriculture Colloquium. USDA's Role in Supporting Farmers of Fish, Shellfish, and Aquatic Plants. U.S. Department of Agriculture. December, 2020.

USDA. 2021. National Aquaculture Health Plan & Standards, 2021-2023. U.S. Department of Agriculture, Animal and Plant Health Inspection Service. Available at: https://www.aphis.usda.gov/sites/default/files/national-aquacult-health-plan-standards-2021-2023_10.pdf.

USDA. 2023. Licensing and Registration Under the Animal Welfare Act: Guidelines for Deales, Exhibitors, Transporters, and Researchers. U.S. Dept. of Agriculture, Animal and Plant Health Inspection Service. Available at: https://www.aphis.usda.gov/sites/default/files/graybook.pdf.

USDA. 2024. USDA Animal and Plant Health Inspection Service, Laws and Regulations website. Accessed June 12, 2024. Available at: aphis.usda.gov/laws-regs.

USFS. 2022. Migratory Bird Treaty Act at the Project Level in the Intermountain Region Executive Order 13186, Unintentional Take, and Mitigation. U.S. Dept. of Agriculture, U.S. Forest Service, Intermountain Regional Office.

USFWS. 2000. U.S. Fish and Wildlife Service, Waterbird bycatch policy statement and task force formation memo webpage. Accessed January 30, 2024. Available at: fws.gov/policy/library/m0091.html.

USFWS. 2005. Regional Seabird Conservation Plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region, Portland, Oregon.

USFWS. 2007. Recovery Plan for the Pacific Coast Population of the Western Snowy Plover (Charadrius alexandrinus nivosus). In 2 volumes. Sacramento, California. xiv + 751 pages.

USFWS. 2021. Birds of Conservation Concern 2021: Migratory Bird Program. United States Department of the Interior, U.S. Fish and Wildlife Service, Migratory Birds, Falls Church, Virginia. Available at: http://www.fws.gov/birds/management/ managed-species/birds-of-conservation-concern.php.

USFWS. 2022. Feasibility Assessment: Sea Otter Reintroduction to the Pacific Coast. Report to Congress prepared by the U.S. Fish and Wildlife Service, Region 9, Portland, Oregon; and Region 10, Sacramento, California.

USFWS. n.d.b. Short tailed albatross (Phoebastria albatrus) webpage. Accessed March 14, 2024. U.S. Fish and Wildlife Service. Available at: https://www.fws.gov/species/short-tailed-albatross-phoebastria-albatrus.

USFWS. n.d. U.S. Fish and Wildlife Service, California condor webpage. Accessed July 1, 2024. Available at: fws.gov/species/california-condor-gymnogyps-californianus.

USGCRP. 2013. U.S. Global Change Research Program - Principal ports for the United States of America as of 2013 webpage. Accessed March 26, 2024. Available at: https://data.globalchange.gov/dataset/noaa-coast-msp-principal-ports.

USGS. 2003. Supporting Sound Management of Our Coasts and Seas. Tracking Contaminants in Santa Monica Bay, Offshore of Greater Los Angeles. U.S. Dept. of the Interior, U.S. Geological Survey. USGS Fact Sheet 155-02. Available at: https://pubs.usgs.gov/publication/fs15502.

Valderrama, D., and J. L. Anderson. 2010. Market interactions between aquaculture and common-property fisheries: Recent evidence from the Bristol Bay sockeye salmon fishery in Alaska. Journal of Environmental Economics and Management 59(2):115–128.

Van Berkel, J., H. Burchard, A. Christensen, L. Mortensen, O. Petersen, and F. Thomsen. 2020. The Effects of Offshore Wind Farms on Hydrodynamics and Implications for Fishes. Oceanography 33(4):108–117.

Veit, R., P. Pyle, and J. McGowan. 1996. Ocean warming and long-term change in pelagic bird abundance within the California current system. Marine Ecology Progress Series 139:11–18.

Verutes, G. M., A. F. Johnson, M. Caillat, L. S. Ponnampalam, C. Peter, L. Vu, C. Junchompoo, R. L. Lewison, and E. M. Hines. 2020. Using GIS and stakeholder involvement to innovate marine mammal bycatch risk assessment in data-limited fisheries. PLOS ONE 15(8):e0237835.

Vetter, R. D., H. G. Moser, W. Watson, G. R. Cochrane, N. Nasby, C. Taylor, and R. Cosgrove. 2003. Egg and Larval Fish Production from Marine Ecological Reserves.

Vita, R., A. Marín, J. Madrid, B. Jiménez-Brinquis, A. Cesar, and L. Marín-Guirao. 2004. Effects of wild fishes on waste exportation from a Mediterranean fish farm. Marine Ecology Progress Series 277:253–261.

Vizek, A., M. Van Oostenburg, and S. Russell. 2020. The transition to catch shares management in the West Coast groundfish trawl fishery: Changing job attitudes and adjusting fishing participation plans. Soc. Nat. Resour., 33(10):1175-1193. https://doi.org/10.1080/08941920.2020.1777491.

Von Thenen, M., H. S. Hansen, and K. S. Schiele. 2021. A generalised marine planning framework for site selection based on ecosystem services. Marine Policy 124:104326.

VPD. 2018. Biological Assessment for the Ventura Shellfish Enterprise Project. Prepared by Dudek, Santa Barbara, California for the Ventura Port District. Dudek No. 9250.

VPD. 2020. Aquaculture Navigation Risk Assessment. Ventura Shellfish Enterprise, Ventura, CA. Prepared by COWI (Oakland, CA) for the Ventura Port District. Document No. A133628-001. Available at: venturaharbor.com/vse-archive/.

VSE. 2017. Ventura port district impacts public workshop presentation. Available at: https://venturaharbor.com/vse-archive/.

Walag, A. M. P. 2022. Ecology and Biodiversity of Benthos: Chapter 1 - Understanding the World of benthos: an introduction to benthology. Elsevier pp 1-19. https://doi.org/10.1016/B978-0-12-821161-8.00002-7.

Waldbusser, G. G., B. Hales, C. J. Langdon, B. A. Haley, P. Schrader, E. L. Brunner, M. W. Gray, C. A. Miller, and I. Gimenez. 2015. Saturation-state sensitivity of marine bivalve larvae to ocean acidification. Nature Climate Change 5(3):273–280.

Walker, J., and G. Beachley. 2019. Evolution of monitoring and modeling of reactive nitrogen deposition in the U.S. U.S. Environmental Protection Agency, Office of Research and Development, Durham, NC; Office of Air and Radiation, Washington, DC.

Wang, Z. 2022. Influence of Climate Change On Marine Species and Its Solutions. IOP Conference Series: Earth and Environmental Science 1011(1):012053.

Waples, R., K. Hindar, and J. Hard. 2012. Genetic Risks Associated with Marine Aquaculture. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-119, 149 p.

Waples, R. S., K. Hindar, S. Karlsson, and J. J. Hard. 2016. Evaluating the Ryman–Laikre effect for marine stock enhancement and aquaculture. Current Zoology 62(6):617–627.

Warlick, A. J., J. L. Huggins, D. M. Lambourn, D. A. Duffield, D. N. D'Alessandro, J. M. Rice, J. Calambokidis, M. B. Hanson, J. K. Gaydos, S. J. Jeffries, J. K. Olson, J. J. Scordino, A. M. Akmajian, M. Klope, S. Berta, S. Dubpernell, B. Carlson, S. Riemer, J. Hodder, V. Souze, A. Elsby, C. King, K. Wilkinson, T. Boothe, and S. A. Norman. 2022. Cetacean Strandings in the US Pacific Northwest 2000–2019 Reveal Potential Linkages to Oceanographic Variability. Frontiers in Marine Science 9:758812.

Warwick, C., P. C. Arena, and C. Steedman. 2013. Health implications associated with exposure to farmed and wild sea turtles. JRSM Short Reports 4(1):1–7.

Washburn, L., B. M. Emery, and J. D. Paduan. 2002. The surface circulation of the Santa Barbara Channel as observed with high frequency radar.

Waterhouse, P. 2024. NPR, A family of 10 orcas has been spotted swimming between Oxnard and San Diego webpage. Accessed January 24, 2024. Available at: https://www.npr.org/2024/01/05/1223036551/a-family-of-10-orcas-has-been-spotted-swimming-between-oxnard-and-san-diego.

Webb, S. J. 2014. Establishment, Immortalization and Toxicological Applications of Primary Skin Fibroblasts from Three Sea Turtle Species. Doctoral Dissertation, Texas Tech University.

Webster, J. P., C. M. Gower, S. C. L. Knowles, D. H. Molyneux, and A. Fenton. 2015. One health – an ecological and evolutionary framework for tackling Neglected Zoonotic Diseases. Evolutionary Applications 9(2):313–333.

Weilgart, L. 2018. The impact of ocean noise pollution on fish and invertebrates. Report for OceanCare, Switzerland.

Weise, A. M., C. J. Cromey, M. D. Callier, P. Archambault, J. Chamberlain, and C. W. McKindsey. 2009. Shellfish-DEPOMOD: Modelling the biodeposition from suspended shellfish aquaculture and assessing benthic effects. Aquaculture 288(3–4):239–253.

Welch, A. W., A. N. Knapp, S. El Tourky, Z. Daughtery, G. Hitchcock, and D. Benetti. 2019. The nutrient footprint of a submerged-cage offshore aquaculture facility located in the tropical Caribbean. Journal of the World Aquaculture Society 50(2):299–316.

West Coast Ocean Tribal Caucus. 2020. Guidance and Responsibilities for Effective Tribal Consultation, Communication, and Engagement: A Guide for Agencies Working with West Coast Tribes on Ocean & Coastal Issues. West Coast Tribal Caucus of the West Coast Ocean Alliance.

WhaleSafe. 2022. WhaleSafe, 2022 year in review: a look back at whales and ships in the Santa Barbara Channel and San Francisco region webpage. Accessed March 4, 2024. Available at: whalesafe.com/2022-year-in-review-a-look-back-at-whales-ships-in-the-santa-barbara-channel-san-francisco-region/.

Whitaker, S. G., D. R. Fong, J. Neiva, E. A. Serrão, L. M. Anderson, and P. T. Raimondi. 2017. Distribution and Genetic Structure of Fucus distichus Linnaeus 1953 (formerly F. gardneri) within Central San Francisco Bay. San Francisco Estuary and Watershed Science 15(3).

Whitmire, C. E., and M. E. Clarke. 2007. State of deep coral ecosystems of the US Pacific Coast: California to Washington. The State of Deep Coral Ecosystems of the United States NOAA Technical Memorandum CRCP-3:109–154.

Wiemeyer, S. N., C. M. Bunck, and C. J. Stafford. 1993. Environmental contaminants in bald eagle eggs 1980-1984 and further interpretations of relationships to productivity and shell thickness. Archives of Environmental Contamination and Toxicology 24, 213-227.

Wilhelmsson, D., and O. Langhamer. 2014. The influence of fisheries exclusion and addition of hard substrate on fish and crustaceans. p. 49–60 in M. A. Shields and A. I. L. Payne (Eds), Marine Renewable Energy Technology and Environmental Interactions. Springer, New York, New York.

Winn, J. P., B. L. Woodward, M. J. Moore, M. L. Peterson, and J. G. Riley. 2008. Modeling whale entanglement injuries: An experimental study of tissue compliance, line tension, and draw-length. Marine Mammal Science 24(2):326–340.

Wishtoyo Chumash Foundation. 2022. Wishtoyo Chumash Foundation, Chumash history webpage. Accessed June 3, 2024. Available at: https://www.wishtoyo.org/history.

World Bank. 2023. Global Seaweed: New and Emerging Markets Report, 2023. Washington, DC: World Bank. http://hdl.handle.net/10986/40187 License: CC BY-NC 3.0 IGO.

World Bank Group. 2020. Women and trade: the role of trade in promoting women's equality webpage. Accessed June 11, 2024. Available at: https://www.worldbank.org/en/topic/trade/publication/women-and-trade-the-role-of-trade-in-promoting-womens-equality.

World Ocean Initiative. 2022. Economist Impact, valuing women in the blue economy for International Women's Day webpage. Accessed June 11, 2024. Available at: https://impact.economist.com/ocean/sustainable-ocean-economy/valuing-women-in-the-blue-economy-for-international-womens-day.

Wright. 2020. Economic and Fiscal Impacts of the Ventura Shellfish Enterprise Project. Illuminas Consulting, California. November 13, 2020 Memorandum. Available at: https://venturaharbor.com.

Würsig, B., and G. A. Gailey. 2002. Marine mammals and aquaculture: conflicts and potential resolutions. Pages 45–59 *in* R. R. Stickney and J. P. McVey, editors. Responsible marine aquaculture, 1st edition. CABI Publishing, UK.

Wysocki, L. E., J. W. Davidson, M. E. Smith, A. S. Frankel, W. T. Ellison, P. M. Mazik, A. N. Popper, and J. Bebak. 2007. Effects of aquaculture production noise on hearing, growth, and disease resistance of rainbow trout Oncorhynchus mykiss. Aquaculture 272(1–4):687–697.

Xiao, X., S. Agustí, Y. Yu, Y. Huang, W. Chen, J. Hu, C. Li, K. Li, F. Wei, Y. Lu, C. Xu, Z. Chen, S. Liu, J. Zeng, J. Wu, and C. M. Duarte. 2021. Seaweed farms provide refugia from ocean acidification. Science of The Total Environment 776:145192.

Yeh, S.-W., J.-S. Kug, B. Dewitte, M.-H. Kwon, B. P. Kirtman, and F.-F. Jin. 2009. El Niño in a changing climate. Nature 461(7263):511–514.

Young, G. 2023. Today's Farmed Fish, Graham Young, Executive Director at the U.S. Western Regional Aquaculture Center webpage. Accessed May 3, 2024. Available at: todaysfarmedfish.org/insider-insights/graham-young-executive-director-at-the-us-western-regional-aquaculture-center.

Young, M. O. 2015. Marine animal entanglements in mussel aquaculture gear. Documented cases from mussel farming regions of the world including first-hand accounts from Iceland. M.S. Thesis. University Centre of the Westfjords, Suðurgata 12, 400 Ísafjörður, Iceland.

Yousavich, D. J., D. Robinson, X. Peng, S. J. E. Krause, F. Wenzhöfer, F. Janssen, N. Liu, J. Tarn, F. Kinnaman, D. L. Valentine, and T. Treude. 2024. Marine anoxia initiates giant sulfur-oxidizing bacterial mat proliferation and associated changes in benthic nitrogen, sulfur, and iron cycling in the Santa Barbara Basin, California Borderland. Biogeosciences 21(3):789–809.

Zeise, L., and J. Blumenfeld. 2021. CalEnviroScreen 4.0. California Environmental Protection Agency and Office of Environmental Health Hazard Assessment. Available at: https://oehha.ca.gov/media/downloads/calenviroscreen/report/calenviroscreen40reportf2021.pdf.

Zeldovich, L. 2019. JSTOR Daily, Is plastic pollution depriving us of oxygen? webpage. Accessed July 23, 2024. Available at: daily.jstor.org/is-plastic-pollution-depriving-us-of-oxygen/.

Zhang, J., X. Zhang, Y. Zhou, Q. Han, X. Wang, C. Song, S. Wang, and S. Zhao. 2023. Occurrence, distribution and risk assessment of antibiotics at various aquaculture stages in typical aquaculture areas surrounding the Yellow Sea. Journal of Environmental Sciences 126:621–632.

ZoBell, V. M., K. E. Frasier, J. A. Morten, S. P. Hastings, L. E. Peavey Reeves, S. M. Wiggins, and J. A. Hildebrand. 2021. Underwater noise mitigation in the Santa Barbara Channel through incentive-based vessel speed reduction. Scientific Reports 11(1):18391.

ZoBell, V. M., J. A. Hildebrand, and K. E. Frasier. 2024. Comparing pre-industrial and modern ocean noise levels in the Santa Barbara Channel. Marine Pollution Bulletin 202:116379.

Zuercher, R., and A. W. E. Galloway. 2019. Coastal marine ecosystem connectivity: pelagic ocean to kelp forest subsidies. Ecosphere 10(2):e02602.

Tables

Table 5: Federally-Protected Species with Potential to Occur in the AOA Alternative Areas

A. Mysticetes (baleen whales)

Table 5-A1: Protected Mysticete Status

Species/Stock	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
Blue Whale (Balaenoptera musculus) Eastern North Pacific Stock	FE, MMPA	Not designated	Historic whaling, entanglement, vessel strikes	Loss of prey base due to oceanographic changes, anthropogenic noise, entanglement	Mexico/Central America to Gulf of AK	Winter
Fin Whale (Balaenoptera physalus) California-Oregon-Washington Stock	FE, MMPA	Not designated	Historic whaling, entanglement, vessel strikes	Changes in prey distribution and navigational/migratory cues due to oceanographic changes, anthropogenic noise, entanglement	Possibly Baja California, Mexico to Gulf of AK; stock may migrate seasonally, but could be resident population in southern CA	Winter

Species/Stock	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
Humpback Whale (Megaptera novaeangliae) Central America DPS Central America / Southern Mexico and California-Oregon-Washington Stocks	FE, MMPA	48,521 sq. nm of marine habitat in the North Pacific within the portions of the CA Current Ecosystem off the coasts of WA, OR, and CA	Historic whaling, entanglement, vessel strikes, harassment, anthropogenic noise	Changes in navigational/migratory cues and prey distribution due to oceanographic changes, entanglement, increased risk of vessel strikes and/or harassment	Central America to southern British Columbia	Winter
Humpback Whale (Megaptera novaeangliae) Mexico DPS Mainland Mexico and California-Oregon-Washington Stocks	FT, MMPA	116,098 sq. nm of marine habitat in the North Pacific including areas in the eastern Bering Sea, Gulf of AK, and CA Current Ecosystem	Historic whaling, entanglement, vessel strikes, harassment, anthropogenic noise	Changes in navigational/migratory cues and prey distribution due to oceanographic changes, entanglement, increased risk of vessel strikes and/or harassment	Pacific coast of Mexico to the Aleutian Islands	Winter
Gray Whale (Eschrichtius robustus) Eastern North Pacific Stock	MMPA	N/A	Historic whaling, entanglement, vessel strikes, anthropogenic noise	Altered prey distribution and navigational cue disruption from melting sea ice/oceanographic changes, habitat impacts, ocean noise, vessel strikes, pollution	Pacific coast of Mexico to the Northern Bering and Chukchi Seas	Winter

Species/Stock	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
Gray Whale (Eschrichtius robustus) Western North Pacific Stock	FE, MMPA	Not designated	Historic whaling, entanglement, vessel strikes, anthropogenic noise, habitat degradation from oil and gas development	Changes in navigational/migratory cues and prey distribution due to oceanographic changes, habitat impacts, ocean noise, vessel strikes, oil and gas development, pipeline infrastructure	East coast of Asia from China to the eastern coast of Russia	Winter
Minke Whale (Balaenoptera acutorostrata) California-Oregon-Washington Stock	MMPA	N/A	Historic and current whaling, entanglement, vessel strikes, anthropogenic noise, hunting	Changes in navigational cues and prey distribution due to oceanographic changes, entanglement, increased risk of vessel strikes and harassment, biotoxins from harmful algal blooms	Stock seems to establish home ranges; present in CA year-round	Winter
North Pacific Right Whale (*Eubalaena japonica*) Eastern North Pacific Stock	FE, MMPA	36,800 sq. miles of marine habitat in the Gulf of AK and southeast Bering Sea	Historic whaling, entanglement, vessel strikes, anthropogenic noise	Prey distribution changes and loss of critical habitat, biotoxins from harmful algal blooms, oil and gas development, entanglement, vessel strikes, ocean noise	Baja California, Mexico to the Bering Sea	Winter
Sei Whale (Balaenoptera borealis) Eastern North Pacific Stock	FE, MMPA	Not designated	Historic whaling, entanglement, vessel strikes	Changes in prey distribution and navigational/foraging cues due to oceanographic changes, ocean noise, entanglement	WA-OR-CA; very rare any further south than CA	Winter

Table 5-A2: Protected Mysticete Potential to Occur in AOAs

Species/Stock	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
Blue Whale (Balaenoptera musculus) Eastern North Pacific Stock	Krill	Winters off Mexico/Central America; Summer feeding off U.S. west coast (i.e. Channel Islands, Southern CA waters); Calving grounds in Gulf of CA; Migrate seasonally from summer feeding and winter breeding grounds	Filter feeding in productive areas	June-December	N/A	Somewh at Likely	Somewh at Likely	Somewh at Likely
Fin Whale (Balaenoptera physalus) California-Oregon-Washington Stock	Krill, small schooling fish, squid	Typically found in deep, offshore waters; Location of winter breeding grounds unknown; Summer feeding near poles; Tropical/subtropical calving mid-winter	Filter feeder, feeds in large, mixed species groups	Summer/Fall but potentially year-round	N/A	Somewh at Likely	Somewh at Likely	Somewh at Likely
Humpback Whale (*Megaptera novaeangliae*) Central America DPS Central America / Southern Mexico and California-Oregon-Washington Stocks	Krill, other crustaceans, small fish	Winter breeding off Central America/Southern coastal Mexico; Summers feeding off U.S. west coast including CA, OR, and WA	Filter feeding, group bubble net feeding, often nearshore and potentially near aquaculture gear	Summer	N/A	Likely	Likely	Likely

Species/Stock	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
Humpback Whale (*Megaptera novaeangliae*) Mexico DPS Mainland Mexico and California-Oregon-Washington Stocks	Krill, other crustaceans, small fish	Winter breeding off Pacific coast of Mexico and Revillagigedo Islands; Transits the Baja California Peninsula; Spends summers feeding across broad range from CA to AK	Filter feeding, group bubble net feeding, often nearshore and potentially near aquaculture gear	Summer	N/A	Likely	Likely	Likely
Gray Whale (Eschrichtius robustus) Eastern North Pacific Stock	Benthic and epibenthic invertebrates	Summer feeding off U.S. west coast (from Bering and Chukchi Seas to Northern CA); Fall migration south along U.S. west coast; Winter breeding / calving off coast of Baja, Mexico; Spring migration north along U.S. west coast	Known for curiosity / approaching vessels, benthic feeders, solo travelers, possibly migrating closer to shore in SCB than previously thought	Unknown	N/A	Likely	Likely	Likely
Gray Whale (Eschrichtius robustus) Western North Pacific Stock	Benthic and epibenthic invertebrates	Primarily found along the coast of eastern Asia; Stocks were thought to be isolated but recent data shows that some whales likely migrate across the eastern Pacific	Known for curiosity / approaching vessels, benthic feeders, solo travelers	Unknown	N/A	Somewhat Likely	Somewhat Likely	Somewhat Likely

Species/Stock	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
Minke Whale (Balaenoptera acutorostrata) California-Oregon-Washington Stock	Crustaceans, plankton, small schooling fish	Can be found in coastal/inshore as well as oceanic/offshore areas; Likely non-migratory; Often seen over continental shelves	Active at surface, can approach vessels (esp. stationary), swim at high speeds, can be found in coastal areas	Year-round	N/A	Likely	Likely	Likely
North Pacific Right Whale (*Eubalaena japonica*) Eastern North Pacific Stock	Zooplankton (copepods, shrimp)	Migration unknown but thought to feed in summer in northern latitudes and migrate south to warmer waters in the winter (i.e. southern CA); Critical habitat in SE Bering Sea; Calving grounds not known in the eastern north Pacific; Most nursery grounds are in coastal waters	Skim feeding, very rarely sighted species	Migrates to warmer waters (i.e. southern CA) during winter	N/A	Unlikely	Unlikely	Unlikely
Sei Whale (Balaenoptera borealis) Eastern North Pacific Stock	Plankton, small schooling fish, cephalopods	Typically found far in deep, offshore waters in temperate seas (i.e. not associated with coastal areas); Breeding grounds unknown; Unpredictable distribution - can be found in an area and then not return for decades	Unpredictable behavior while foraging	Unknown	N/A	Unlikely	Unlikely	Unlikely

B. Odonotcetes (toothed whales, dolphins, and porpoises)

Table 5-B1: Protected Odontocete Status

Species/Stock	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
Sperm Whale (Physeter macrocephalus) California-Oregon-Washington Stock	FE, MMPA	Not designated	Historic whaling, entanglement	Vessel strikes, entanglement, anthropogenic noise, pollution: oil spills, contaminants, marine debris	Wide global distribution - this stock is WA-OR-CA	Spring and Summer
Baird's Beaked Whale (*Berardius bairdii*) California-Oregon-Washington Stock	MMPA	N/A	Historic whaling, entanglement, anthropogenic noise, marine debris, predation	Entanglement, consuming marine debris, anthropogenic noise	Pacific coast of Mexico to AK	Summer
Cuvier's Beaked Whale (Ziphius cavirostris) California-Oregon-Washington Stock	MMPA	N/A	Current whaling, entanglement, anthropogenic noise	Entanglement, anthropogenic noise	Baja California, Mexico to AK	Year-round, often during spring
Dwarf Sperm Whale (*Kogia sima*) California-Oregon-Washington Stock	MMPA	N/A	Entanglement, vessel strikes, marine debris	Increased vessel strikes, entanglement, consuming marine debris, anthropogenic noise, disease	Pacific Northwest and CA, limited data	December to March

Species/Stock	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
Killer Whale (Orcinus orca) West Coast Transient Stock	MMPA	N/A	Commercial whaling, entanglement, overfishing, habitat loss	Entanglement, anthropogenic noise, oil spills, contaminant pollution	AK to CA	No distinct season
Killer Whale (Orcinus orca) Eastern North Pacific Offshore Stock	MMPA	N/A	Commercial whaling, entanglement, overfishing, habitat loss	Entanglement, anthropogenic noise, oil spills, contaminant pollution	AK to CA	No distinct season
Short-Finned Pilot Whale (*Globicephala macrorhynchus*) California-Oregon-Washington Stock	MMPA	N/A	Current whaling, entanglement, vessel strikes	Increased vessel strikes, entanglement	WA to CA	Unknown
Pygmy Sperm Whale (*Kogia breviceps*) California-Oregon-Washington Stock	MMPA	N/A	Historic whaling, entanglement, vessel strikes, marine debris	Increased vessel strikes, entanglement, consuming marine debris, anthropogenic noise	Pacific Northwest and CA, limited data	Peaks in March-August

Species/Stock	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
Common Bottlenose Dolphin (Tursiops truncatus) California Coastal Stock	MMPA	N/A	Entanglement, habitat destruction and degradation, toxic algal blooms, harassment	Further habitat degradation, entanglement, pollution, anthropogenic noise	San Quintin, Mexico to Central CA	No distinct season
Common Bottlenose Dolphin (Tursiops truncatus) California-Oregon-Washington Offshore Stock	MMPA	N/A	Entanglement, habitat destruction and degradation, toxic algal blooms, harassment	Further habitat degradation, entanglement, pollution, anthropogenic noise	Baja, California, Mexico to WA	No distinct season
Long-Beaked Common Dolphin (*Delphinius capensis*) California Stock	MMPA	N/A	Current whaling, entanglement, toxic algal blooms, anthropogenic noise	Entanglement	Baja California, Mexico to Central CA	Spring to Fall
Short-Beaked Common Dolphin (*Delphinius delphis*) California-Oregon-Washington Stock	MMPA	N/A	Current whaling, entanglement	Entanglement	Southern coast of Mexico to WA	Spring and Fall

Species/Stock	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
Northern Right Whale Dolphin (Lissodelphis borealis) California-Oregon-Washington Stock	MMPA	N/A	Current whaling, entanglement, anthropogenic noise	Entanglement, increased anthropogenic noise	Northern Baja California, Mexico to Gulf of AK	Unknown
Risso's Dolphin (Grampus griseus) California-Oregon-Washington Stock	MMPA	N/A	Current whaling, entanglement, anthropogenic noise, pollution	Entanglement, increased risk of anthropogenic noise and contaminants	Baja California, Mexico to WA	Possibly year-round
Striped Dolphin (Stenella coeruleoalba) California-Oregon-Washington Stock	MMPA	N/A	Current whaling, entanglement, disease	Entanglement, pollution-disease vectors	Baja California, Mexico to OR	Unknown
Pacific White-Sided Dolphin (*Lagenorhynchus obliquidens*) California-Oregon-Washington, Northern, and Southern Stocks	MMPA	N/A	Entanglement, anthropogenic noise	Entanglement, anthropogenic noise	Southern CA to AK	Late Spring to Fall

Species/Stock	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
Dall's Porpoise (*Phocoenoides dalli*) California-Oregon-Washington Stock	MMPA	N/A	Current whaling, entanglement, anthropogenic noise, pollution	Entanglement, increased risk of anthropogenic noise and contaminants	Baja California, Mexico to Bering Sea	Early Spring and late Summer

Table 5-B2: Protected Odontocete Potential to Occur in AOAs

Species	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
Sperm Whale (Physeter macrocephalus) California-Oregon-Washington Stock	Deep water fish, squid, sharks, skates	Mostly occur in deep waters offshore; Migrations not predictable or well understood; Some populations appear to have adult males making long oceanic migrations w/ females and juveniles remaining in warm, tropical waters year-round	Feeding occurs in deep waters, surface logging between dives	Year-round, peak abundance April-June and August-November	N/A	Unlikely	Unlikely	Unlikely
Baird's Beaked Whale (*Berardius bairdii*) California-Oregon-Washington Stock	Fish, crustaceans, sea cukes, squid, octopus	Prefer cold, oceanic waters deeper than 3,300 feet but can occasionally be found nearshore along narrow continental shelves; Sightings are rare; Uncertain migration patterns	Surface logging between dives, sightings are rare	Late Spring to early Fall	N/A	Unlikely	Unlikely	Unlikely
Cuvier's Beaked Whale (*Ziphius cavirostris*) California-Oregon-Washington Stock	Cephalopods, fish, crustaceans	Temperate, subtropical, and tropical waters; Prefer deep pelagic (greater than 3,300 feet) waters; May favor current and current boundaries; Migration patterns unknown	Deep divers, rare displays at surface which hinders visibility	Unknown	N/A	Unlikely	Unlikely	Unlikely

Species	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
Dwarf Sperm Whale (*Kogia sima*) California-Oregon-Washington Stock	Cephalopods, fish, crustaceans	Deep waters and along continental slopes, in temperate and tropical seas; Movement patterns unknown	Echolocation, logging, no confirmed sightings on U.S. west coast	Unknown	N/A	Unlikely	Unlikely	Unlikely
Killer Whale (*Orcinus orca*) West Coast Transient Stock	Marine mammals, squid, fish	Both open seas and coastal waters; Their habitat can overlap with resident and offshore populations along the U.S. west coast	Coordinated group hunting, preying upon marine mammals in shallow waters	Unknown	N/A	Unlikely	Unlikely	Unlikely
Killer Whale (*Orcinus orca*) Eastern North Pacific Offshore Stock	Marine mammals, squid, fish	Often occur more than 9 miles offshore, though not exclusively offshore; Can be found in coastal nearshore waters and can overlap with other populations along U.S. west coast	Coordinated group hunting, preying upon marine mammals	Unknown	N/A	Unlikely	Unlikely	Unlikely
Short-Finned Pilot Whale (*Globicephala macrorhynchus*) California-Oregon-Washington Stock	Squid	Deep temperate and tropical waters; Can occur near continental shelf; No known movement patterns; There was a resident population near Santa Catalina Island prior to El Niño in 1982-83.	High speed dives chasing squid, travel and forage in large groups, can occur in abundant squid areas	Unknown	N/A	Unlikely	Unlikely	Unlikely

Species	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
Pygmy Sperm Whale (*Kogia breviceps*) California-Oregon-Washington Stock	Cephalopods, fish, crustaceans	Off coasts and along continental shelves in temperate, subtropical, and tropical seas; No information on movement patterns	Echolocation, logging at surface, rarely sighted along U.S. west coast	Unknown	N/A	Unlikely	Unlikely	Unlikely
Common Bottlenose Dolphin (*Tursiops truncatus*) California Coastal Stock	Fish, squid, crustaceans	Often found within 1 km of shore in coastal waters such harbors, bays, and estuaries; Oceanographic events may affect residency patterns	Shallow water coordinated group feeding, echolocation	Year-round	N/A	Likely	Likely	Likely
Common Bottlenose Dolphin (*Tursiops truncatus*) California-Oregon-Washington Offshore Stock	Fish, squid, crustaceans	Temperate and tropical waters; Have been found at distances greater than a few kilometers from the mainland and throughout the Southern California Bight	Coordinated group feeding, echolocation	Year-round	N/A	Somewhat Likely	Somewhat Likely	Somewhat Likely

Species	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
Long-Beaked Common Dolphin (*Delphinius capensis*) California Stock	Small schooling fish, krill, cephalopods	Shallow tropical, subtropical and warmer temperate waters; Within 50 to 100 nautical miles of the coast, and on the continental shelf.	Shallow water feeding	Year-round	N/A	Likely	Likely	Likely
Short-Beaked Common Dolphin (*Delphinius delphis*) California-Oregon-Washington Stock	Schooling fish, cephalopods	Warm tropical to cool temperate waters, primarily offshore; Associated w/ CA current and abundant off CA year-round from nearshore to 300 miles offshore	Night feeding, highly abundant off CA coast	Year-round	N/A	Likely	Likely	Likely
Northern Right Whale Dolphin (*Lissodelphis borealis*) California-Oregon-Washington Stock	Small fish, cephalopods	Temperate waters from outer continental shelf to oceanic regions between 30 and 50 degrees N; May occur closer to coast in deep waters with canyons; Migrate with water temperature	Travel in large groups, sometimes interact with vessel traffic	Fall and Winter	N/A	Likely	Likely	Likely

Species	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
Risso's Dolphin (Grampus griseus) California-Oregon-Washington Stock	Fish, krill, cephalopods	Tropical and warm temperate waters; Commonly seen on shelf in Southern California Bight, and in slope of CA, OR, and WA waters; Prefer deep waters but do inhabit coastal shelves	Night feeding especially in search of squid	Fall and Winter	N/A	Likely	Likely	Likely
Striped Dolphin (Stenella coeruleoalba) California-Oregon-Washington Stock	Fish, cephalopods	Prefer deep, oceanic, tropical to warm temperate waters; Mainly found seaward of continental shelf from 40 to 50 deg. N; Often linked to upwelling and convergent zones; No information on movement patterns	Active at surface, vessel avoidance	Unknown	N/A	Unlikely	Unlikely	Unlikely
Pacific White-Sided Dolphin (*Lagenorhynchus obliquidens*) California-Oregon-Washington, Northern, and Southern Stocks	Small schooling fish, squid	Open ocean and nearshore temperate waters; Primarily found in shelf and slope waters, unlikely to be found close to shore; North-south seasonality	Group feeding/fish herding	Fall and Winter	N/A	Unlikely	Unlikely	Unlikely

Species	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
Dall's Porpoise (*Phocoenoides dalli*) California-Oregon-Washington Stock	Small schooling fish, mid- and deep-water fish, cephalopods	Temperate to boreal waters; Found in shelf, slope, and offshore waters; Prefer depths greater than 600 feet; Migration patterns based on morphology, geography, seasonality, and oceanographic conditions	Night feeding, attracted to fast moving vessels, presumed to use echolocation	Winter	N/A	Unlikely	Unlikely	Unlikely

C. Pinnipeds (seals and sea lions)

Table 5-C1: Protected Pinniped Status

Species/Stock	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
CA Harbor Seal (*Phoca vitulina*) California Stock	MMPA	N/A	Entanglement, vessel strike, habitat degradation, pollution, illegal feeding	Entanglement, increased risk of harassment, vessel strikes, pollution, and habitat degradation	Pacific Coast of Mexico to AK	Spring and Summer
Northern Elephant Seal (*Mirounga angustirostris*)* California Breeding Stock	MMPA	N/A	Historic sealing, entanglement, vessel strikes	Entanglement, increased risk of vessel strikes	Southern CA to Gulf of AK	December - March
California Sea Lion (*Zalophus californianus*) United States Stock	MMPA	N/A	Entanglement, human harassment and mortality, toxic algal blooms	Entanglement, increased risk of harassment	Baja California, Mexico to southeast AK	June-August
Guadalupe Fur Seal (Arctocephalus townsendi) Mexico Stock	FT, MMPA ST	Not designated	Historic sealing, entanglement, anthropogenic noise, oil spills, military activity	Entanglement, increased risk of oil spills and ocean noise	Pacific coast of Mexico to southern CA (strandings as far north as WA)	May-August
Northern Fur Seal (*Callorhinus ursinus*) California Stock	MMPA	N/A	Historic sealing, entanglement, changes in prey distribution due to fisheries, predation	Entanglement, habitat degradation, possible climate change effects such as temperature changes, sea level rise, ocean acidification, and harmful algal blooms	Southern CA to the Bering Sea (CA stock refers to San Miguel and Farallon Islands populations)	June-August

Table 5-C2: Protected Pinniped Potential to Occur in AOAs

Species/Stock	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
CA Harbor Seal (*Phoca vitulina*) California Stock	Fish, shellfish, crustaceans	Temperate coastal habitats, typically stay near their natal area; Found widely on mainland and offshore-island hall out sites including sandbars, rocky shores, and beaches; Mostly non-migratory	Commonly haul out on human structures	Year-round	N/A	Likely	Likely	Likely
Northern Elephant Seal (*Mirounga angustirostris*) * California Breeding Stock	Squid, fish, sharks, rays	Breeding grounds in CA (San Miguel, Santa Rosa, Santa Barbara Islands); Males migrate to feed in Gulf of AK, females feed in the offshore waters of WA, OR, and AK; Adults return to land between March and August to molt, with males returning later than females; Adults return to feeding areas again between the spring / summer molt and winter breeding season	Winter breeding in SCB	December to March	N/A	Likely	Likely	Likely
California Sea Lion (*Zalophus californianus*) United States Stock	Fish, squid	Shallow waters of eastern north Pacific; Primary breeding range is from Channel Islands, CA to central Mexico; Males migrate north to feed as far as Southeast AK; Females stay near breeding grounds until pups are weaned; Females can be found feeding as far north as OR and WA	Take fish from commercial gear, rafting, haul out on human structures, pups left on shore while mother hunts	Year-round	N/A	Likely	Likely	Likely

Species/Stock	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
Guadalupe Fur Seal (Arctocephalus townsendi) Mexico Stock	Coastal and pelagic squid, small pelagic fish	Breeding grounds almost entirely on Guadalupe Island, Mexico, but small breeding populations off Baja California and San Miguel Island, CA	Immature pups can become stranded great distances from breeding grounds	Unknown	N/A	Unlikel y	Unlikely	Unlikely
Northern Fur Seal (*Callorhinus ursinus*) California Stock	Variety of midwater fish and squid	Highly pelagic, spend majority of time offshore; Use rocky or sandy beaches for resting, breeding, and molting	Nocturnal, aggressive during breeding	Possibly year-round	N/A	Unlikel y	Unlikely	Unlikely

D. Sea turtles

Table 5-D1: Protected Sea Turtle Status

Species/Stock	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
Loggerhead Sea Turtle (Caretta caretta) North Pacific Ocean DPS	FE	Not designated	Bycatch, loss of nesting habitat, vessel strikes, harvesting turtles and eggs, marine debris	Entanglement, loss of nesting habitat, increased risk of vessel strikes, marine debris, changes in beach morphology, sand temperature, and food distribution	North Pacific Ocean, bound by the equator and the 60 deg. N parallel	March-June
Green Sea Turtle (Chelonia mydas) East Pacific DPS	FT	Not designated	Wildlife trafficking, bycatch, vessel strikes, habitat loss due to coastal development, disease	Entanglement, habitat loss, increased risk of vessel strikes, oil spills, marine debris ingestion, changes in beach morphology, sand temperature, and food distribution	Northwestern Mexico to southern AK	Late Spring to Summer
Olive Ridley Sea Turtle (Lepidochelys olivacea)	FT	Not designated	Hunting, bycatch, vessel strikes, predation, loss of nesting habitat, marine debris	Entanglement, habitat loss, increased risk of vessel strikes, oil spills, marine debris ingestion, changes in beach morphology, temperature, and food distribution	Northern Chile to southern CA	Variable depending on location

Species/Stock	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
Leatherback Sea Turtle (Dermochelys coriacea) Western Pacific	FE SE	16,910 sq. mi of CA coast from Point Arena to Point Arguello E. of 3000m depth contour; 25,004 sq. mi from Cape Flattery, WA to Cape Blanco, OR E. of 2000m depth contour	Hunting, bycatch, vessel strikes, loss of nesting habitat, marine debris	Entanglement, loss of habitat, increased risk of vessel strikes, oil spills, marine debris ingestion, changes in beach morphology/sand temperature, and food distribution	Indo-Pacific region to the Pacific coast of North America	Variable depending on location

Table 5-D2: Protected Sea Turtle Potential to Occur in AOAs

Species/Stock	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
Loggerhead Sea Turtle (Caretta caretta) North Pacific Ocean DPS	Carnivores - mostly benthic invertebrates in coastal habitat	Nest in Japan; Hatchlings and juveniles spend 7 to 15 years in open ocean, trans-Pacific migration to foraging grounds in Mexico and Central America; Spend years maturing, later migrating back to nest in Japan; Rarely seen in southern CA during anomalously warm periods	Forage in nearshore areas later in life	Unknown	N/A	Unlikely	Unlikely	Unlikely
Green Sea Turtle (Chelonia mydas) East Pacific DPS	Herbivores - algae, seagrasses	Common from NW Mexico to southern CA; Nest in Mexico and migrate to CA nearshore areas to forage - San Diego bay especially; Adults migrate every 2 to 5 years from foraging to nesting grounds where they originally hatched; Hatchlings live in pelagic zones for several years, juveniles then migrate to foraging grounds	Beach nesting, foraging in nearshore areas	Unknown	N/A	Somewhat Likely	Likely	Likely
Olive Ridley Sea Turtle (Lepidochelys olivacea)	Omnivores - algae, lobster, crab, tunicates, and mollusks	Mainly a tropical pelagic species, also known to inhabit coastal areas and forage in deep waters of the Pacific; Nesting occurs throughout range, but large population in Costa Rica; Can be seen in CA	Beach nesting, benthic foraging	Unknown	N/A	Unlikely	Unlikely	Unlikely

Species/Stock	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
Leatherback Sea Turtle (Dermochelys coriacea) Western Pacific	Soft-bodied open ocean prey such as jellyfish and salps	Pelagic but feed and migrate in coastal waters; Nesting in Indo-Pacific region; Trans-Pacific migration to forage off of the U.S. coast; Critical foraging habitat off of WA, OR, and CA; Spend most of life in open ocean	Foraging in nearshore areas	Spring and Summer	N/A	Unlikely	Unlikely	Unlikely

E. Sharks, rays and fish

Table 5-E1: Protected Sharks, Rays and Fish Status

Species/Stock	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
Oceanic Whitetip Shark (*Carcharhinus longimanus*)	FT	Not designated	Bycatch, harvest for fin trade	Vulnerable to depletion due to low reproductive output	Globally in tropical and subtropical waters	Unknown
Scalloped Hammerhead Shark (Sphyrna lewini) Eastern Pacific DPS	FE	Not designated	Bycatch, harvest for fin trade	Pollution and degradation of water quality could threaten juvenile and nursery habitats	Globally in temperate and tropical seas; this stock occurs in the eastern Pacific Ocean	Unknown
Giant Manta Ray (Manta birostris)	FT	Not designated	Bycatch, commercial fishing for international gill plate trade	Vulnerable to depletion due to low reproductive output	Globally in tropical, subtropical, and temperate waters	Unknown
Steelhead Trout (*Oncorhynchus mykis*s)* Southern California DPS	FE SC	Ventura River, Coyote Creek, and Santa Clara River	Habitat loss due to development, overfishing, urban and agricultural land use practices, blocked spawning access	Habitat loss, disruption of return to natal waterways, changes of ocean and river conditions due to climate change	Coastal basins from the Santa Maria River to the U.S./ Mexico border	Winter - during high flow

Table 5-E2: Protected Sharks, Rays and Fish Potential to Occur in AOAs

Species/Stock	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
Oceanic Whitetip Shark (*Carcharhinus longimanus*)	Primarily bony fish and cephalopods	Prefer offshore waters but typically found high in water column near surface	Tend to remain at the surface, more likely to encounter threats	Unknown	N/A	Unlikely	Unlikely	Unlikely
Scalloped Hammerhead Shark (Sphyrna lewini) Eastern Pacific DPS	Bony fish, cephalopods, sharks, rays	Occurs over continental and insular shelves as well as adjacent deep waters; Highly mobile, partly migratory	-	Unknown	N/A	Unlikely	Unlikely	Unlikely
Giant Manta Ray (Manta birostris)	Euphausiids, copepods, mysids, shrimp	Commonly found offshore in oceanic waters and in productive coastal areas; Also observed in estuarine waters, oceanic inlets, and within bays and intercoastal waterways; Migration varies and the population structure is not well understood	Seasonally visit productive coastlines with upwelling, may be found aggregating in shallow waters to feed	Unknown	N/A	Unlikely	Unlikely	Unlikely
Steelhead Trout (*Oncorhynchus mykiss*)* Southern California DPS	Invertebrates, small forage fish, crustaceans	Gravel bottom, fast flowing rivers and streams for spawning; Estuaries and nearshore areas for juvenile feeding; Open ocean during adult development prior to returning to natal grounds	Anadromous fish (steelhead) co-occur and sometimes interbreed with freshwater resident fish (rainbow trout)	Winter to Spring	N/A	Unlikely	Unlikely	Unlikely

F. Invertebrates

Table 5-F1: Protected Invertebrates Status

Species/Stock	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
White Abalone (Haliotis sorenseni)	FE	Not designated	Commercial fishing, disease, low reproduction rates	Possible habitat loss/degradation	Punta Abreojos, Baja California, Mexico to Point Conception, CA	Unknown
Black Abalone (Haliotis cracherodii)	FE	360 sq. km of habitat along the CA coast and offshore islands (including Channel Islands)	Commercial fishing, illegal harvest, disease, low reproduction rates	Possible habitat loss/degradation, oil spills, sedimentation events	Bahai Tortugas and Isla Guadalupe, Mexico to Point Arena, CA	Unknown

Table 5-F2: Protected Invertebrates Potential to Occur in AOAs

Species/Stock	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
White Abalone (Haliotis sorenseni)	Various algae	Small numbers along mainland coast of CA and on a few offshore islands and banks; Live on rocky substrate alongside sand channels; Can be found at depths of 5 to 180 feet; Slow moving bottom dwellers	May be found in kelp rich areas, broadcast spawners	Year-round	N/A	Unlikely	Unlikel y	Unlikely
Black Abalone (Haliotis cracherodii)	Various algae	Rocky intertidal and shallow subtidal reefs along the CA and Baja California coast; Slow moving bottom dwellers to about 18 feet deep	May be found in kelp rich areas, broadcast spawners	Year-round	N/A	Unlikely	Unlikel y	Unlikely

G. Birds

Table 5-G1: Protected Birds Status

Species	Federal/State Protections	Critical Habitat	Historic and Current Threats	Predicted Threats	Historic Range	Breeding Season
California Least Tern (Sterna antillarum browni)*	FE, MBTA SE	Not designated	Loss of nest habitat, invasive plants, human disturbance, lack of resources, predation	Increased disturbance and habitat loss in shoreline areas, urban development	Pacific coast of Mexico to central CA	April - September
Western Snowy Plover (Charadrius alexandrinus)* Pacific Coast Population DPS	FT, MBTA	24,527 acres along the Pacific Coast of WA, OR, and CA	Habitat loss from coastal development, recreation	Further loss of habitat, sea level rise, oil spills	Along coasts of WA, OR, CA and Mexico	March to September
Short-Tailed Albatross (*Phoebastria albatrus*)*	FE, MBTA	Not designated	Hunting, plastic pollution, entanglement, habitat destruction	Oil spills, increased exposures to plastics, contaminants	From Japan east to the Bering Sea/Gulf of AK, and south to CA	Winter

Table 5-G2: Protected Birds Potential to Occur in AOAs

Species	Primary Diet	Primary Habitat	Behaviors	Known Seasonal Abundance	PO Alt. 1	PO Alt. 2	PO Alt. 3	PO Alt. 4
California Least Tern (Sterna antillarum browni)*	Small fish and nearshore prey	Nesting limited to colonies in San Francisco Bay, Sacramento River delta, and areas along the coast from San Luis Obispo County to San Diego County; Wintering locations unknown but may be in Mexico or Central America	Nests on open, sandy areas along coast, migratory	Spring to Fall	N/A	Unlikely	Unlikely	Unlikely
Western Snowy Plover (Charadrius alexandrinus)* Pacific Coast Population DPS	Invertebrates including insects and crustaceans	Breeds on sparsely vegetated sandy beaches and dry salt flats; In the winter mostly found on sandy beaches; Short north-south migration to winter areas for Pacific coast breeders	Sensitive to disturbance while nesting, nest on sand and open spaces	Year-round	N/A	Unlikely	Unlikely	Unlikely
Short-Tailed Albatross (*Phoebastria albatrus*)*	Squids, crustaceans, various fishes	Breeding occurs primarily on several remote islands in the western Pacific; During non-breeding season range along the Pacific Rim from southern Japan to the west coast of North America	Attracted to fishing operations for feeding	Unknown	N/A	Unlikely	Unlikely	Unlikely

*Indicates species that were not included in the species list considered during site characterization in the Atlas.

Table 6: Fisheries Gear Calendar

Fisheries Description					Seasonal Likelihood of Occurrence			
List of Fisheries	Gear Type	MMPA Category	Est. # of Participants	Effort Distribution / General Season	**Winter** (Dec. 1 - Feb. 28)	**Spring** (Mar. 1 - May 31)	**Summer** (June 1 - Aug. 31)	Fall (Sept. 1 - Nov. 30)
POT/TRAP FISHERIES								
CA SPINY LOBSTER TRAP FISHERY	Pot / Trap	II	189	**Distribution:** U.S./Mexico border to Pt. Conception, including areas around the Channel Islands. **General Season:** Early Oct. - mid-Mar.	Likely	Likely	Unlikely	Likely
CA SPOT PRAWN POT FISHERY	Pot / Trap	II	22	**Distribution:** U.S./Mexico border to Central CA **General Season:** Northern CA: Aug. 1 - Apr. 30 and Southern CA: Feb. 1 - Oct. 30	Likely	Likely	Likely	Likely
CA ROCK CRAB POT FISHERY	Pot / Trap	III	113	**Distribution:** Entire CA coastline, including offshore islands **General Season:** Year-round	Likely	Likely	Likely	Likely

Fisheries Description					Seasonal Likelihood of Occurrence			
List of Fisheries	Gear Type	MMPA Category	Est. # of Participants	Effort Distribution / General Season	**Winter** (Dec. 1 - Feb. 28)	**Spring** (Mar. 1 - May 31)	**Summer** (June 1 - Aug. 31)	Fall (Sept. 1 - Nov. 30)
WA/OR/CA SABLEFISH POT FISHERY	Pot / Trap	II	144	**Distribution:** In federal waters off WA, OR, and CA **General Season:** Tier endorsed limited entry: Apr. 1 - Dec. 31 Open access and non-tier endorsed limited entry: Year-round	Likely	Likely	Likely	Likely
WA/OR/CA HAGFISH POT FISHERY	Pot / Trap	III	63	**Distribution:** Coastline of WA, OR, and CA **General Season:** Year-round	Possible *	Possible *	Possible *	Possible *
CA NEARSHORE FINFISH TRAP FISHERY	Pot / Trap	III	42	**Distribution:** Entire CA coastline, up to 5 miles offshore. Effort typically occurs in CA state waters **General Season:** Year-round	Likely	Likely	Likely	Likely
CA DUNGENESS CRAB POT FISHERY	Pot / Trap	I	471	**Distribution:** Northern and Central CA **General Season:** Northern CA: Dec. 1 - July 15 Central CA: Nov. 15 - June 30	Possible *	Possible *	Possible *	Possible *

Fisheries Description					Seasonal Likelihood of Occurrence			
List of Fisheries	Gear Type	MMPA Category	Est. # of Participants	Effort Distribution / General Season	**Winter** (Dec. 1 - Feb. 28)	**Spring** (Mar. 1 - May 31)	**Summer** (June 1 - Aug. 31)	Fall (Sept. 1 - Nov. 30)
CA COONSTRIPE SHRIMP POT FISHERY	Pot / Trap	II	9	Distribution: Northern CA General Season: May 1 - Oct. 31	Unlikely	Unlikely	Unlikely	Unlikely
CA TANNER CRAB POT FISHERY	Pot / Trap	III	1	Distribution: Northern CA General Season: Unspecified	Unlikely	Unlikely	Unlikely	Unlikely
HOOK AND LINE FISHERIES								
WA/OR/CA GROUNDFISH, BOTTOMFISH, LONGLINE/SET LINE FISHERY	Long Line / Set Line	III	314	**Distribution:** In federal waters off WA, OR, and CA **General Season:** Main effort is Apr. - Oct. but can occur year-round	Possible *	Possible *	Possible *	Possible *
WA/OR/CA PACIFIC HALIBUT LONGLINE FISHERY	Long Line / Set Line	III	130	Distribution: Entire EEZ off WA, OR, and CA General Season: June - July	Unlikely	Unlikely	Possible *	Unlikely

Fisheries Description					Seasonal Likelihood of Occurrence			
List of Fisheries	Gear Type	MMPA Category	Est. # of Participants	Effort Distribution / General Season	**Winter** (Dec. 1 - Feb. 28)	**Spring** (Mar. 1 - May 31)	**Summer** (June 1 - Aug. 31)	Fall (Sept. 1 - Nov. 30)
CA/OR/WA NON-ALBACORE HMS HOOK AND LINE FISHERY	Troll; Pole and Line	III	124	**Distribution:** Primarily in SCB, with little effort north of Pt. Conception **General Season:** Allowed year-round, but majority of effort occurs late spring - early winter	Likely	Likely	Possible	Possible
WA/OR/CA ALBACORE SURFACE HOOK AND LINE/TROLL FISHERY	Troll; Pole and Line	III	556	**Distribution:** Coastline of WA, OR, and CA **General Season:** Allowed year-round, but most effort occurs late summer - early fall	Possible *	Possible *	Possible *	Possible *
CA/OR/WA SALMON TROLL FISHERY	Troll	III	1030	**Distribution:** Coastline of WA, OR, and CA **General Season:** Varies, primarily during summer / fall with area specific spring effort at times	Unlikely	Possible *	Possible *	Possible *
WA/OR/CA GROUNDFISH/ FINFISH HOOK AND LINE FISHERY	Troll; Pole and Line; Vertical Long line; Stick Gear	III	689	Distribution: Coastline of WA, OR, and CA General Season: Year-round	Likely	Likely	Likely	Likely

Fisheries Description					Seasonal Likelihood of Occurrence			
List of Fisheries	Gear Type	MMPA Category	Est. # of Participants	Effort Distribution / General Season	**Winter** (Dec. 1 - Feb. 28)	**Spring** (Mar. 1 - May 31)	**Summer** (June 1 - Aug. 31)	Fall (Sept. 1 - Nov. 30)
CA HALIBUT, WHITE SEABASS, YELLOWTAIL HOOK AND LINE/HANDLINE FISHERY	Troll; Pole and Line; Handline	III	388	**Distribution:** Coastline of CA, effort generally occurs in CA state waters **General Season:** Year-round ; white seabass fishery is closed south of Pt. Conception from Mar. 15 - June 15	Likely	Likely	Likely	Likely
CA DEEP SET BUOY GEAR FISHERY (Authorized June 2023*)	Standard and Linked Deep Set Buoy Gear	*Not yet listed in MMPA List of Fisheries	Unknown	**Distribution:** In federal waters within the SCB. Little effort typically occurs north of Pt. Conception. **General Season:** Year-round but effort occurs late July - Nov.	Likely	Likely	Likely	Likely
AK/WA/OR/CA COMMERCIAL PASSENGER FISHING VESSEL FISHERY	Hook and Line; some Pot/Trap	III	7000+ (321-CA)	**Distribution:** Can occur in both state and federal waters **General Season:** Varies by state, species group, etc.	Likely	Likely	Likely	Likely
NET FISHERIES								

Fisheries Description					Seasonal Likelihood of Occurrence			
List of Fisheries	Gear Type	MMPA Category	Est. # of Participants	Effort Distribution / General Season	**Winter** (Dec. 1 - Feb. 28)	**Spring** (Mar. 1 - May 31)	**Summer** (June 1 - Aug. 31)	Fall (Sept. 1 - Nov. 30)
CA THRESHER SHARK/ SWORDFISH DRIFT GILLNET FISHERY	Drift Gillnet (>/=14 in. mesh)	II	21	**Distribution:** U.S./Mexico border to OR **General Season:** Feb. 1 - Apr. 30 occurs >200 nm offshore ; May 1 –-Aug. 14 occurs >75 nm offshore ; Aug. 15 - Jan. 31 occurs >12 nm from shore ; numerous smaller closures including a Loggerhead sea turtle closure in SCB during El Niño years.	Likely	Unlikely	Likely	Likely
CA YELLOWTAIL, BARRACUDA, WHITE SEABASS DRIFT GILLNET FISHERY	Drift Gillnet (>/=3.5 in. and <14 in. mesh)	II	20	**Distribution:** In federal waters primarily south of Pt. Conception, including effort around San Clemente and San Nicolas Islands **General Season:** Year-round	Likely	Likely	Likely	Likely

Fisheries Description					Seasonal Likelihood of Occurrence			
List of Fisheries	Gear Type	MMPA Category	Est. # of Participants	Effort Distribution / General Season	**Winter** (Dec. 1 - Feb. 28)	**Spring** (Mar. 1 - May 31)	**Summer** (June 1 - Aug. 31)	Fall (Sept. 1 - Nov. 30)
CA HALIBUT, WHITE SEABASS, AND OTHER SPECIES SET GILLNET FISHERY	Set Gillnet (>3.5 in. mesh)	II	39	**Distribution:** In federal waters from U.S./Mexico border to Monterey Bay **General Season:** Year-round; White seabass catch prohibited south of Pt. Conception Mar. 15 - June 15	Likely	Likely	Likely	Likely
CA HALIBUT BOTTOM TRAWL FISHERY	Bottom Trawl	III	23	**Distribution:** Generally within federal waters off central CA from Pt. Reyes to Pt. Sal, and throughout the SCB; effort in CA waters occurs in the California Halibut Trawling Grounds (CHTG) which is 1-3nm from shore between Port Arguello and Point Mugu **General Season:** Year-round in federal waters; CA season is June 16 – Mar. 14 (within CHTG only)	Likely	Likely	Likely	Likely

Fisheries Description					Seasonal Likelihood of Occurrence			
List of Fisheries	Gear Type	MMPA Category	Est. # of Participants	Effort Distribution / General Season	**Winter** (Dec. 1 - Feb. 28)	**Spring** (Mar. 1 - May 31)	**Summer** (June 1 - Aug. 31)	Fall (Sept. 1 - Nov. 30)
CA SEA CUCUMBER TRAWL FISHERY	Bottom Trawl	III	11	**Distribution:** San Diego to Pt. Conception **General Season:** Year-round in federal waters w/ exception of warty sea cucumber trawling closure Mar. 1 - June 14; closed in CHTG Mar. 1 - June 15	Likely	Likely	Likely	Likely
WA/OR/CA SHRIMP TRAWL FISHERY	Bottom Trawl	III	130	**Distribution:** Coastline of WA, OR, and CA; generally within federal waters with some effort in OR and WA state waters **General Season:** Apr. 1 - Oct. 31 ; Southern CA fishery for ridgeback and golden prawns is closed from June 1 - Sept. 31	Unlikely	Likely	Unlikely	Likely
WA/OR/CA GROUNDFISH TRAWL FISHERY	Midwater Trawl; Bottom Trawl	III	118	**Distribution:** In federal waters off WA, OR, and CA **General Season:** Year-round	Possible *	Possible *	Possible *	Possible *

Fisheries Description					Seasonal Likelihood of Occurrence			
List of Fisheries	Gear Type	MMPA Category	Est. # of Participants	Effort Distribution / General Season	**Winter** (Dec. 1 - Feb. 28)	**Spring** (Mar. 1 - May 31)	**Summer** (June 1 - Aug. 31)	Fall (Sept. 1 - Nov. 30)
CA ANCHOVY, MACKEREL, SARDINE PURSE SEINE FISHERY	Purse Seine	III	53	**Distribution:** Occurs in federal waters throughout CA coast but primarily operates in San Diego, Oceanside, Dana Point, San Pedro, and Monterey **General Season:** Northern anchovy and Jack mackerel: Jan. 1 - Dec. 31 ; Pacific sardine and Pacific mackerel: July 1 - June 30; *Pacific sardine fishery has been closed since 2015.*	Likely	Likely	Likely	Likely
CA SQUID PURSE SEINE FISHERY	Purse Seine	III	68	**Distribution:** Primarily southern and central CA coast **General Season:** North of Pt. Conception: Apr. - Sept. South of Pt. Conception: Oct. - Mar.	Likely	Likely	Likely	Likely

Fisheries Description					Seasonal Likelihood of Occurrence			
List of Fisheries	Gear Type	MMPA Category	Est. # of Participants	Effort Distribution / General Season	**Winter** (Dec. 1 - Feb. 28)	**Spring** (Mar. 1 - May 31)	**Summer** (June 1 - Aug. 31)	Fall (Sept. 1 - Nov. 30)
CA SQUID DIP NET FISHERY	Brail Gear; Dip Net	III	19	**Distribution:** Primarily southern and central CA coast **General Season:** North of Pt. Conception: Apr. - Sept. South of Pt. Conception: Oct. - Mar.	Likely	Likely	Possible	Likely
CA TUNA PURSE SEINE FISHERY	Purse Seine	III	14	**Distribution:** Primarily in federal waters off CA coast **General Season:** Typically May-Oct. during years when target species enter SCB	Unlikely	Possible	Possible	Possible
CA HERRING SET GILLNET FISHERY	Set Gillnet	III	11	**Distribution:** Operates in and near San Francisco Bay, Crescent City Harbor, Humboldt Bay, and Tomales Bay **General Season:** Jan. 2 - Mar. 15	Unlikely	Unlikely	Unlikely	Unlikely
MECHANICAL/HAND COLLECTION FISHERIES								

Fisheries Description					Seasonal Likelihood of Occurrence			
List of Fisheries	Gear Type	MMPA Category	Est. # of Participants	Effort Distribution / General Season	**Winter** (Dec. 1 - Feb. 28)	**Spring** (Mar. 1 - May 31)	**Summer** (June 1 - Aug. 31)	Fall (Sept. 1 - Nov. 30)
CA SWORDFISH HARPOON FISHERY	Harpoon	III	21	**Distribution:** Typically concentrated off San Diego in early season and shifts as far north as OR in later season **General Season:** May - Dec.	Possible	Likely	Likely	Likely
CA/OR/WA DIVE COLLECTION FISHERY	Dive; Scuba	III	186	**Distribution:** Coastline of CA, OR, and WA **General Season:** Year-round with species specific area/time restrictions	Likely	Likely	Likely	Likely
WA/OR/CA HAND / MECHANICAL COLLECTION FISHERY	Mechanical, Hand Collection	III	320	**Distribution:** Coastline of CA, OR, and WA **General Season:** Varies by state with area/time restrictions **mechanical devices to harvest mollusk prohibited in CA (hand only)*	Likely	Likely	Likely	Likely
CA/WA KELP, SEAWEED, AND ALGAE FISHERY	Mechanical, Hand Collection	III	4	**Distribution:** Coastline of CA and WA **General Season:** Varies by state with area/time restrictions	Unlikely	Unlikely	Unlikely	Unlikely

Fisheries Description					Seasonal Likelihood of Occurrence			
List of Fisheries	Gear Type	MMPA Category	Est. # of Participants	Effort Distribution / General Season	**Winter** (Dec. 1 - Feb. 28)	**Spring** (Mar. 1 - May 31)	**Summer** (June 1 - Aug. 31)	Fall (Sept. 1 - Nov. 30)

Notes:

All information is from the most recent profiles of the NOAA MMPA 2024 List of Fisheries: https://www.fisheries.noaa.gov/national/marine-mammal-protection/list-fisheries-summary-tables .

Est. # of Participants was last updated in 2023 and reflects fishery-wide participants (i.e. not SCB specific). Participants are considered as all permit holders (88 FR 16899); data was not available for this DPEIS to further divide participants to vessels or individuals.

Definitions:

"Occurrence": for the purposes of this table, occurrence is intended to mean active fishing effort or fishing transect in or near the Alternative Areas

"Likely:" Peak season fishing can occur within SCB during this time of year

"Possible:" Outside of peak season, but fishing allowed year-round and could occur within SCB during this time as well

"Possible *:" Majority of effort occurs outside of SCB, but historic fishery distribution does include SCB

"Unlikely:" Outside of general season and/or historic fishery distribution does not include SCB

SCB: Southern California Bight

CHTG: California Halibut Trawling Grounds

Table 7: Fishery Management Plans in the SCB

SPECIES COVERED UNDER THE FMP	PREDICTED THREATS	BEHAVIORS	PO ALT. 1	PO ALT. 2	PO ALT. 3	PO ALT. 4
Coastal Pelagic Species (CPS) FMP CPS are schooling fish ranging from the shore to the open ocean. CPS occur in the water column from 0-1,000 meters, typically found above the continental shelf.						
Pacific sardine (*Sardinops sagax*), Pacific mackerel (*Scomber japonicus*), Jack mackerel (*Trachurus symmetricus*), Northern anchovy (*Engraulis mordax*), Market squid[1] (*Doryte*uthis opalescens), Krill[2](*euphausiid sp.*) Ecosystem Component Species[3]: Pacific herring (*Clupea pallasii*), Jacksmelt (*Atherinopsis californiensis*)	Fluctuating oceanographic conditions including water temperatures, currents, upwelling, and the timing of changes to these relative to CPS life histories could affect their recruitment, distribution, and abundance.	CPS play an important role in the CA Current ecosystem as a critical food source for marine mammals, sea birds, and larger fish. Market squid abundance is known to rapidly expand in cool and productive oceanographic conditions associated with La Niña events, and contract in warm and unproductive regimes associated with El Niño events.	N/A	LIKELY CPS seining occurs within the SCB and can occur specifically within the Santa Barbara channel and surrounding Channel Islands. Port Hueneme and Ventura Harbor are main ports in southern CA for CPS finfish and market squid fisheries. The market squid dipnet/brail fishery can occur here as well.	LIKELY CPS bait fishing is allowed and other commercial CPS fishing occurs near boundary line. Port of LA is a major landing port for CPS.	LIKELY
Highly Migratory Species (HMS) FMP Open ocean, pelagic and nearshore coastal zones are all important, although HMS are most often found offshore. HMS often inhabit areas with distinct temperature and nutrient gradients, such as nutrient-rich waters influenced by upwelling. HMS exhibit significant migratory patterns throughout the Pacific Ocean, are highly adaptable to oceanic conditions, and range widely in search of prey and suitable breeding grounds.						

SPECIES COVERED UNDER THE FMP	PREDICTED THREATS	BEHAVIORS	PO ALT. 1	PO ALT. 2	PO ALT. 3	PO ALT. 4
<u>Tunas</u>: Albacore tuna (*Thunnus alalunga*), Yellowfin tuna (*Thunnus albacares*), Bigeye tuna (*Thunnus obesus*), Skipjack tuna (*Katsuwonus pelamis*), Pacific bluefin tuna (*Thunnus orientalis*) <u>Sharks</u>: Common thresher shark (*Alopias vulpinus*), Shortfin mako shark *(Isur*us oxyrinchus), Blue shark (*Prionace glauca*) <u>Billfish/swordfish</u>: Striped marlin *(Kajikia audax*), Broadbill swordfish (*Xiphias gladius*) <u>Other</u>: Dorado (Coryphaena hippurus) <u>Ecosystem Component Species</u>[3]: Bigeye thresher shark (*Alopias superciliosus*), Common mola (*Mola mola*), Escolar (*Lepidocybium flavobrunneum*), Lancetfishes (*Alepisauridae*), Louvar (*Luvarus imperialis*), Pelagic sting ray (*Dasyetis violacea*), Pelagic thresher shark (*Alopias pelagicus*), Wahoo (*Acathocybium solandri*)	Alterations in ocean temperatures and currents can impact the distribution and abundance of prey. Changes such as alterations in upwelling patterns could affect the overall ecosystem dynamics for HMS. Being upper level predators, they are prone to accumulating toxins within their tissues, so pollution and contaminants could be a concern. Shifting migration routes could occur as ocean conditions change.	Being highly migratory and predominantly pelagic, HMS may be less vulnerable to coastal development than other species, but not immune. As high-level predators, any changes to the food web disrupting key organisms upon which they depend could negatively affect HMS.	N/A	LIKELY The majority of DSBG, Harpoon, and Hook and Line effort occurs within the SCB south of Pt. Conception, as does most DGN effort. (UNLIKELY fisheries components under the same FMP): Some DGN trips occur north of Pt. Conception, and far offshore near the outer boundary of the EEZ. West Coast-based longline fishing only occurs outside the EEZ. The WA/OR/CA Albacore Surface Hook and Line/Troll Fishery is focused in OR and WA.	LIKELY Drift Gillnet is allowed in SMB. There is a conditional time/area closure called the Loggerhead Conservation Area, which closes part of the SCB to DGN fishing during El Niño conditions. This conditional closure area overlaps in part with the SMB.	LIKELY

SPECIES COVERED UNDER THE FMP	PREDICTED THREATS	BEHAVIORS	PO ALT. 1	PO ALT. 2	PO ALT. 3	PO ALT. 4
Groundfish FMP With a few exceptions, groundfish live on or near the ocean floor. Most species are coastwide stocks. Some of them vary in concentration from north to south, and some are common from the U.S./Canada border to the U.S./Mexico border. Groundfish inhabit a variety of depths, ranging from intertidal and nearshore to waters as deep as 3,500 meters. Most individual species tend to localize by depth more than latitude.						

West Coast rockfish[4]:(65+ species) <u>Flatfish</u>: Arrowtooth flounder (*Atheresthes stomias*), Butter sole (*Isopsetta isolepis*), Curlfin sole (*Pleuronichthys decurrens*), Dover sole (*Microstomus pacificus*), English sole *(Parophrys vetulus*), Flathead sole (*Hippoglossoides elassodon*), Pacific sanddab (*Citharichthys sordidus*), Petrale sole (*Eopsetta jordani*), Rex sole (*Glyptocephalus zachirus*), Rock sole (*Lepidopsetta bilineata*), Sand sole (*Psettichthys melanostictus*), Starry flounder (*Platichthys stellatus*) <u>Roundfish</u>: Cabezon (Scorpaenichthys marmoratus), Kelp greenling (Hexagrammos decagrammus), Lingcod (Ophiodon elongatus), Pacific cod (Gadus macrocephalus), Pacific whiting (Merluccius productus), Sablefish (Anoplopoma fimbria) <u>Sharks and Skates:</u> Big skate (*Beringraja binoculata*), Longnose skate (*Beringraja rhina*), Leopard shark (*Triakis semifasciata*), Spiny dogfish (*Squalus suckleyi*) <u>Ecosystem Component Species</u>[3]: Shortbelly rockfish (*Sebastes jordani*), Aleutian skate (*Bathyraja aleutica*), Bering/sandpiper skate (Bathyraja interrupta), California skate (*Raja inornata*), Roughtail/black skate (*Bathyraja trachura*), All other skates except Big and Longnose skate	Oceanographic fluctuations such as sea temperature changes, altered currents, and changes in upwelling productivity can directly impact shifts in the abundance and distribution of groundfish.	Structures associated with aquaculture could serve as artificial habitats for groundfish, attracting or repelling certain species. Waste byproducts from aquaculture operations could alter the benthic habitat critical to local groundfish populations.	N/A	LIKELY Santa Barbara is a major port for Groundfish landings, with Sablefish being an important component. The ATLAS (Morris et al. 2021) showed Vessel Monitoring data from multiple Groundfish fisheries to overlap with the larger, overall North study area at varying degrees, especially Pot/ Trap gear and Line gear.	LIKELY Port of LA is a landing port for Groundfish fisheries. The ATLAS (Morris et al. 2021) showed Vessel Monitoring data from multiple Groundfish fisheries to overlap with the larger, overall Central North study area at varying degrees, especially Open Access Line gear.	LIKELY

SPECIES COVERED UNDER THE FMP	PREDICTED THREATS	BEHAVIORS	PO ALT. 1	PO ALT. 2	PO ALT. 3	PO ALT. 4
(Endemic species in the family *Arhynchobatidae*), Pacific grenadier (*Coryphaenoides acrolepis*), Giant grenadier (*Coryphaenoides pectoralis*), All other grenadiers (Endemic species in the family *Macrouridae*), Finescale codling *(Antimora microlepis*), Ratfish (*Hydrolagus colliei*), Soupfin shark (*Galeorhinus zyopterus*)						

SPECIES COVERED UNDER THE FMP	PREDICTED THREATS	BEHAVIORS	PO ALT. 1	PO ALT. 2	PO ALT. 3	PO ALT. 4
White Seabass FMP[5] White seabass occur in or near kelp beds bordering beaches and rocky headlands in southern CA and offshore islands. They can also be found several miles offshore in schools of various sizes, and can occur close to the seafloor in deep water at certain times of year. White seabass have been found off Long Pt., Palos Verdes Peninsula; Pt. Loma; Dana Pt.; the west end of Santa Catalina Island; San Clemente Island; Santa Barbara Island; and Santa Cruz Island.						
White seabass (Atractoscion nobilis)	Oceanographic changes could affect distribution and abundance. The fishery exploits the northern fringe of the stock and distribution appears to be strongly influenced by ocean temperatures, currents, winds, and upwelling. El Niño events are known to affect White seabass habitats, prey, and migration patterns. Loss of kelp habitat could potentially impact shelter and prey availability for both juveniles.	Kelp and eelgrass beds serve as refuge for juveniles, so habitat degradation is a concern. White seabass are integral to the food chain in southern CA waters and are known to prey upon other fish such as CPS species (northern anchovy, market squid, Pacific sardines, and Pacific mackerel) as well as crustaceans (mysid shrimp, pelagic red crab).	N/A	LIKELY White seabass gillnet fisheries can occur within SBC, but are restricted from occurring within 3 miles from mainland and 1 mile from offshore islands.	LIKELY White seabass gillnet fisheries can occur within SMB, but are restricted from occurring within 3 miles from mainland and 1 mile from offshore islands.	LIKELY

SPECIES COVERED UNDER THE FMP	PREDICTED THREATS	BEHAVIORS	PO ALT. 1	PO ALT. 2	PO ALT. 3	PO ALT. 4

NOTES

1 Market squid fishery management was taken over by CFGC in 2011.

2 All Krill harvest is prohibited under CPS FMP.

3 Ecosystem Component species are not targeted, but incidental stock landings can be monitored.

4 For a complete list of the Rockfish species included in the Groundfish FMP, please see PFMC's most recent Groundfish SAFE report.

5 The White Seabass FMP is a CA State program, not a federal FMP.

DEFINITIONS

FMP: Fishery Management Plan

Predicted Threats: Predicted threats associated with climate change or marine planning.

Behaviors: Relevant behaviors that may lead to interactions with aquaculture operations.

PO: Potential to Occur within one of the Alternative areas (Alternative 2: Santa Barbara Channel, Alternative 3: Santa Monica Bay, Alternative 4: Both geographic areas).

CPS: Coastal Pelagic Species

HMS: Highly Migratory Species

DSBG: Deep Sea Buoy Gear

DGN: Drift gill net

Appendix 1: Possible Mitigation for Offshore Aquaculture Facilities

While this PEIS analyzes the impacts of siting aquaculture facilities in AOAs, it does not propose any avoidance, minimization, mitigation, and monitoring measures, however, possible mitigation that could be considered for aquaculture facility development are discussed below.

A. Physical Environment

i. Oceanography and Climate

Pre-construction sampling, ongoing monitoring within and around farm sites, and modeling as part of permitting could assist in predicting potential impacts of individual operations. This information could be combined with a gradual expansion of farm sites based on adaptive management frameworks to prevent development of high-density aquaculture that could affect hydrodynamic circulation patterns. Environmental models (e.g. deposition, water quality) can be used to forecast impacts. Ecological Carrying Capacity (ECC) models could be developed to predict upper limits of expansion in a given area. Hydrodynamic models used to examine water quality and biosecurity (reviewed in Rhodes et al. 2023a) can be used to better predict impacts.

Ongoing Monitoring and Coordination outside of the AOA process

Information sources about oceanography and climate of the areas that can be considered in project-specific analyses include the National Oceanographic Partnership Program (NOPP) portal, NCCOS Ocean Reports online mapping tool, NOAA Physical Sciences Laboratory, and the Southern California Coastal Ocean Observing System.

ii. Marine Managed Areas

Hydrodynamic modeling could assist in predicting impacts to marine managed areas. These predictions could inform project-specific planning or potential mitigation, e.g., design modifications or monitoring protocols.

Ongoing Monitoring and Coordination outside of the AOA process

NOS Ocean Reports and Marine Cadastre, NOAA Office of National Marine Sanctuaries Real-time Monitoring Data, Sea Grant Marine Protected Area Monitoring Program, and MPA Collaborative Network are potential sources of information for modeling and monitoring.

iii. Seafloor Characteristics

Siting and designing facilities using baseline environmental survey results and depositional modeling could minimize potential impacts to sensitive seafloor characteristics. Mitigation measures for impacts to the seafloor may be defined at permitting by the USACE and by the EPA. Potential mitigation measures or BMPs/SOPs adopted to minimize impacts, based on similar aquaculture projects and comments received during scoping, include:

- visual survey of the ocean floor prior to anchor placement; visual monitoring during and after project;
- antifouling treatment limitations and onsite use restrictions for gear and anchors; and
- site-specific modeling and monitoring, e.g., depositional modeling; sediment monitoring for dissolved oxygen Carbon, Total Organic (TOC), Hydrogen sulfide, Sediment Oxygen Demand,

Nitrogen, Particle size distribution, Phosphorus, Solids, and Total volatile solids at and around the site; monitoring before construction to obtain baseline information, throughout the project operation and following removal.

Ongoing Monitoring and Coordination outside of the AOA process

In addition to the Atlas, additional sources for information on seafloor characteristics include Ocean Reports, the California Seafloor Mapping Project (CSMP) project, BOEM (Poti et al. 2020), and the Southern California Bight Regional Monitoring Program.

iv. Water Quality

Siting and mitigation strategies may minimize or avoid many adverse water quality impacts. NPDES permit requirements for finfish operations may specify water quality compliance and monitoring requirements. A proposed facility may be considered a Concentrated Aquatic Animal Production (CAAP) facility if the facility produces more than 100,000 pounds of aquatic animals annually. CAAP performance standards and effluent-limit guidelines consist of a series of management practices designed to control pollutant discharges. In addition to compliance with NPDES, aquaculture operations will need to comply with other state and federal laws and water quality control plans as applicable. For example, NSSP language mandates that if gear may attract birds or mammals, farms must have an operational plan to deter them so that water quality (and sanitation) are protected from their potentially accumulating feces.

Mitigation strategies may include monitoring and procedures to reduce any effluent discharge problems discovered during monitoring. Equipment maintenance requirements could be designed to minimize or avoid water quality-related impacts. Mitigation could also include conducting a comprehensive site analysis with water quality modeling to prevent operating beyond carrying capacity. BMPs may include steps for reporting the accidental release of contaminants, excess feed or waste material, and methods of containment. They may also include measures to prevent spills, fires, or other sources of hazardous materials, and procedures to manage and clean up any chemical and fuel spills or leaks, incident reporting agreements, and identification of responsible parties. Recommended BMPs may include washing copper-treated nets or using net cleaning robots and copper alloy nets that do not require these treatments. Minimization measures to prevent spills, fires, or other sources of hazardous materials would likely be required as part of a USACE Section 10 permit for all types of aquaculture. Measures may include procedures, supplies to manage and clean up any chemical and fuel spills or leaks, incident reporting agreements, and responsible parties.

Models can be used to predict discharge and solids accumulation and deposition from aquaculture farms (see Cromey et al. 2002; Cromey et al. 2012; and Frieder et al. 2022). Siting evaluations can include consideration of carrying capacity. Monitoring changes in water quality or ecosystem composition may be needed to track impacts. Dissolved and particulate organics, dissolved oxygen saturation, and redox potential are key metrics to monitor to identify impacts, especially at facilities that could be sited near to appropriate reference locations (Fujita et al. 2023). Effluent sampling at existing hatcheries along the Southern California coast include flow rate, monthly sampling for salinity, pH, temperature, suspended solids, nitrogen, nitrate, nitrite, ammonia, unionized ammonia, phosphorus, orthophosphate, zinc and copper; annual sampling for acute toxicity; and one-time sampling for chronic toxicity and CTR priority organic and inorganic pollutants (CDFG 2010). Visual inspection and monitoring of the bottom could also be considered.

Ongoing Monitoring and Coordination outside of the AOA process

Resources for project-specific analyses include the Southern California Coastal Observing System (including information about HABs), which incorporates California Cooperative Oceanic Fisheries Investigations data. CA State resources include the State of the Ocean and Coast reports, Surface Water

Ambient Monitoring Program, and the Southern California Bight Regional Monitoring Program. Santa Monica Bay specific resources include the California Environmental Data Exchange Network and My Water Quality web portal. Information about HABs and associated toxins of concern in State waters can be found through the California Department of Public Health, Environmental Management Branch's Marine Biotoxin and Phytoplankton Monitoring Program and in COST (2016). DDT dump site information can be found at EPA websites.

v. Air Quality and Aesthetics

All future aquaculture projects would comply with the EPA's NAAQS (42 U.S.C. §7403, 78 FR 3086), the CA Ambient Air Quality Standards (CAAQS) and local air district emission significance thresholds regardless of their siting location; project-specific air quality modeling may be required. Random air monitoring or fixed station daily monitoring could be implemented to ensure air quality is within standards. Potential mitigation measures could be implemented to reduce air quality and aesthetic impacts may include modifying the feed, vessel, and engine types or restricting the type of facility (finfish vs bivalves or algae), structure (e.g., submerged cages and longlines), and lights (number, type, duration, and shield-use).

Mitigation or adaptation strategies may simultaneously make aquaculture operations more resilient to climate change while also lessening the impacts of operations on climate change. Updating on-farm production and husbandry practices, selection of species for environmental tolerance and production efficiency, selective breeding for characteristics that confer resilience to climate change, and improved gear and equipment will also be important for adapting to climate change.

Reducing direct and indirect GHG emissions and/or increasing the overall carbon sequestration potential for an aquaculture operation can help mitigate impacts from climate change. TNC (2022) found that improving the FCR and shipping frozen products instead of shipping fresh products by air freight could reduce GHG emissions. Other research has shown the placement of seaweed and shellfish operations may help sequester carbon, denitrify water, and stabilize environments (Gentry et al. 2020). Additional mitigation measures may include: integrating more energy efficient or renewable energy sources into production; more efficient or lower-emitting transportation and shipping options; policy options such as tax credits, insurance programs, or carbon and nutrient banking, offsetting, or trading programs; use of on-farm technologies to monitor and reduce feed waste; and use of sustainably-sourced alternative feed ingredients (MacLeod et al. 2020, Jones et al. 2022, and Rub et al. *in press*). Integrated multi-trophic aquaculture (IMTA) operations may offer a mechanism for adaptation to climate change and emissions reduction (Raul et al. 2020, Rub et al. *in press*); impacts from and on production can be consolidated or reduced for multispecies production. Integrating bivalves or seaweed into an IMTA operation may help increase a facility's carbon sink potential and reduce local ocean acidification impacts, but the scale of operation and product fate are key to carbon sequestration potential (Froehlich et al. 2019, Jones et al. 2022).

Ongoing Monitoring and Coordination outside of the AOA process

Ventura, Santa Barbara, and South Coast Air Quality Management Plans are currently developed and ongoing. CA monitors the air quality in Ventura, Santa Barbara, and South Coast counties using stations located at strategic sites throughout each county.

vi. Acoustic Environment

Consultation requirements in accordance with ESA Section 7, MBTA, FWCA, and MMPA are discussed in Section 3.C.i (Federally Protected Species and Habitat). There are many established mitigation methods used by marine industries to reduce noise impacts that could be considered, e.g., the use of low-noise foundation/piling methods in the limited cases where pile driving occurs, or the use of noise abatement technologies (e.g. bubble curtains) during construction. BMPs regarding noise would likely be associated with potential biological impacts as well as human health and safety.

Ongoing Monitoring and Coordination outside of the AOA process

Resources for project-specific analyses include NOAA and U.S. Navy SanctSound Project, NOAA Fisheries Acoustics Program Research, and NOAA Fisheries Ocean Noise Strategy Roadmap (2016 - 2026). Estimates of sound generation from different types of vessels found in the BOEM 2023 Sounds Source List document (BOEM 2023a) can be used for project level analysis.

B. Biological Environment

i. Federally-Protected Species and Habitat

Compliance with any and all consultation requirements in accordance with ESA Section 7, MBTA, FWCA, and MMPA may be required to minimize adverse impacts on protected species and their habitat.

The risk of entanglement impacts on protected species remains one of the greatest areas of unknowns associated with offshore aquaculture, as well as near-term and long-term effects of competing ocean uses, such as offshore wind or other energy development, offshore area leasing, shipping, acoustic survey and other ocean noise, commercial fishing, and other ocean-based activities. Mitigation for secondary entanglement used in the offshore wind industry includes regular cleaning and maintenance of gear. Avoidance and minimization measures to decrease the risk of entanglement are provided in Appendix H of Mori and Riley (2021). Gear and engineering guides may be used to develop entanglement mitigation (Moore and Wieting 1999; Fredriksson and Beck-Stimpert 2019; and Sunny et al. 2023 (draft)).

Monitoring and reporting requirements for gear maintenance and line tension may be important to reduce the risk of entanglement and marine debris. Weighted lines under a breaking tension less than 1,700lbs reduces the risk of serious injuries from entanglement (Gladics et al. 2017, Knowlton et al. 2016, VPD 2018, and USACE 2021). Some research suggests that changing the color of line may improve visibility and decrease entanglements; but the response to any one color appears to be species-specific (Hamilton and Baker, 2019). Ensuring all lines are under sufficient tension and regular monitoring for damaged lines and gear has been required under previous USACE permits.

Reporting any interactions with marine life immediately would likely be required under USACE permits, through use of observers or remote systems. A qualified marine wildlife observer could provide the following:

- monitoring during vessel activity and in-water work;
- require continuous education of construction personnel regarding how to properly interact with protected species if encountered during operations;
- enforce safe distance requirements from protected species; and
- enforce compliance for the operation and maintenance of structures and systems as required by permits.

USACE and NOAA determined that, based on the state of technology and the size of the facility, remote monitoring was not practicable to reduce the risk of gear entanglement in a recent 86 acre (35 ha) kelp aquaculture project (USACE 2021). Instead, weekly monitoring of the site during the first month following installation and every two-weeks thereafter was required as part of the USACE permit conditions. It is likely that any facility sited in an AOA would be analyzed similarly and further evaluation of how to use remote or observer monitoring in the future could be required during permitting decisions. Rescue and release of any entangled wildlife could be required.

Codes of conduct or mitigation measures could be adapted from other regional industries to reduce potential impacts. For example, NMFS works with the fishing industry and other partners to develop regulations, monitoring plans, engineering studies, and gear modifications to reduce bycatch of sea turtles, marine mammals, sea birds, and non-target fish (NMFS 2022f). Measures include line cutting devices, timed buoy releases, and marked gear. Marked gear may be required. Setting or maintaining gear at night may help mitigate some predation activity for birds (Gladics et al. 2017). Region-wide vessel pathways and speed reductions are already in place across the SCB, and could be adapted at a smaller scale within an AOA (WhaleSafe 2022, Syed 2023) to reduce the risk of vessel strike.

Actions and technologies to reduce the attractiveness of farms to wild species may mitigate adverse impacts to protected species (Rhodes et al. 2023a). Siting facilities in areas with strong currents for nutrient dispersal may act as mitigation for wildlife aggregations, reducing the potential for adverse interactions with protected species (Bath et al. 2023). Local experience shows that removing dead or dying fish from cages promptly reduces the attraction to predators (CDFW 2010). Setting lines below the surface of the water prevents bird predation (Gladics et al. 2017). Curtailing the growth of biofouling on nets would also reduce attraction.

The MMPA allows the use of deterrents to discourage marine mammals from damaging gear or other private property, and to deter marine mammals from endangering human safety, as long as the deterrents do not cause serious injury or death. While the use of deterrents is mitigation, deterrents may also pose a risk to marine predators and birds, including protected species. The following considerations may minimize adverse risks from deterrents (Moore and Wieting 1999):

- Minimal level of use for effective harassment;
- Non-acoustic measures when available;
- Non-permanent measures when available; and
- Use close monitoring and adaptive management for records of what does and does not work.

Methods to deter or remove individual predators would likely need to be reviewed and approved by USACE in coordination with USFWS and NMFS, and considerations may include identifying the most effective, selective, and humane techniques available. Methods used globally include visual devices (e.g. mirrors, model predators, flashing lights), physical actions (e.g., water sprays, boat chasing), acoustic devices, and exclusionary nets (Bath et al. 2023, Rhodes et al. 2023a). Some existing facilities use brightly colored, large mesh nets underwater to surround net pens, with a 1 m space between the predator net and fish containment (CDFW 2010). Chain link fencing that has shade cloth stretched over it has been used to prevent birds from becoming entangled and pinnipeds from hauling out (CDFW 2010). Netting deterrents are thought to be more effective for pinnipeds than acoustic devices and other methods (Moore and Wieting 1999).

Additional examples of wildlife mitigation strategies are based on the best available science and knowledge gained from proposed, current, and previous marine aquaculture facilities in the U.S. and elsewhere, or are featured from other standard practice in other marine industries in the SCB and CCE. Examples include:

- Section III. Special Conditions of the CCC Staff Report on Carlsbad Aquafarms, Inc. lists recommendations from the State for a nearshore shellfish operation in the SCB (CCC 2019).
- Section 2.6 on pp. 26 and 27 of Olesiuk et al. (2012) discusses how to eliminate or mitigate noise as a stressor from aquaculture in Canada.
- Table 2 on pp. 211 and 212 of Kemper et al. (2003) summarizes mitigation for each type of conflict reviewed for marine mammals and seabirds, and some mitigation methods are detailed on pp. 219 through 222.
- Mitigation measures for protected species associated with vessel strikes and different types of gear in the water is described in Section 2.2.2 on pp. 2-17 through 2-28 of the NOAA Northwest Fisheries Science Center (NWFSC) PEA for Fisheries Research (2018).

Ongoing Monitoring and Coordination outside of the AOA process

The following lists of resources are provided as resources for future project-specific analyses.

Federal consultation resources:

- NOAA Fisheries Endangered Species Act Section 7 Consultations webpage, available online at: https://www.fisheries.noaa.gov/national/endangered-species-conservation/endangered-species-act-section-7-consultations.
- NOAA Fisheries Greater Atlantic Region documents for aquaculture ESA consultations (regional information that may be adapted for WCR), available online at: https://sites.google.com/a/noaa.gov/nmfs-hq-pr-aquaculture-coordination/esa-consultation.
- NOAA Fisheries Technical Guidance for Assessing Effects of Anthropogenic Sound on Marine Mammal Hearing (2018) user guide and alternatives calculator, available online at: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance.
- Guidance for pre and post-construction monitoring to detect changes in seabird distribution and habitat are being developed for offshore wind development, abstract available in references (Avian Displacement Guidance Committee 2024).

High resolution physical models in use on the west coast to forecast ecosystem insights (e.g. distribution and entanglement risk based on patterns of upwelling and associated hydrographic fronts) (Harvey et al. 2023):

- JSCOPE (JISAO's Seasonal Coastal Ocean Prediction of the Ecosystem), available online at: https://www.nanoos.org/products/j-scope/.
- WCOFS (West Coast Operational Forecast System), available online at: https://tidesandcurrents.noaa.gov/ofs/dev/wcofs/wcofs.html.

Habitat models that are either in development or that are consistently updated based on field surveys and stock information for living marine resources in the CCE, including the SCB and alternative areas:

- USGS Birds, Bats, and Beyond: Networked Wildlife Tracking in the Southern California Bight, available online at: https://www.usgs.gov/centers/werc/science/birds-bats-and-beyond-networked-wildlife-tracking-southern-california-bight.
- The SIMoN Species Database for distribution and habitat use of these species around NMSs, available online at: https://sanctuarysimon.org/.
- BOEM and USGS Seabird and Marine Mammal Surveys Near Potential Renewable Energy Sites Offshore Central and Southern California, abstract available in references (BOEM 2023b).
- BOEM and USGS Offshore Acoustic Bat Study along the California Coastline and Networked Wildlife Tracking in Offshore Southern California, abstract available in references (BOEM 2023b).
- U.S. Navy and Oregon State University whale telemetry study in Santa Barbara Channel, abstract available in references (BOEM 2023b).
- U.S. West Coast BIAs were updated and published in Calambokidis et al. (2024), with an interactive website and mapping tool for the SCB available here https://experience.arcgis.com/experience/51a9e25c75a1470386827439a918e056?views=View-3. These updates were not available at the time of the spatial modeling done in the Atlas (Morris et al. 2021). Any future compliance should consider the updated BIAs.

The following computer simulations to assess entanglement risk are in development across the U.S.:

- NCCOS whale entanglement simulator model

- BOEM and NCCOS Whales and Leatherback Sea Turtles in Offshore Floating Wind Turbine Moorings, Cables, and Associated Derelict Fishing Gear Offshore California, abstract available in references (BOEM 2023b).
- According to Mori and Riley (2021), Hubbs-Sea World Research Institute (HSWRI) received federal funding in 2018 to monitor and reduce the risk of protected species entanglement with marine aquaculture gear in California; project goals were to review available information, effectiveness of current mitigation measures, and to develop engineering and monitoring tools to reduce entanglement risks.

Web-based and smart-phone live-tracking applications:

- NOAA Southwest Fisheries Science Center (SWFSC) Loggerhead turtle movements in the Southern California Bight, available online at: http://www.seaturtle.org/tracking/index.shtml?project_id=1090.
- WhaleSafe Program and Tool for the Santa Barbara Channel, available online at: https://whalesafe.com/whale-safe-tool/.

ii. Wild Fish Stocks

Implementation of EFH conservation recommendations pursuant to Section 305(b)(2) of MSA may help avoid, minimize, mitigate, or otherwise offset adverse impacts on wild fish habitat. Compliance with USDA Animal and Plant Health Inspection Service (APHIS) rules and guidance would also be expected to minimize potential adverse impacts to wild fish stocks. Provided examples of mitigation strategies are based on the best available science and knowledge gained from proposed, current, and previous marine aquaculture facilities in the U.S. and elsewhere, or are featured from other standard practice in other marine industries in the SCB and CCE. See the measures discussed for Federally-protected species above, which could minimize potential impacts to all marine life. Table ES-1 in the CDFW's Draft PEIR for a Coastal Marine Aquaculture Program (CDFW 2019) provides examples of mitigation measures for effects of aquaculture on wild fish stocks.

Due to the uncertainty and natural variability associated with open water ecosystems and the responses to new offshore aquaculture operations adaptive management could be considered (Price and Morris 2013, Rust et al. 2014, and CDFW 2019). Changes may occur in the offshore marine environment, in technological or operational developments, or because of evolving market demands, societal priorities, or a variety of other factors. An adaptive management approach can reduce reactionary responses and strengthen the sustainability of offshore marine aquaculture, and is required for aquaculture in state waters (CDFW 2019).

The Atlas incorporated setbacks from certain habitats or management areas (rocky reef EFH HAPCs, deep sea coral and sponge observations, hard bottom habitat, fish havens, and National Marine Sanctuaries). The buffers used in the Atlas could be refined based on site-specific, comprehensive site analyses, baseline environmental surveys and adaptive management. An example of how farms may be spaced to mitigate impacts is provided in Table 10 on p. 30 of Aguilar-Manjarrez et al. (2017).

Actions and technologies to reduce the attractiveness of farms to wild species may mitigate adverse impacts associated with wildlife aggregations. Siting facilities in areas with strong currents for nutrient dispersal may reduce the potential for adverse interactions with wild species (Bath et al. 2023). Local experience shows that removing dead or dying fish from cages promptly reduces the attraction to predators (CDFW 2010). Good husbandry practices such as removing sick or dead fish promptly from cages is also an effective predator deterrent for sharks (Price and Morris 2013, NMFS 2021a). The seasonality of white shark breeding further south in the SCB may also be an important consideration for mitigating shark attraction and mitigation. Setting lines below the surface of the water prevents bird predation (Gladics et al. 2017). Curtailing the growth of biofouling on nets would also reduce attraction.

The MMPA allows the use of deterrents to discourage marine mammals from damaging gear or other private property, and to deter marine mammals from endangering human safety, as long as the deterrents do not cause serious injury or death. While the use of deterrents is mitigation, deterrents may also pose a risk to wild fish stocks. The following considerations may minimize adverse risks from deterrents (Moore and Wieting 1999):

- Minimal level of use for effective harassment;
- Non-acoustic measures when available;
- Non-permanent measures when available; and
- Use close monitoring and adaptive management for records of what does and does not work.

Methods used globally to deter or remove individual predators include visual devices (e.g. mirrors, model predators, flashing lights), physical actions (e.g., water sprays, boat chasing), acoustic devices, and exclusionary nets (Bath et al. 2023, Rhodes et al. 2023a). Some existing facilities use brightly colored, large mesh nets underwater to surround net pens, with a 1 m space between the predator net and fish containment (CDFW 2010). Chain link fencing that has shade cloth stretched over it has been used to prevent birds from becoming entangled and pinnipeds from hauling out (CDFW 2010). These methods may also indirectly help mitigate impacts of predation on wild fish stocks.

In the U.S., farmers are required to have strategies in place to prevent escapes that include strategic site selection and engineering designs, regular monitoring and response plans, and sterilization and selective breeding of finfish (Nelson et al. 2019, Purcell et al. 2023 (draft)). If operations in an AOA are assumed to grow native or naturalized species only, choosing species strategically by certain life-history characteristics and tailoring operations may help minimize the genetic impacts from fish escapes or released reproductive material. Choosing species with wild populations that have long adult lifespans, overlapping generations, and large population sizes in the region may buffer genetic impacts (Tringali and Bert 1998, Katalinas et al. 2019). Example strategies to minimize genetic effects have used a quantified genetic contribution threshold of below 10% (Waples et al. 2012, Waples et al. 2016). FADs may also effectively mitigate adverse effects of fish escapes due to the large and diverse fish assemblages often found near pens, leading to high mortality of any escaped fish (Dempster et al. 2009, Dempster et al. 2018, Arechavala-Lopez et al. 2018, and Purcell et al. 2023 (draft)). According to the literature in Purcell et al. (2023 draft), Norway has the most extensive monitoring of fish escapes (e.g., Norwegian standard NS 9415: Marine fish farms - Requirements for site survey, risk analyses, design, dimensioning, production, installation, and operation) which may provide example strategies for site-specific planning. Detailed reporting for infrastructure damage may be critical to developing mitigation measures for escapes.

Example measures to reduce ecological, interspecific impacts of escapes have included limiting the number of marine releases of juvenile fish annually. Example BMPs for fish releases from the State are listed in section 6.7.6 of the White Seabass Enhancement Plan (CDFG 2010). Careful planning in engineering designed to be less prone to failure, and rigorous testing to withstand severe ocean conditions and other circumstances that may damage the integrity of gear may mitigate the risk of escapes. Structural failures are the most common way Atlantic salmon escape followed by operational-related failure (Jensen et al. 2010). In a gear guide published for potential offshore aquaculture in the Gulf of Mexico, system analyses included hydrostatic and stability calculations, static tension configurations, and dynamic load assessments (Fredriksson and Beck-Stimpert 2019). Potential scenarios and conditions through construction, harvests, maintenance, storms, and biofouling may be factored into load assessments. Sunny et al. (2024) provides an example for how extreme waves and currents in the offshore environment may be factored into aquaculture design.

Ongoing Monitoring and Coordination outside of the AOA process

Published consultation requirements and permitting guidance is available on NOAA Fisheries Consultations for Essential Fish Habitat website, available online at https://www.fisheries.noaa.gov/national/habitat-conservation/consultations-essential-fish-habitat.

The most up to date CCIEA reports, CalCOFI and NMFS survey data, fisheries data, stock reports, and other regional datasets may be incorporated into site specific NEPA analyses and permitting decisions.

The Southern California Coastal Water Research Project (SCCWRP) is a public intergovernmental agency and aquatic sciences research institute that works to study and develop management strategies for water-quality in the SCB (SCCWRP 2024). Offshore work by SCCWRP includes evaluation of discharges in the offshore environment and monitoring kelp beds. The Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) provides scuba diver visual census data collected at various kelp bed sites throughout the SCB, recording fish abundance and size (NCCOS 2005).

In the absence of specific project designs that would contain project size and production scales, the OMEGA model was used for case studies of candidate aquaculture species in Southern California to consider potential genetic impacts of escapes. The OMEGA reports include example mitigation measures to minimize adverse effects from escapes.

iii. Ecologically-Important Marine Communities

The rules and regulations surrounding ecosystem health that have been set up by Federal and state authorities are based in science and designed to minimize potential impacts (pers. comm. FDA and NOAA 2021). Project-specific proposed mitigation should be consistent with regulations and policy directives described in Chapter 3, Section A.ii. (Federal and State Regulatory Frameworks).

Many potential adverse ecological impacts could be minimized by restrictions on facility size and rate of development under adaptive management (CDFW 2019). Baseline Assessment Plans could be prepared in addition to monitoring plans, with spatial coverage beyond the proposed lease area to account for drift effects (PFMC 2022a). Baseline information could be gathered seasonally and for a minimum of two years to account for natural variability that occurs in the SCB; and used to assess whether the proposed buffers from EFH, HAPCs, deep sea coral and sponges, and hard bottom habitat are sufficient to avoid impacts to those sensitive habitats (PFMC 2022a).

Benthic monitoring with physical and biological indicators may be required for aquaculture projects sited in an AOA, pursuant to MSA and EFH, which could be considered against thresholds of percent change in site-specific habitat and benthic community attributes. Changes in free sediment sulfide concentrations have been used in the Pacific Northwest salmon farming industry as a proxy for changes in the benthic community (Brooks and Mahnken 2003). Benchmarks to minimize impacts on benthic communities from nutrient depositions that have been set by regulatory bodies outside of California include sulfide, zinc, and copper; if the benchmarks are exceeded, the farm is required to lie fallow until the benthos has remediated or returned to pre-farm conditions (CDFG 2010). Using local reference locations as part of monitoring benthic sediments for associated biological risk could be considered (CDFG 2010; Brooks 2004 monitoring report as cited in CDFG 2010; Brooks 2006 monitoring report as cited in CDFG 2012).

The following mitigation recommendations and considerations related to escapes of genetic material are all from literature reviewed in Purcell et al. (2023 draft):

- collection and development of a genetically diverse seedstock or broodstock that is representative of the population most likely to be impacted by the farm site;
- patterns of genetic connectivity over distances greater than a km are likely influenced by oceanographic currents throughout the year, which should be factored into operations' grow-out periods and harvesting schedules;

- aligning aquaculture conditions with natural environmental conditions can reduce selection favoring aquaculture-specific traits and prevent those traits from entering the wild gene pool;
- procuring new broodstock in shellfish aquaculture can minimize inbreeding and maximize genetic diversity within cultured populations, further mitigating genetic risk to wild populations;
- some species of shellfish grow rapidly and can be harvested before sexual maturity;
- to mitigate macroalgae breakage in high-energy environments, growers could allow sufficient time for holdfasts to firmly attach to lines; transplant young sporophytes early to subject them to current velocities to strengthen holdfasts and stipes; and ensure lines are not overcrowded to allow individual holdfasts enough space for attachment; and
- harvesting earlier in the spring compared to summer may lower blade erosion from kelp, and lower rates of reproductive kelp, has been shown if harvested earlier in the spring compared to summer.

The best prevention strategy to avoid adverse impacts via the introduction of invasive species may be to avoid cultivating species outside of their native range (Rhodes et al. 2023a). In addition, the USCG's Navigation and Vessel Inspection Circular 01-18 (USCG 2018) includes practices and methods that are required of the maritime industry to prevent the spread of invasive species. Many of these may be applied to offshore aquaculture facilities as well.

Ongoing Monitoring and Coordination outside of the AOA process

The following resources may be used to incorporate the most up to date and detailed information for site specific NEPA analyses and associated permitting decisions. See also, Chapter 3, Sections C.i. and Cii. for habitat models and species databases.

- The Southern California Coastal Water Research Project Authority has been conducting regional monitoring of the benthic infauna of the SCB for decades (Aquarium of the Pacific 2015). Nearby stations could serve to define the reference baseline conditions for aquaculture facilities sited in an AOA. Publications and data are available online at https://www.sccwrp.org/.
- The Southern California Bight Regional Monitoring Program is a marine monitoring collaboration including participants from regulatory agencies, as well as nongovernmental and academic organizations. The program conducts studies, interprets findings, and releases reports on the ecological health of the Southern California Bight (SCCWRP 2024). The organization's most recent publications and data portal are available online at https://www.sccwrp.org/about/research-areas/regional-monitoring/southern-california-bight-regional-monitoring-program/.
- Kelpwatch.org hosts the world's largest dynamic map of canopy-forming kelp species, which provides visualization and an analysis tool to explore kelp canopy dynamics in the Southern California Bight (Bell et al. 2023, 2024).
- The State's kelp restoration plan is available online at https://wildlife.ca.gov/Conservation/Marine/Kelp/KRMP.

iv. Potentially-Farmed Species

Compliance with the following Federal rules and regulations surrounding animal health, biosecurity planning and disease control may require mitigation measures:

- FDA Veterinary Feed Directives;
- USDA APHIS biosecurity plans;
- NSSP's model ordinances for project operations, FDA jurisdiction (codes enforced by the state);
- Biotoxin management plan according to NSSP HACCP guidance; and
- rules and regulations for "seed" sourcing from licensed facilities, and necessary certifications upon transport to offshore sites through the Regional Shellfish Seed Biosecurity Program.

Many Federal codes for shellfish aquaculture are enforced by the state. CDFW also has a regulatory framework for importation and fish health oversight that coordinates with APHIS. Additional State regulatory conditions that may include mitigation include:

- California Sustainable Oceans Act (2006);
- California Fish and Game Code Section 2118, Sections 5503 and 15300, Section 15007, Sections 15101 and 15102;
- California Fish and Game Code Section 15300; and
- California Code of Regulations, Title 14, §245 - Aquaculture Disease Control Regulations.

The OREHP program provides BMPs for finfish grow-out facilities provided in Sections 6.5; 9.1.5.2; 9.1.6.2; 9.1.7.2; 9.1.8.2; and 9.1.9.2 (CDFG 2010).

Plans that may be encouraged or required for permitting include an operational plan; monitoring plan for abundance and distribution of non-native fouling organisms; marine biotoxin contingency plan; marine biotoxin management plan; harvester training; vibrio risk assessment (for shellfish); reports of accidental release of contaminants, excess feed or waste material (for finfish); and (depending on the market), additional measures that may be required under a NOAA Seafood Inspection Program (SIP) contract (pers. comm. FDA and NOAA 2021). At the State level in California, Hatchery Genetic and Management Plans (HGMPs) are being prepared for all stocks propagated at public finfish hatcheries, submitted for federal review to NMFS to evaluate potential interactions with listed fish stocks (CDFW 2010). All of these could be used as a template for a commercial operation that may be sited in an AOA.

Additional biosecurity resources applicable to organism health include:

- NMFS Northwest Fishery Science Center's (NWFSC's) Review of best practices for biosecurity and disease management for marine aquaculture in US waters (Rhodes et al. 2023b);
- NWFSC's Scientific Support for Health Management and Biosecurity for Marine Aquaculture in the United States (Rhodes et al. 2023a);
- FDA's Guide for molluscan shellfish aquaculture harvesting from Federal waters (FDA, n.d.);
- USDA's National Aquaculture Health Plan and Standards, 2021-2023 (USDA 2021); and
- CDFG's White Seabass Enhancement Plan Best Management Practices (BMPs) for finfish transport (Chapter 5); stocking density (Chapter 6, Section 6.2); and monitoring net pens (Chapter 6, Section 6.5).

Species may be chosen strategically based on comprehensive site analyses, to reduce economic costs and environmental impacts (e.g. knowledge of ambient water temperature and salinity fluctuations, other seasonal changes that may affect organisms, localized predation patterns, finfish species that require the least fishmeal or fish oil inputs, native species only, sterilized animals only, etc.).

Pathogens that may affect offshore aquaculture may not be fully understood until facilities are operational and at scale, and potential mitigation tools for those future pathogens may require research, development, and licensing, before becoming viable solutions (Fujita et al. 2023). When disease outbreaks occur in California hatcheries, the stocks are destroyed and systems disinfected, and this is considered the most economically and environmentally practical approach by the industry (CDFW 2010). Monitoring of appropriate biomass density and health, and reporting any incidents of high mortality could mitigate adverse impacts to cultivated populations. Cannibalism in finfish pens can be reduced by optimizing feeding and nutrition and by grading the fish (CDFW 2010). The control of biofouling in shellfish and finfish marine aquaculture is reviewed in detail on pp. 656 through 662 of Fitridge et al. (2012). Copper alloy mesh is a preventative mitigation against biofouling (pers. comm. NWFSC 2023).

Considering the carrying capacity of the local ecosystem and managing for maximum productivity rather than maximum biomass could reduce adverse impacts of stress on cultivated organisms as well as adverse impacts to the marine environment and biosecurity costs (Diana 2009, Aguilar-Manjarrez et al. 2017). Breeding practices in a culture setting to increase the effective population size as a way to maintain genetic fitness and diversity are described on p. 33 of Purcell et al. (2023 draft). Area management agreements with biosecurity plans are now considered the industry standard in some areas around the world, including Maine (Fujita et al. 2023). There may not be information specific enough to quantify these potential impacts before an operation goes underway, which stresses the importance of monitoring and adaptive management in all projects that may be sited in an AOA. Strict production protocols, with ramped-up steps and incremental proof of concept may be required.

Ongoing Monitoring and Coordination outside of the AOA process

The following are existing seafood safety, sanitation, therapeutant, and drug approval programs as they relate to animal health. For public health topics see Chapter 3, Section D.viii. (Public Health and Safety).

USDA has supported shellfish production research on oyster herpes virus microvariant – 1 (OsHV-1) disease resistance, resilience to ocean acidification, and triploid oyster mortality; NOAA is conducting research to improve the production of sterile oysters, a novel approach that could lead to lower mortality (USDA 2020).

FDA-CVM maintains a list of approved drugs for aquaculture, categorized by the method of administration (e.g. immersion, injectable, medicated feed). The list is available online at https://www.fda.gov/animal-veterinary/aquaculture/approved-aquaculture-drugs.

Alaska Mariculture Alliance maintains a webpage with information on how to start or grow an ocean-based shellfish or seaweed farm, with national resources available. Information is online at https://alaskamariculture.org/resources/.

Ventura Port District's shellfish quality and safety assurance plan (Imodi and Hori 2017), and other materials for offshore shellfish aquaculture are available online at https://venturaharbor.com/vse-archive/.

C. Socioeconomic Environment

i. Commercial Fishing

To mitigate adverse ecological impacts on commercial fisheries, see measures discussed above for Wild Fish Stocks, including fish habitat buffers and appropriate distances between facilities. In the CDFW Draft EIR for Coastal Marine Aquaculture (2019), it states that potential facilities that may be sited in State waters would be required to be separated from one another by an appropriate minimum distance to avoid adverse impacts on water quality and wildlife, and not sited in areas that have a documented record of being important fishing grounds for a given fishery. These limitations could minimize conflict with commercial fishers and allow open water users to be aware of lease locations to avoid collisions with nets or anchor systems (CDFW 2019). The spatial analysis in the Atlas created a foundation for this approach in Federal waters, a due diligence effort to create local optimized marine aquaculture that overlaps with fishing grounds.

As aquaculture projects were sited in an AOA, more comprehensive, project-based site analyses during permitting decisions could help to avoid documented high-use, high-value areas for commercial fishing. Temporal considerations could also be applied to this approach. For example, construction windows that overlap with fishing seasons could be avoided to minimize any area closures for safety and reduce vessel traffic. Strong stakeholder input in any project-specific planning would be necessary for these mitigation measures to be successful.

A carrying capacity strategy has been proposed as a way to cooperatively manage fisheries and marine aquaculture, and has been put into place in Chile, Turkey, Japan, and in New Zealand (Hoagland et al. 2003, Mikkelsen 2007, and Aguilar-Manjarrez et al. 2017). Such a framework would manage for maximum overall economic yield, while accounting for the tradeoffs between rights to fishing quotas and rights to geographic space. Lester et al. (2018b) found that a trade-off, strategic development of up to

25% of the maximum value of mussel farms (used as a proxy for offshore shellfish aquaculture) could reduce the adverse impact in annuity losses to the halibut fishery from greater than $100,000 to less than $4,000 annually, while still generating new value of about $2 billion to the aquaculture sector. Additional potential modeling methods to estimate a carrying capacity between marine aquaculture and fishing effort is described in Hoagland et al. (2003) and in Mikkelsen (2007), which could be used to create parameters for project-specific footprints and production sizes in an AOA. A literature review and more on potential inputs to ecological carrying capacity models is described in Aguilar-Manjarrez et al. (2017).

Conflict with commercial fishers from offshore aquaculture in an AOA could be minimized with these management considerations. However, in the case where conflicts may not be avoided, replacement costs to commercial fleets may be considered (defined in Appendix 3). Historic, regionally-based compensatory mitigation examples from other industries include:

- CCC authorized the use of $4.8 million in mitigation funds to be used for marine fish hatcheries and recovery of fish in the field, paid in 1992 by Southern California Edison (SCE) for environmental effects of the San Onofre Nuclear Generating Station (SONGS) (CDFG 2010); and
- A settlement in 2003 between the CDFG and the British Petroleum for the American Trader oil spill off Huntington Beach (the spill occurred in 1991) ordered $585,000 be paid to CDFG as mitigation for fish killed as a result of the spill (CDFG 2010).

Ongoing Monitoring and Coordination outside of the AOA process

Published consultation requirements and permitting guidance in accordance to MSA and EFH are described in Chapter 3 Section C.ii. (Wild Fish Stocks). The following information may be used by site specific NEPA analyses to ensure the most up to date fisheries and revenue data are included in permitting decisions.

NOAA Fisheries' Office of Sustainable Fisheries posts quarterly fish stock status updates for those managed under federal fishery management plans based on stock assessments completed during that quarter. This information is then compiled in the Status of Stocks Annual Report to Congress. NOAA Office of Science and Technology houses an online data portal for commercial fisheries statistics that include monthly or annual landings by gear or species groups, by major U.S. ports, and by imports online at https://www.st.nmfs.noaa.gov/st1/commercial/.

The PFMC website hosts a large amount of material including Stock Assessments and Fishery Evaluation (SAFE) documents. The annual SAFE reports provide overviews of the fisheries as well as data tables. While the reports do not always provide statistics for specific geographic locations, they do provide overviews.

The CDFW catch block system uses georeferenced ocean locations to manage sustainable fisheries in State and Federal waters by recording the origin location of where fish are caught, anywhere between the coastline to the extent of the EEZ. CDFW has been monitoring statewide fisheries landings and participation since 1916 and releases confidential versions of this data through authorized data requests and non-confidential summaries of this data in landings reports. Understanding how fisheries have developed in space and time is critical for managing fisheries and interpreting interactions with fisheries (Miller et al. 2014a, Free et al. 2022). Catch block charts for Southern California are available online at https://wildlife.ca.gov/Fishing/Commercial.

Incorporating environmental data into stock assessments also provides essential data for fisheries managers. The tools listed here and in Chapter 3 Section C.ii. (Wild Fish Stocks) may inform site specific NEPA permitting decisions. Site specific NEPA analyses may be able to use these, or similar resources, to predict interactions between aquaculture and fisheries.

The Distribution Mapping and Analysis Portal (DisMAP) is an interactive website (available online at https://apps-st.fisheries.noaa.gov/dismap/) designed to provide visualization and analysis tools to better track, understand, and respond to shifting distributions of marine species. It allows users to examine changes in species distributions over time by looking at both location maps as well as graphs of key indicators of a species distribution (changes over time in latitude, depth, range limits). Additionally, a major impact of changing climate and ocean conditions is the large-scale shifts in distributions of many marine species as they attempt to remain within their preferred environmental conditions (e.g., temperature). These shifts in distribution pose a central challenge to fisheries managers as they can and already are affecting commercial and recreational fisheries, and the economies of communities that rely on them. Easy access to information on current and projected future fish distributions can help fisheries managers and the fishing industry better plan for and respond to changes.

The EcoCast mapping tool is another sustainable fisheries tool being developed among academic, NGO, and government agencies to understand fish species and protected species responses to environmental conditions in Southern California. This tool could be applied to aquaculture and fisheries interactions, as it uses real-time and near real-time data to support management responses that can change in space and time, at scales relevant for animal movement and human use (available online at https://coastwatch.pfeg.noaa.gov/ecocast/map_product.html).

Seasketch, based out of UC Santa Barbara, is a marine spatial planning tool for collaboration among stakeholders, monitoring, and compliance. Demonstration projects and tools help inform coordinated resource mapping in the SCB, including work with NOAA and PSMFC. Examples of past and present Seasketch efforts are featured online at https://legacy.seasketch.org/projects/.

ii. Recreational Fishing

Mitigation measures discussed for wild fish stocks and commercial fisheries may also be useful to reduce potential adverse impacts recreational fishers. Generally, BMPs based on the best available science and knowledge gained from current and previous marine aquaculture could consider recreational fishing access and safety. Comprehensive site analyses may help to avoid high-use, high-value areas. Section 3.8 of the BOEM Beta Unit Geophysical Survey EA (2018) lists measures to reduce potential impacts on recreational fishing opportunity in the SCB.

Strong stakeholder input in any project-specific planning may be necessary to implement effective mitigation measures. According to the NMFS National Saltwater Recreational Fisheries Summit Report (2022), there is room for increased collaboration around:

- Collecting baseline data early in the process, including data on human dimensions, in addition to physical and biological data;
- Long-term monitoring to ensure that adverse impacts can be recognized and corrected as they arise;
- Ensuring anglers are aware of scoping and public comment opportunities to share their fishing locations and concerns;
- Creating task forces (or similar groups) that can help to coordinate local involvement in federally-permitted processes; and
- Establishing federal guidance around mitigation and compensation.

As these impacts are better understood, there may be a need for flexibility and creativity on the part of anglers to embrace new opportunities (such as increased availability of new species), as well as on the part of fisheries managers to support anglers as they adapt. There are opportunities to be creative. The AOA programmatic NEPA planning approach is designed to incorporate local knowledge through multiple opportunities for public participation.

<u>Ongoing Monitoring and Coordination outside of the AOA process</u>

All materials listed above for wild fish stocks and commercial fishing may also inform site-specific analyses for recreational fishing.

NMFS WCR, the NWFSC, and the SWFSC are pursuing a collaborative effort with the recreational fishing community between 2024 and 2026 to achieve the goals of the revised saltwater recreational fisheries policy (2015, rev. 2023) through strategies that include outreach, engagement, and collaboration, research, and fisheries management (NMFS 2023l). Information on efforts to support, maintain, and recover resources related to recreational fishing on the west coast are available online at https://www.fisheries.noaa.gov/west-coast/recreational-fishing/west-coast-region-saltwater-recreational-fisheries-implementation.

A CDFW, state-maintained summary of recreational regulations in the SCB, including in-season updates, is available online at https://wildlife.ca.gov/Fishing/Ocean/Regulations/Fishing-Map/Southern.

iii. Markets and Regional Food Systems

Compliance with applicable rules and regulations (Chapter 5) and BMPs associated with aquaculture project siting, construction, operations, maintenance, and decommission may optimize efficiency and mitigate costs to operators and investors. Compliance risks associated with CITES and the Lacey Act could be minimized by limiting broodstock sourcing and shipping products in-state (Rumley 2010). This may benefit California's economy; however, it may not be a reasonable or feasible option for many producers. Compliance with applicable rules and regulations, and BMPs for offshore, in-water activities may reduce potential environmental impacts, which could also support a more low-cost product as well as mitigate potential costs to fisheries.

Collaborative business pathways could mitigate the potential lost advantage of local or regional small businesses to participate in the AOA planning process. These include opportunities for research, private-public collaborations in research and market diversification. A collaborative, distribution process may create a multiplier of positive economic impact and create additional value by involving the activity of additional business and associated jobs (Wright 2020). For examples of existing efforts in the SCB to support local communities with the growth of aquaculture, see Chapter 4, Section A.iii. Vertical and collaborative business pathways are defined in Appendix 3.

New marketing techniques, and the creation of different market segments for wild-caught products has historically mitigated for the adverse impacts of competition between aquacultured and wild-harvested products, and helped stabilize prices for wild-caught fish after the introduction of farmed species to seafood markets (Nelson et al. 2019). A proposal for how wild-capture fisheries may successfully compete with aquaculture products, using an example from Alaska salmon, is provided in Section 4.2 of Valderrama and Anderson (2010).

Comprehensive market analyses based on project design and goals may help mitigate cost and adverse impacts to local and regional markets. For example, aquaculture project designs could report the details of production, including species, weight, product form (frozen, fresh, fileted, round, etc.), and to the extent possible, the destination markets of aquacultured products during the application process and operations. This information would help decision makers understand the potential effects on wild-caught fisheries and markets (PFMC 2022a). This DPEIS may mitigate some of the cost for applicants that site projects in an AOA, if identified, by gathering background information necessary for a project-specific NEPA analysis.

<u>Ongoing Monitoring and Coordination outside of the AOA process</u>

The NMFS Seafood Import Monitoring Program monitors 13 species and species groups, comprising more than 1,100 individual species, to ensure the integrity of seafood entering the U.S. market. The risk-based framework is one of multiple tools the U.S. government employs to combat the issue of IUU fishing and seafood fraud. The program is currently under a comprehensive review to strengthen its impact and effectiveness. Additional U.S. IUUF Task Force recommendations are available in the Federal Register (79 FR 75536, December 18, 2014). Updates can be found online at https://www.fisheries.noaa.gov/international/international-affairs/seafood-import-monitoring-program.

NOAA's Office for coastal management maintains a webpage of databases and tools to conduct economic analyses for marine resources, available online at https://coast.noaa.gov/digitalcoast/topics/economy.html. Other resources to analyze market impacts include:

- NOAA Fisheries National Seafood Strategy (2023), available online at www.fisheries.noaa.gov/s3/2023-08/2023-07-NOAAFisheries-Natl-Seafood-Strategy-final.pdf;
- for macroalgae: Sea Grant's Integrated Financial Model for Kelp Aquaculture, a collaboration with Keene State College, series of YouTube videos are listed in Appendix 5;
- for shellfish: VSE sample business plan for shellfish, available online at https://venturaharbor.com/wp-content/uploads/VSE/23_VSE%20-%2024%20LL%20farm%20-%2010%20year%20v5%20updated%2011.10.20.sl.pdf; and
- for finfish: CDFW Final California Commercial Landings Tables, available online at https://wildlife.ca.gov/Conservation/Marine/Data-Management-Research/MFDE.

iv. Ports and Working Waterfronts

Strong stakeholder input and surveys could be considered in any project-specific planning, once shore side auxiliary facilities and locations were identified. Federal permitting agencies do not have authority to enforce state or local laws. Permit applicants may need to consult with CDFW and other relevant State agencies to ensure that all state required procedures, permits, and fees are anticipated and adhered to, such as for moving products through state waters and landing products at state ports. See Chapter 3 Section A.ii. for information about Federal and State coordination in site specific NEPA analyses.

Ongoing Monitoring and Coordination outside of the AOA process

Information for SCB port resources for aquaculture planning include, but are not limited to:

- Port of San Diego Aquaculture and Blue Technology Program, available online at https://www.portofsandiego.org/waterfront-development/blue-economy;
- Port of Los Angeles Alta Sea public-private ocean institute, available online at https://altasea.org/; and
- Ventura Port District sustainable aquaculture overview, available online at https://venturaharbor.com/sustainable-aquaculture/.

Sea Grant has national initiatives to support sustainable fisheries and aquaculture, and is funding projects nationally for research, technical assistance and education and training programming. Sea Grant's aquaculture portfolio includes a broad range of research and technical assistance efforts to inform marine aquaculture, including knowledge exchange hubs, technical research, social science, and resources for new business owners. More on Sea Grant's aquaculture workforce and coastal community portolio can be found online at https://seagrant.noaa.gov/how-we-work/topics/fisheries-aquaculture/aquaculture/.

The NOAA Fisheries Online Social Indicators Tool, used in Michaelis (2024 (draft)), is available online at https://www.st.nmfs.noaa.gov/data-and-tools/social-indicators/.

v. Tourism and Recreation

Future projects would comply with all permit conditions, lease requirements, and applicable resource management and preservation mandates. Potential mitigation and BMPs/SOPs to minimize or avoid potential adverse impacts to tourism and recreation, based on previous aquaculture permitting and AOA public scoping, could include:

- additional data gathering for comprehensive site analyses, e.g., identification of known recreation sites within a specified distance;
- requirements for stakeholder input on project-specific planning, e.g., consultation with the Coastal Commission or other applicable agency and/or authorized officer(s) of identified recreation areas; and

- deconfliction measures, e.g., scheduling construction and installation to avoid heavy recreational use periods, including major holidays, to the maximum extent feasible, etc.

Ongoing Monitoring and Coordination outside of the AOA process

The following list of references is provided as potential resources for future project-specific analyses.

- NOAA Office of Coastal Management ENOW Explorer,
- CINMS and CINP websites include a variety of reports for the Sanctuary and National Park,
- CDFW MPA monitoring program,
- Southern California Bight Regional Monitoring Program,
- The Partnership for Interdisciplinary Studies of Coastal Oceans Kelp Visual Census
- State kelp restoration plan,
- Visit California monthly research dashboard.

vi. Transportation and Navigation

Future projects would comply with all navigation and vessel regulations and all permit requirements (33 C.F.R. 1223 vessel operating requirements, COLREGs, CG-2554 Private Aids to Navigation permit, USACE Section 10 permit, etc.) adopted to ensure the right of the public to free navigation on all navigable waters of the United States as defined by 33 C.F.R. Part 329. Engineering considerations to minimize the risk of failure for offshore aquaculture equipment include the buoyancy components and mooring systems, the design of anchoring systems (cables, chains, shackles, and anchors) in consideration of average conditions and storms, construction and material requirements for basic equipment (e.g. mesh, cages, and lines) (Fredriksson and Beck-Stimpert 2019). Equipment may need to be checked, maintained, and replaced on a regular basis. Potential mitigation or compliance measures that may be required, based on similar aquaculture projects and comments received during scoping, include:

- appropriate markings for infrastructure and operations (PATONs);
- notification to and coordination with USCG, and the use of Local Notices to Mariners;
- notification to NOAA's Office of Coast Survey has been required as a standard special condition for Section 10 structures and would likely be included with projects sited in an AOA;
- site-specific planning, e.g. Navigation Safety Risk Assessment Plan likely to be requested in the PATON application process, mapping of currents and where ghost gear might end up, etc.
- monitoring and reporting requirements for gear maintenance and line tension;
- best practices regarding gear configurations and deployment, e.g. grow lines for shellfish operations weighted and incapable of floating to the surface, gear should have as small a surface footprint as possible, GPS transponders on gear, secure placement, crew training, etc.;
- immediately report any interactions or accidents such as interactions with non-project vessels and/or gear deployed by those vessels;
- immediately report any loss of aquaculture gear or other infrastructure associated with the facility;
- insurance, bonding requirements, or other financial guarantees to ensure necessary gear cleanup and/or any damages; and
- recommendations for aquaculture vessels to be equipped with AIS.

Ongoing Monitoring and Coordination outside of the AOA process

The following list of references is provided as potential resources for future project-specific analyses:

- AIS,
- OCS Shipping Fairways, Lanes, and Zones for US waters and chart locator/electronic navigational charts,
- Marine Exchange Vessel Traffic Service Los Angeles-Long Beach,
- USCG Navigation Center,

- USCG Navigation and Vessel Inspection Circulars,
- USCG PACPARS report.

vii. Offshore Energy and Public Services

In general, potential mitigation and best management practices for minimizing impacts associated with offshore activities are related to safety and navigation hazards. Best management practices could include emergency and safety plans in case inclement weather or an accident occurs to help reduce impacts, such as a potential oil and sewage pipeline rupture.

Ongoing Monitoring and Coordination outside of the AOA process

Monitoring and coordination outside of the AOA process is ongoing for various offshore activities. Several state and federal agencies manage, regulate, and monitor offshore energy (traditional [oil and gas]), marine minerals, submarine utilities (cables and pipelines), direct ocean-outfalls, vessel traffic, and scientific research and surveys. BOEM and EPA monitor discharge from oil and gas operations under the requirements of the NPDES program. BOEM and USACE monitor sand resources in the OCS and approve beach renourishment projects. Direct ocean-outfalls are also monitored by the EPA under the NPDES program and vessel traffic is monitored in real-time by the USCG under the AIS for vessels 65 ft and larger. Under the CalCOFI program, the state, Scripps Institution of Oceanography, and NOAA monitor and assess oceanographic conditions, distribution and abundance of pelagic fish stocks, and their prey in the California Current ecosystem. All of these ongoing monitoring programs may be important for reducing risk and potential impacts to and from aquaculture operations and offshore activities.

viii. Public Health and Safety

Compliance with USCG navigation safety requirements under 33 C.F.R. 66 for work, including buoys, lights, notice to mariners, maintaining distance, and other regulatory standards are expected to reduce risk of collisions and other mishaps at sea. Adopting some of the corrective and preventative considerations developed for mariners in the USCG Quality Action Team's report on Reducing Fall-Overboard Crew Fatalities may minimize risk to human safety on offshore structures and associated vessels (USCG 2012). Considerations for project site designs and gear configurations could use public information about USCG search and rescue methods to minimize emergency response times and to minimize potential conflicts with other USCG emergency operations.

Engineering designs, proof of concepts, monitoring and maintenance plans, response and contingency plans for spills may also mitigate public health and safety risks related to gear failures and marine debris. Mooring strategies based on prevailing ocean conditions may also help maintain gear integrity. A Basis-of-Design is a standard document used in the U.S. to communicate the engineering criteria, techniques, reasoning and decisions employed to develop an aquaculture system in the offshore environment (Fredriksson and Beck-Stimpert 2019). The Basis-of-Design document includes at a minimum, the following information:

- site characteristics and environmental conditions;
- system analysis and loading;
- design factors to address uncertainty;
- replacement period and risk;
- specification of components;
- system layout and technical drawings;
- auxiliary equipment; and
- deployment and operational protocols.

Requirements may include that all lines utilized by a facility remain taut and in good working condition; net pens would be cleaned and maintained; and any derelict fishing gear or marine debris that may collect on the facility would be removed and disposed of at an appropriate onshore facility to minimize risk of gear failure or interactions with marine debris in the ocean. To mitigate the risk of gear failures, structural performance monitoring has been required as a permit condition for a kelp farm in the SCB (USACE 2021) as well as post-construction and post-removal surveys. Fredriksson et al. (2023) provides a modeling approach to analyze the performance of macroalgae line tension under exposed oceanographic conditions and physical processes that may apply to farming systems with high volume growth. Mooring system response as a function of current and wave forcing magnitudes and directionality is an area that needs substantial attention to reduce uncertainty during the design process (Fredrikkson et al. 2023).

Marine Debris Management and Monitoring Plans may minimize the risk of aquatic pollution. Insurance plans, bond requirements, or other financial guarantees could be applied to permits in order to ensure a project operator would have funds available for any necessary gear clean-up and potential damages from gear failure or marine debris (PFMC 2022a, Sea Grant 2022, and Fujita et al. 2023). Previously permitted aquaculture operations in Federal waters off the Southern California coast were required to implement a Lost/Damaged Fishing Gear Compensation Plan as a condition for their consistency certification from the State (CCC 2014). The State of Maine requires all commercial leaseholders to carry a bond large enough to pay for gear recovery (DMR 2004). Similar measures may be proposed for future facilities sited in Federal waters. Gear marking, and immediate reporting of lost gear may also mitigate impacts from marine debris. West coast fisheries are required to use unique markings, and similar standards could be applied to aquaculture gear. Buffer zones and temporary exclusions during certain activities would minimize potential impacts to public safety around aquaculture facilities.

Establishing a cooperative area management entity may help develop public health and safety mitigation (Aguilar-Manjarrez et al. 2017). Examples where this type of association has been implemented include Chile, China, India, Thailand, the UK, Ireland, Scotland, and Ireland. Information and efforts that were generated in a cooperative manner, within a predictable boundary, helped to create baseline conditions as an ecological unit, inform monitoring systems, and improve early warning systems for potential adverse impacts.

Seafood safety

Compliance with the following regulatory measures and/or state-recommended mitigation may minimize the risk of adverse public health impacts. Recordkeeping and inspectional access are essential components of a HACCP-type seafood system (60 FR 65096). Considerations and components of a biosecurity plan are described on pp. 2 through 4 of Rhodes et al. (2023b). The control of biofouling could help mitigate associated public health and safety concerns associated with animal husbandry. Incorporating suggestions from public comments, as well as from other offshore planning stakeholder engagement in the region can inform mitigation in permitting applications by applying regional knowledge from those who are most familiar with the local conditions at a project site within an AOA.

Existing regulatory mechanisms and programs that would apply to any type of aquaculture seafood product include:

- use of Good Manufacturing Practices, Hazards Analysis, and Preventative Controls under FDA regulations that apply to all seafood (detailed on pp. 94 through 101 of Janasie (2023));
- compliance with the NOAA Fisheries Seafood Inspection Program;
- compliance with FDA critical control points and other consultation requirements for seafood products with FDA and the State;
- compliance with FDA veterinary drug use requirements and guidance for human health topics; and
- consideration of compliance with FGC §5654, which details protocols and recommendations from the OEHHA to minimize public health risks associated with seafood consumption following aquatic oil spills in California.

Using the following resources could also help mitigate cost and confusion during permitting decisions and during operations of seaweed aquaculture projects in an AOA:

- Mitigation requirements under the FDA's PCHF regulation and Seafood HACCP regulations that would likely apply to seaweed farms sited in an AOA are summarized on pp. 9 through 14 of NSGLC (2023).
- The FDA sets maximum daily amounts per common species of macroalgae to prevent humans from consuming too much iodine (Janasie 2023).
- Figure 1 on p. 87 of Janasie (2023) shows a flowchart to help determine what food safety measures would apply to a seaweed farm.
- Best management practices in biosecurity for seaweed and macroalgae (including lab-based enclosed systems) are reviewed on pp. 22 and 23 of Rhodes et al. (2023b).
- An example of best practices for macroalgae operations and maintenance are described in Section 3 on pp. 20 through 28 of Mooney-McAuley et al. (2016).

For shellfish, the NSSP manages seafood safety of shellfish through partnerships among states, and provides guidance on classification of growing areas based on product and water quality testing through regular updates of the Guide for the Control of Molluscan Shellfish (FDA 2020). Guidance for operators to manage the potential presence of human pathogens and the potential presence of toxic substances in shellfish meats are detailed on pp. 32 through 39 of the Guide. The latest version contains provisions for aquaculture harvest in federal waters (3–200 miles from shore), including marine biotoxins. Thresholds for domoic acid and other toxin levels are set by the USDA to trigger actions for shellfish tissues in California (Harvey et al. 2023). Data is compiled by the California Department of Public Health (DPH) from samples collected by a variety of local, tribal, and state partners (CDFW 2010, Harvey et al. 2023). Additional existing programs and protocols applicable to shellfish aquaculture that would minimize risks of seafood safety impacts in shellfish aquaculture include:

- Human health and quality control aspects of the National Shellfish Sanitation Program (NSSP) and Interstate Shellfish Sanitation Conference model ordinances;
- FDA HACCPs;
- USDA seafood labeling rules and standards;
- USDA National Bioengineered Food Disclosure Standard;
- NOAA Fisheries Seafood Inspection Program;
- protocols and recommendations for aquaculture harvests following an oil spill, mandated in State waters under FGC §5654; and
- other consultation requirements for seafood products with the State, as water quality impacts to coastal waters could also affect offshore aquaculture growing areas.

In California, Fish Contaminant Goals (FCGs), used by the OEHHA, are estimates of contaminant levels in fish that pose no significant health risk to individuals consuming fish at a standard consumption rate over a lifetime. FCGs are based solely on public health considerations without regard to economic considerations, technical feasibility, or the counterbalancing benefits of fish consumption (LARWQCB 2011). Advisory Tissue Levels (ATLs), also developed by OEHHA, provide a number of recommended fish servings that correspond to the range of contaminant concentrations found in fish and are used to provide consumption advice to prevent consumers from being exposed to more than certain reference doses, while still encouraging the consumption of fish in quantities that provide significant health benefits (LARWQCB 2011). The EPA and FDA and USDA have issued guidelines for eating fish and shellfish that may contain mercury. The federal advisory can be found online at https://www.epa.gov/mercury/guidelines-eating-fish-contain-mercury. Programs and protocols to finfish and IMTA aquaculture that would minimize risks of seafood safety impacts include:

- 50 C.F.R. § 260 (A) Inspection and Certification of Establishments and Fishery Products for Human Consumption, in accordance with the Agricultural Marketing Act (1946, amended 2016);

- FDA HACCPs;
- FDA veterinary drug use requirements and guidance for human health topics;
- USDA seafood labeling rules and standards;
- USDA National Bioengineered Food Disclosure Standard;
- NOAA Fisheries Seafood Inspection Program;
- protocols and recommendations for aquaculture harvests following an oil spill, mandated in State waters under FGC §5654; and
- other consultation requirements for seafood products with the State, as water quality impacts to coastal waters could also affect offshore aquaculture growing areas.

Ongoing Monitoring and Coordination outside of the AOA process

The USACE Engineering Requirement Provisions can be found online. The FDA maintains an aquaculture seafood regulatory information webpage, available online at https://www.fda.gov/food/seafood-guidance-documents-regulatory-information/aquacultured-seafood.

The FDA NSSP Model Ordinance reference site is online at: https://www.fda.gov/food/guidanceregulation/federalstatefoodprograms/ucm2006754.htm. FDA-maintained information for consumers, specifically, is available online at https://www.fda.gov/food/resources-you-food/seafood.

NOAA maintains a webpage with a seafood inspection manual, a handbook that provides procedures of how services shall be scheduled, planned, conducted, documented and describes services that conform to global activities that harmonize inspection protocols. The manual can be found online at https://fisheries.noaa.gov/national/seafood-commerce-trade/seafood-inspection-manual.

The Interagency Working Group for Farming Seaweeds and Seagrasses reports on opportunities for farming seaweeds and seagrasses to deacidify ocean environments and provide agricultural products, such as livestock feeds. NOAA Sea Grant in many regions of the U.S. is working with the USDA, FDA, and universities on projects that will better develop science and safety protocols for seaweed aquaculture. A list of projects is maintained by the National Sea Grant Law Center.

The Fish Contamination Education Collaborative (FCEC) is the public outreach and education component of the USEPA's program to protect the most vulnerable populations from the health effects of consuming contaminated fish related to the Palos Verdes Shelf Superfund Site. FCEC is a major part of EPA's Institutional Controls program and works in conjunction with monitoring and enforcement efforts.

To help the public choose the fish they eat wisely, the OEHHA provides guidelines for species commonly bought at stores and restaurants. Information is available online at oehha.ca.gov/fish or call (916) 324-7572. Current advisories to recreational fishers and to the public may provide an example and potential sources for aquaculture operators to effectively manage a finfish facility in the area, with concerns related to toxins.

Products cultivated in an AOA may be exported from the region, state, and country. For large, geographic-scale awareness, the FAO Code of Conduct for Responsible Fisheries is a reference for a sustainable use of fisheries and aquaculture resources, with frameworks, agreements and guidelines aiming at securing both human and animal health (Brugere et al. 2010).

ix. Environmental Justice Considerations

The EJ screening and socioeconomic indicators described in this DPEIS could be revisited to ensure that the most up to date census information, and the most up to date tool capabilities, are used at the time of future permitting decisions. Knowledge gained from conducting an early EJ screening process can make early discussions more meaningful and productive and add predictability and efficiency to the permitting process (EPA 2022). Screenings can indicate whether a permitting decision has the potential to cause or contribute to significant public health or environmental impacts, whether a community may be particularly vulnerable to any adverse effects of the proposed permitting action, and whether a community is already disproportionately bearing public health or environmental burdens. A sound screening practice would also provide important information as to whether there are residents of an affected community who could be disproportionately subjected to adverse health, environmental, and/or quality of life impacts on the basis of race, color, or national origin. Best practices for an EJ screening are provided on pp. 8 through 12 of EPA (2022). Proactive mitigation measures that may be incorporated into the terms of a permit are listed on pp. 15 and 16 of EPA (2022).

Strong stakeholder input in any project-specific planning can help mitigate EJ concerns. Stakeholder input is the opportunity in planning to get more information at a more intricate level than census tracts and other data sources. Active engagement can address the vulnerability of basic capabilities and political rights while bringing in a variety of understandings and values regarding the impacts (Schlosberg et al. 2017, CSLC 2018). The stakes for engagement may be much higher for communities with EJ concerns, compared to other scoping efforts. The goal of proactive community engagement is to ensure that the people most affected by the permit have input into the decisions that will impact their lives. Best practices to demonstrate EJ compliance are listed on pp. 17 through 19 of EPA (2022).

Ongoing Monitoring and Coordination outside of the AOA process

The U.S. Ocean Justice Strategy (U.S. Ocean Policy Committee 2023) is the first strategy to advance environmental justice for communities that rely on the ocean for economic, cultural, spiritual, recreational, and food security purposes. The federal document outlines how principles of equity and environmental justice should be integrated into federal ocean activities, including conservation, management of marine resources, and infrastructure projects, as well as practices that the federal government can adopt in order to provide long-term, sustainable benefits for people, communities, and the environment. The document was developed with input from public comments, government-to-government consultation with Tribal Nations, roundtables with U.S. Territories and Native Hawaiian organizations, and a 2023 virtual Ocean Justice Summit.

Outside of the AOA process, the West Coast Ocean Tribal Caucus of the West Coast Ocean Alliance continues to meet and discuss aquaculture and other ocean activities. The Chumash are a member of this caucus and contributed to a guidance document for agencies to engage West Coast Tribes (West Coast Ocean Tribal Caucus 2020). NOAA's Tribal Consultation Handbook was updated recently (NOAA 2023b), and agencies continue to update policies and procedures associated with EJ to be compliant with EOs and other legal frameworks and serve these communities better than in the past. The EPA, a cooperating agency on this PEIS, has developed guidance that can be applied in conjunction with newer administrative requirements to address EJ in assessment of proposed projects in AOAs (EPA 2015a). Coordination with EJ communities may continue beyond the AOA process and address project-specific considerations at the project proposal stage. Community-led workforce development is still in its early stages, with Minorities in Aquaculture (founded in 2020) currently the only minority-led workforce development group active in the industry globally.

In addition to screening tools, Federal community resources that support EJ efforts include:

- U.S Census Bureau's American Community Survey (ACS) releases new data every year in the form of estimates, tables, tools, and analytical reports;
- NMFS Equity and Environmental Justice Strategy is a guide for serving all communities more equitably and effectively;
- The Federal Interagency Working Group on EJ and NEPA Committee have a NEPA Community Guide (2019);
- EPA's EJ website has resources for strategic planning, grants, and other community resources, and publishes the EJScreen: Environmental Justice Screening and Mapping Tool; and

- EPA's Fish Contamination Education Collaborative (FCEC) is the public outreach and education component of the EPA's program to protect the most vulnerable populations from the health effects of consuming contaminated fish related to the Palos Verdes Shelf Superfund Site.

D. Cultural and Historic Environment

i. Tribal Resources and Cultural Practices

When future projects are proposed, Tribal engagement as required by state and federal statutes, executive orders, and other policies may deconflict and mitigate potential adverse impacts to Tribal resources and cultural practices. Mitigation described above for other resource areas may also reduce adverse effects to resources that are important to Tribes and Tribal well-being and relationship with the proposed AOA locations, wildlife, and habitats.

Ongoing Monitoring and Coordination outside of the AOA process

Additional consultation with Tribes may be required if aquaculture operations are proposed in identified AOAs. NOAA and the cooperating agencies authoring the PEIS continue to develop and update policies on engagement with Tribes and addressing Tribal and culture resources. The White House Memorandum "Tribal Consultation and Strengthening Nation-to-Nation Relationships" (2021) requires agencies to formulate detailed plans of action to implement policies and directives of EO 13175. The White House Memorandum "Uniform Standards for Tribal Consultation" (2022) requires that information obtained from Tribes be given meaningful consideration and that agencies should strive for consensus with Tribes or a mutually desired outcome.

In 2023, NOAA issued guidance on Indigenous Knowledge (IK) that centers upon three foundational principles applicable to the use of IK by decision makers: 1) Cause No Harm; 2) Free, Prior and Informed Consent; and 3) Knowledge Sovereignty. These principles are intended to guide the motivation, character, and intent of collaborative initiatives undertaken by NOAA and IK holders. These principles recognize that each indigenous community has its own customs, practices and requirements that may guide IK interactions with outside entities and may restrict how different facets of IK are shared and used by Tribal and non-tribal entities. In 2023, NOAA also issued NOAA Administrative Order (NAO) 218-8A - NOAA Procedures for Government-to-Government Consultation with Federally Recognized Indian Tribal Governments. This NAO strengthens the government-to-government relationship between NOAA and Indian Tribal governments; acknowledges that Indian tribes exercise inherent sovereign powers over their members and territory; and establishes a policy of regular and meaningful consultation and collaboration with Tribal officials to address issues concerning Indian Tribal self-government, Tribal trust resources, and Indian Tribal treaty and other rights.

The California Native American Heritage Commission (CNAHC) toolkits and guidance online provide support for CEQA, Tribal consultation, and protection of cultural resources (CNAHC, 2024). There may be approvals from the state associated with aquaculture operations in which CEQA would become relevant. CDFW's Tribal Communications and Consultation Policy (CDFW 2014) focuses on 12 guiding principles starting with respectful outreach, cooperation, and protection of Tribal cultural and historic resources.

Other organizations have developed guidance that can improve further engagement with Tribes regarding aquaculture development in AOAs in the future. For example, the West Coast Ocean Tribal Caucus published a guidance document (West Coast Ocean Tribal Caucus 2020) that articulates a set of best practices for Tribal consultation.

ii. Non-Tribal Cultural and Traditional Practices

When future projects are proposed, public engagement as required by state and federal statutes, executive orders, and other policies may deconflict and mitigate potential adverse impacts to non-tribal resources and cultural practices. Mitigation described above for other resource areas may also reduce adverse effects to resources that are important to communities and their well-being and relationship with the proposed AOA locations, wildlife, and habitats.

Ongoing Monitoring and Coordination outside of the AOA process

Outside of the AOA identification process, additional public engagement will be required if aquaculture operations are proposed in identified AOAs. In addition, as applicable, enforceable policies in the California Coastal Zone Management Plan will be addressed through federal consistency review of any proposed aquaculture projects.

iii. Archeological Resources

The legal framework for documenting and avoiding archaeological resources is well established, and procedures similar to those associated with other offshore infrastructure development, such as oil and gas and offshore wind, would be expected (e.g., Poti et al. 2020). Design and installation of projects can avoid bottom disturbance in areas where archaeological resources are identified or likely to be present. Most impacts are expected to be avoided through requirements associated with identification and avoidance of archaeological resources and the reporting requirements for inadvertent discoveries that minimize likelihood of looting or other damage from outside sources as projects are proposed and surveys are conducted. Engagement with Tribes, SHPO, THPOs, and ACHP, may reduce potential to impact archaeological resources, regardless of the type of aquaculture proposed.

Ongoing Monitoring and Coordination outside of the AOA process

The NOAA Office of Coast Survey and the California State Lands Commission maintain and update information on wrecks located in the area where the AOAs are proposed. The Channel Islands National Marine Sanctuary conducts seafloor mapping (Channel Islands National Marine Sanctuary n.d.) that may discover new archaeological sites and provide more information about likelihood of archaeological resources in the proposed AOAs. Protocols for archaeological discovery are anticipated for any aquaculture operations proposed in AOAs, as is typical for infrastructure development offshore. For example, BOEM provides guidance on reporting and confidentiality regarding historic sites and discoveries (BOEM 2015).

E. Potential Mitigation for Cumulative Impacts

Siting is an important consideration in mitigating the potential to cause cumulative impacts across activities in the ocean. A site suitability analysis (Morris et al. 2021) and scoping was applied to the development of proposed potential AOAs in Southern California to avoid and minimize impacts prior to identification of proposed potential AOAs. It is anticipated that mitigation measures will be applied at the project-level to further avoid, minimize, and offset impacts in conjunction with authorization processes and statutory compliance for each project. There is potential for aquaculture operations to contribute to vessel traffic and its impacts, water quality reduction, disease, marine debris, fisheries displacement, and other effects in accumulation with other actions. Mitigation aimed at specific impacts, such as vessel strike guidance and water quality standards, will minimize the increment of impact associated with cumulative effects at the project and AOA level. The final mitigation requirements will be a result of authorization and consultation processes that are outside the scope of this DPEIS. It is highly likely that mitigation will be imposed to reduce direct, indirect, and cumulative impacts as part of authorization processes, achieving at minimum, statutory requirements for CAA, RHA, MSA, ESA, MMPA, Coastal Zone Management Act, National Historic Preservation Act, and other applicable laws.

For aquaculture projects in which the impact analysis finds that climate change is likely to exacerbate the adverse effects of the action, an adaptive management approach may be incorporated that includes the following:

- Adequate monitoring of appropriate variables;
- Identification of appropriate triggers related to those variables; and
- Identification of protective measures that can be implemented.

Appendix 2: List of Mass Mortality Events in the California Current Ecosystem

Stranding Location/Date: SBC Summer 2023

Species: California sea lion, Longnose common dolphin

Attributed/Probable Cause: Harmful algal bloom

Citation: https://www.fisheries.noaa.gov/feature-story/toxic-algal-bloom-suspected-dolphin-and-sea-lion-deaths-southern-california

Stranding Location/Date: SBC Summer 2022

Species: California sea lion

Attributed/Probable Cause: Harmful algal bloom

Citation: https://www.fisheries.noaa.gov/feature-story/toxic-algal-bloom-spreads-along-california-coast-poisoning-sea-lions

Stranding Location/Date: Central/Southern California Summer 2022

Species: California brown pelican

Attributed/Probable Cause: Starvation/undetermined

Citation: https://wildlife.ca.gov/News/Archive/cdfw-provides-update-on-california-brown-pelican-stranding-event#gsc.tab=0

Stranding Location/Date: U.S. West Coast 2019-2023

Species: Gray whale

Attributed/Probable Cause: Undetermined

Citation: https://www.fisheries.noaa.gov/national/marine-life-distress/2019-2023-gray-whale-unusual-mortality-event-along-west-coast-and

Stranding Location/Date: Southern California Summer 2017

Species: multiple species of pelagic birds

Attributed/Probable Cause: Domoic acid poisoning (HABs)

Citation: https://www.independent.com/2017/04/25/scores-birds-sea-lions-suffering-likely-domoic-acid-poisoning/

Stranding Location/Date: California, Oregon, Washington 2015-2021

Species: Guadalupe fur seal, Northern fur seal (2015 only)

Attributed/Probable Cause: Malnutrition, ecological factors (prey availability/oceanographic conditions)

Citation: https://www.fisheries.noaa.gov/national/marine-life-distress/2015-2021-guadalupe-fur-seal-and-2015-northern-fur-seal-unusual

Stranding Location/Date: California 2013-2016

Species: California sea lion

Attributed/Probable Cause: Malnutrition in juveniles due to ecological factors (prey shifts)

Citation: https://www.fisheries.noaa.gov/national/marine-life-distress/2013-2016-california-sea-lion-unusual-mortality-event-california

Stranding Location/Date: California 2014-2016

Species: multiple species of pelagic birds

Attributed/Probable Cause: unproductive prey, starvation

Citation: Harvey et al. 2023

Appendix 3: Glossary

This appendix provides meanings for words and phrases as they are to be interpreted in the context of the DPEIS. Whenever possible, definitions come from a Federal source.

Term	Definition
Adaptive Management	That which "improves the management of biological resources over time by using new information gathered through monitoring, evaluation, and other credible sources as they become available, and adjusts management strategies and practices to assist in meeting conservation and management goals" (CFGC § 13.5).
AOA Alternative(s)	(for the AOA NEPA process).
AOA Option(s)	These are the modeling results - the areas with the highest relative suitability scores within each study area • For Southern California: Modeling results identified ten AOA options. • For Gulf of Mexico: Modeling results identified nine AOA options.
Aquaculture	See Chapter 1, Section A for characterization of this term.
Aquaculture Facility	"Any land, structure, or other appurtenance that is used for aquaculture" (85 FR 28471).
Aquaculture Literacy	"A community's familiarity with information about aquaculture and related environmental, economic, and social topics" (NMFS 2022g).

Term	Definition
Aquaculture Opportunity Area (AOA)	A defined geographic area that NOAA has evaluated through both spatial analysis and the programmatic National Environmental Policy Act (NEPA) process and may be environmentally, socially, and economically appropriate to support multiple commercial aquaculture operations.
Aquaculture Project	“A project to develop the physical assets designed to provide or support services to activities in the aquaculture sector, including projects for the development or construction of an aquaculture facility” (85 FR 28471). The EPA also defines an aquaculture project as “a defined managed water area which uses discharges of pollutants into that designated area for the maintenance or production of harvestable freshwater, estuarine, or marine plants or animals” (40 C.F.R. § 122.25(b)(1)).
Archaeological Resources	“Any material remains of human life or activities that are at least 50 years of age and of archaeological interest“(30 C.F.R. § 251.1).
Areas of Special Biological Significance (ASBS)	Areas monitored and maintained for water quality by the California State Water Resources Control Board that support an unusual variety of aquatic life, and often host unique individual species; and are considered to be basic building blocks for a sustainable, resilient coastal environment and economy (SWRCB 2021).
Authorization	“Any license, permit, approval, finding, determination, or other administrative decision issued by an agency that is required or authorized under Federal law in order to implement a proposed action” (40 C.F.R. § 1508.1).
Benefit Transfer (see also, “Damages Avoided,” and “Replacement Costs”)	An economic impact method of study that measures certain results of a project or action that alleviate some need to provide other services (Lovett 2022).
Biodeposition	The process by which living organisms deposit organic materials, such as feces and pseudofeces, that fall to the sediment. Increased sedimentation via biodeposition can alter the characteristics and community composition of the benthic environment (Weise et al. 2009). The increase of organic matter could serve as an additional food source for benthic organisms, and may lead to habitat degradation (Cranford et al. 2006).

Term	Definition
Biofouling, or, Fouling Organisms	"Biofouling is the attachment of organisms to a surface in contact with water over time, and begins with the growth of a biofilm (slime layer), which occurs on a marine surface under the right conditions. Biofilm growth can progress to a point where it provides a foundation for seaweed, barnacles, and other organisms, some of which may be invasive species" (USCG 2015).
Biogeography	"The study of the relationship of species' distribution patterns relative to geographical differences in the environment." Classifications are made using "biogeographic regions, provinces, and life zones. Biogeographic regions are related to global climatic zones, with latitudinal differences in ranges of temperature, day length, and primary production." (NCCOS 2005).
Biotoxin	"Biological poisons (biotoxins) are water pollutants produced by microbes, animals or plants that can cause illness or death in humans, pets, fish, livestock, and birds" (EPA 2015b).
Blue Economy, Blue Growth	"The sustainable use of ocean resources for economic growth, improved livelihoods and job creation" (NOAA 2022b).
Blue Food(s)	"Aquatic foods captured or cultivated in marine and freshwater systems, to meet rising population and income-driven demand" (Naylor et al. 2021).
Closed Containment	Finfish aquaculture infrastructure that separates physically the 'internal' farm environment from the 'external' ambient environment. Physical separation allows isolation of the farm population from potentially-harmful ambient risks [to the environment]… [this type of infrastructure introduces] the need to intake, circulate, and discharge water, as well as maintain its quality to support fish health and growth." (Chu et al. 2020, as cited in Fujita et al 2022).

Term	Definition
Coastal Zone	The coastal zone is defined under 16 U.S.C. § 1453(1)) as "the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each other and in proximity to the shorelines of the several coastal states, and includes islands, transitional and intertidal areas, salt marshes, wetlands, and beaches. The zone extends, in Great Lakes waters, to the international boundary between the United States and Canada and, in other areas, seaward to the outer limit of State title and ownership under the Submerged Lands Act (43 U.S.C. 1301 et seq.), the Act of March 2, 1917 (48 U.S.C. 749) [48 U.S.C. 731 et seq.], the Covenant to Establish a Commonwealth of the Northern Mariana Islands in Political Union with the United States of America, as approved by the Act of March 24, 1976 [48 U.S.C. 1801 et seq.], or section 1 of the Act of November 20, 1963 (48 U.S.C. 1705), as applicable. The zone extends inland from the shorelines only to the extent necessary to control shorelands, the uses of which have a direct and significant impact on the coastal waters, and to control those geographical areas which are likely to be affected by or vulnerable to sea level rise. Excluded from the coastal zone are lands the use of which is by law subject solely to the discretion of or which is held in trust by the Federal Government, its officers or agents." Additionally, California PRC § 30103(a) defines California's Coastal Zone as "that land and water area of the State of California from the Oregon border to the border of the Republic of Mexico, specified on the maps identified and set forth in Section 17 of Chapter 1330 of the Statutes of 1976, extending seaward to the state's outer limit of jurisdiction, including all offshore islands, and 11 extending inland generally 1,000 yards from the mean high tide line of the sea. In significant coastal estuarine, habitat, and recreational areas it extends inland to the first major ridgeline paralleling the sea or five miles from the mean high tide line of the sea, whichever is less, and in developed urban areas the zone generally extends inland less than 1,000 yards. The coastal zone does not include the area of jurisdiction of the San Francisco Bay Conservation and Development Commission, established pursuant to Title 7.2 (commencing with Section 66600) of the Government Code, nor any area contiguous thereto, including any river, stream, tributary, creek, or flood control or drainage channel flowing into such area".

Term	Definition
Collaborative Business Pathway(see also, Vertically-Integrated Business Pathway)	A business that is new and starting out in aquaculture hoping to leverage existing connections and resources in the commercial fishing industry or allied marine trades (NCCOS 2022).
Concentrated Aquatic Animal Production (CAAP) facility	Defined according to discharge frequency and production level – cold-water facilities that discharge at least 30 days per year, produce more than 20k lbs of fish per year, and use 5k lbs or more of feed per month; warm-water facilities that discharge at least 30 days per year and produce at least 100k lbs fish per year (40 C.F.R. § 122.24(a)).
Controlled Unclassified Information	"Information that requires safeguarding or dissemination controls pursuant to and consistent with applicable law, regulations, and government-wide policies but is not classified" (NARA 2019).
Cooperating Agency	"Any Federal agency (and a State, Tribal, or local agency with agreement of the lead agency) other than a lead agency that has jurisdiction by law or special expertise with respect to any environmental impact involved in a proposal (or a reasonable alternative) for legislation or other major Federal action that may significantly affect the quality of the human environment" (40 C.F.R. § 1508.1(e)).
Critical Habitat	"Specific areas within the geographical area occupied by the species at the time of listing that contain physical or biological features essential to conservation of the species and that may require special management considerations or protection; and specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation" (NMFS 2024f).

Term	Definition
Culture	“Under the National Historic Preservation Act, 54 U.S.C. § 300101 et seq., the National Register of Historic Places’ definition of “culture” illustrates the types of information that may be culturally sensitive. It defines, “culture” to mean the traditions, beliefs, practices, lifeways, arts, crafts and social institutions of any community… Traditional Cultural Properties are those properties eligible for listing on the National Register of Historic Properties based on its associations with the cultural practices, traditions, beliefs, lifeways, arts, crafts or social institutions of a living community… The traditional cultural significance of a historic property is derived from the role the property plays in a community’s historically rooted beliefs, customs and practices” (NOAA 2023c).
Cumulative Effects (see also “Effects”)	“Effects on the environment that result from the incremental effects of the action when added to the effects of other past, present, and reasonably foreseeable actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time" (40 C.F.R. § 1508.1 (g)(3)).
Damages Avoided (see also, “Benefit Transfer,” and “Replacement Costs”)	Economic impact method of study that “measures the value of property protected, or the costs of actions taken to avoid damages” (Lovett 2022).
De Facto MPA	An area of the ocean where access or activities are restricted by law for reasons other than conservation or natural resource management (National Marine Protected Areas Center 2008).
Deepwater Port	“Any fixed or floating manmade structure other than a vessel, or any group of such structures, that are located beyond state seaward boundaries and that are used or intended for use as a port or terminal for the transportation, storage, or further handling of oil or natural gas for transportation to or from any State, except as otherwise provided in section 1522 of this title, and for other uses not inconsistent with the purposes of this chapter, including transportation of oil or natural gas from the United States outer continental shelf” (33 U.S.C § 1502 (9)(a)).

Term	Definition
Designated Project Area	The EPA defined this as "portions of the waters of the United States within which the permittee or permit applicant plans to confine the cultivated species, using a method or plan or operation (including, but not limited to, physical confinement) which, on the basis of reliable scientific evidence, is expected to ensure that specific individual organisms comprising an aquaculture crop will enjoy increased growth attributable to the discharge of pollutants, and be harvested within a defined geographic area" (40 C.F.R. § 122.25(b)(2)).
Direct Effects	see "Effects"
Disease	"A clinical or non-clinical infection with one or more pathogenic agents (from WOAH Aquatic Code), characterized by specific signs or symptoms in which normal functions are disturbed or altered at a cellular, tissue, organ, or whole-organism level" (Rhodes et al. 2023a).
Economic Benefit	Market and nonmarket values that impact social welfare (ERG 2021).
Economic Contribution	The gross change in economic activity associated with an industry, event, or policy in an existing regional economy (ERG 2021).
Economic Cost	Monetary payments from one group to another that affect resources available to society and yield net reduction in social welfare (ERG 2021).
Economic Impact	The net changes in new economic activity associated with an industry, event, or policy in an existing regional economy that otherwise wouldn't happen in the absence of the industry, event, or policy (ERG 2021).
Ecosystem Approach to Aquaculture (EAA)	"A strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity, and resilience of interlinked social-ecological systems" (FAO 2010).

Term	Definition
Ecosystem-Based Fishery Management (EBFM)	"A systematic approach to fisheries management in a geographically specific area that contributes to the resilience and sustainability of the ecosystem; recognizes the physical, biological, economic, and social interactions among the affected fishery-related components of the ecosystem, including humans; and seeks to optimize benefits among a diverse set of societal goals" (NMFS 2016b).
Effects	"Effects or impacts means changes to the human environment from the proposed action or alternatives that are reasonably foreseeable and include the following: (1) Direct effects, which are caused by the action and occur at the same time and place. (2) Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems. (3) Cumulative effects, which are effects on the environment that result from the incremental effects of the action when added to the effects of other past, present, and reasonably foreseeable actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time. (4) Effects include ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Effects may also include those resulting from actions which may have both beneficial and detrimental effects, even if on balance the agency believes that the effects will be beneficial" (40 C.F.R. § 1508.1 (g)).
Effective Communication	"Communication sufficient to provide the Limited English Proficient (LEP) individual with substantially the same level of access to services and information received by individuals who are not LEP" (EPA 2011b).

Term	Definition
El Niño Southern Oscillation	“The Oceanic Niño Index (ONI) describes the equatorial El Niño Southern Oscillation (ENSO). An ONI above 0.5°C indicates El Niño conditions, associated with lower primary production, weaker upwelling, poleward transport of equatorial waters and species, and more southerly storm tracks in the CCE. An ONI below -0.5°C means La Niña conditions, which create atmospheric pressure conditions leading to upwelling-favorable winds driving productivity in the CCE” (Harvey et al. 2023).
Environmental Justice	The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (SOST 2021).
Essential Fish Habitat	“Waters and substrates necessary to fish for spawning, breeding, feeding or growth to maturity” (16 U.S.C. § 1802(10)). NOAA regulations further define EFH by specifying that ““necessary” means the habitat required to support a sustainable fishery and the managed species contribution to a healthy ecosystem” (50 C.F.R. § 600.10).
Essential Fish Habitat Conservation Areas	“Spatially discrete areas of particularly sensitive or productive benthic habitats where fishing with some or all types of bottom-contact fishing gear is prohibited” (PFMC 2022a).

Term	Definition
Exclusive Economic Zone	“The U.S. Exclusive Economic Zone (EEZ) extends no more than 200 nautical miles from the territorial sea baseline and is adjacent to the 12 nautical mile territorial sea of the U.S., including the Commonwealth of Puerto Rico, Guam, American Samoa, the U.S. Virgin Islands, the Commonwealth of the Northern Mariana Islands, and any other territory or possession over which the United States exercises sovereignty. Within the EEZ, the U.S. has: Sovereign rights for the purpose of exploring, exploiting, conserving and managing natural resources, whether living and nonliving, of the seabed and subsoil and the superjacent waters and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds; Jurisdiction as provided for in international and domestic laws with regard to the establishment and use of artificial islands, installations, and structures, marine scientific research, and the protection and preservation of the marine environment; and other rights and duties provided for under international and domestic laws. Note: Under certain U.S. fisheries laws, such as the Magnuson-Stevens Fishery Conservation and Management Act, the term "exclusive economic zone" is defined as having an inner boundary that is coterminous with the seaward (or outer) boundary of each of the coastal states. While its outer limit is the same as the EEZ on NOAA charts, its inner limit is coterminous with the coastal states' boundary at 3 nautical miles, except for Texas, western Florida, and Puerto Rico, which claim a 9 nautical mile belt” (NOAA 2023d).
Fallowing	The practice of relocating or not restocking marine fish cages to allow the sediment below to recover naturally, both geochemically and ecologically, from the nutrient loading impacts. This is a method to prevent damage to benthic environments (Price and Morris 2013).
Fecundity	“The potential reproductive capacity of an organism or population expressed in the number of eggs (or offspring) produced during each reproductive cycle. Fecundity usually increases with age and size. The information is used to compute spawning potential.” (Blackhart et al. 2006).

Federal Action	Related to the Coastal Zone Management Act, Federal action means an activity or series of activities when coastal effects are reasonably foreseeable, to physically alter coastal resources, a plan that is used to direct future agency actions, or a proposed rulemaking that alters uses of the coastal zone; also includes modifications of any such activity or development project which affect any coastal use or resource (15 C.F.R. § 930.31(a)). "Major Federal action or action means an activity or decision subject to Federal control and responsibility subject to the following: (1) Major Federal action does not include the following activities or decisions: (i) Extraterritorial activities or decisions, which means agency activities or decisions with effects located entirely outside of the jurisdiction of the United States; (ii) Activities or decisions that are non-discretionary and made in accordance with the agency's statutory authority; (iii) Activities or decisions that do not result in final agency action under the Administrative Procedure Act or other statute that also includes a finality requirement; (iv) Judicial or administrative civil or criminal enforcement actions; (v) Funding assistance solely in the form of general revenue sharing funds with no Federal agency control over the subsequent use of such funds; (vi) Non-Federal projects with minimal Federal funding or minimal Federal involvement where the agency does not exercise sufficient control and responsibility over the outcome of the project; and (vii) Loans, loan guarantees, or other forms of financial assistance where the Federal agency does not exercise sufficient control and responsibility over the effects of such assistance (for example, action does not include farm ownership and operating loan guarantees by the Farm Service Agency pursuant to 7 U.S.C. 1925 and 1941 through 1949 and business loan guarantees by the Small Business Administration pursuant to 15 U.S.C. 636(a), 636(m), and 695 through 697g). (2) Major Federal actions may include new and continuing activities, including projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by Federal agencies; new or revised agency rules, regulations, plans, policies, or procedures; and legislative proposals (§ 1506.8 of this chapter).

Term	Definition
	(3) Major Federal actions tend to fall within one of the following categories: (i) Adoption of official policy, such as rules, regulations, and interpretations adopted under the Administrative Procedure Act, 5 U.S.C. 551 et seq. or other statutes; implementation of treaties and international conventions or agreements, including those implemented pursuant to statute or regulation; formal documents establishing an agency's policies which will result in or substantially alter agency programs. (ii) Adoption of formal plans, such as official documents prepared or approved by Federal agencies, which prescribe alternative uses of Federal resources, upon which future agency actions will be based. (iii) Adoption of programs, such as a group of concerted actions to implement a specific policy or plan; systematic and connected agency decisions allocating agency resources to implement a specific statutory program or executive directive. (iv) Approval of specific projects, such as construction or management activities located in a defined geographic area. Projects include actions approved by permit or other regulatory decision as well as Federal and federally assisted activities" (40 C.F.R. § 1508.1(q)).
Federal Consistency	"Fully consistent with the enforceable policies of management programs unless full consistency is prohibited by existing law applicable to the Federal agency" (15 C.F.R. § 930.32(a)(1)); "effects are determined by looking at reasonably foreseeable direct and indirect effects on any coastal use or resource" (15 C.F.R. § 930.33(a)(1)).
Federal Waters	"Defined as having an inner boundary coterminous with the seaward (or outer) boundary of the state of California. This is coterminous with the boundary of most coastal states at 5.6 km (3.0 nm). The outer boundary, established by Presidential Proclamation 50308 and consistent with the UN Convention of the Law of the Sea, extends out to the 370-km (200-nm) limit" (Morris et al. 2021).

Term	Definition
Fetch	"1. The area in which ocean waves are generated by the wind. Also refers to the length of the fetch area, measured in the direction of the wind. 2. In hydrologic terms, ● The effective distance which waves have traversed in open water, from their point of origin to the point where they break. ● The distance of the water or the homogenous type surface over which the wind blows without appreciable change in direction." (NOAA 2009b).
Finfish	"Vertebrate and cartilaginous fishery species, not including crustaceans, cephalopods, or other mollusks" (Blackhart et al. 2006).
Fish Haven	Defined as artificial reefs or submerged structures deliberately constructed or placed on the seabed to emulate a natural reef, by protecting, regenerating, concentrating, and/or enhancing populations of living marine resources (Fabi et al. 2015).
Fishing Community	"A community which is substantially dependent on or substantially engaged in the harvesting or processing of fishery resources to meet social and economic needs, and includes fishing vessel owners, operators, and crew and US fish processors that are based in such a community" (16 U.S.C. § 1802(17)); "A social or economic group whose members reside in a specific location and share a common dependency on commercial, recreational, or subsistence fishing or on directly related fisheries-dependent service and industries (for example, boatyards, ice suppliers, tackle shops)"(50 C.F.R. § 600.345(b)(3)).
Food Fish	Fish destined for human consumption, excluding fish for non-food uses (fish oil, fish food, etc.) (FAO 2020a).
Food Resilience	"The capacity over time of a food system and its units at multiple levels, to provide sufficient, appropriate and accessible food to all, in the face of various and even unforeseen disturbances" (Tendall et al. 2015).

Term	Definition
Food Security	“When all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs for a productive and healthy life” (FAO et al. 2017).
Genetically Modified Organism, Transgenic Organism	“A plant, animal, or microorganism that has had its genetic material (DNA) changed using technology that generally involves the specific modification of DNA, including the transfer of specific DNA from one organism to another” (FDA 2023b).
Historic Property (see also, “Archeological Resources”)	Any prehistoric or historic district, site, building structure or object included or eligible for inclusion in the NRHP, maintained by the Secretary of the Interior (NPS), including artifacts, records, and material remains that are related to and located within such properties; properties of tradition religious and cultural importance to a tribe may be eligible (36 C.F.R. § 800.16(l)(1)).
Human Environment	“Means comprehensively the natural and physical environment and the relationship of present and future generations of Americans with that environment” (40 C.F.R. § 1508.1(m)).
Impacts	see “Effects”
Indigenous	“Peoples of long settlement and connection to specific lands who have been adversely affected by incursions by industrial economies, displacement, and settlement of their traditional territories by others” (UBC 2009a). “Under international law, there is no official definition of Indigenous, although the United Nations generally identifies Indigenous groups as autonomous and self-sustaining societies that have faced discrimination, marginalization and assimilation of their cultures and peoples due to the arrival of a larger or more dominant settler population” (UBC 2009b).
Indirect Effects	see “Effects”

Term	Definition
Invasive Species, aka nonnative species	“Species that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat. Through their impacts on natural ecosystems, agricultural and other developed lands, water delivery and flood protection systems, invasive species may also negatively affect human health and/or the economy” (CNRA 2008).
La Nina	(see EL Niño Southern Oscillation (ENSO))
Lead Agency	“The agency or agencies, in the case of joint lead agencies, preparing or having taken primary responsibility for preparing the environmental impact statement” (40 C.F.R. § 1508.1 (o)).
Limited English Proficient (LEP) Individuals	“Individuals who do not speak English as their primary language and who have a limited ability to read, write, speak, or understand English” (EPA 2011b).
Local (see also, Regional)	“Considered to be the marine waters of the Southern California Bight Ecosystem (the CA Bight), from Point Conception to the north, to the United States/Mexico border to the south, encompassing the Channel Islands. Local/regional is also considered to include the coastal Counties of Santa Barbara, Ventura, and Los Angeles, agencies that serve constituents within those counties, and the communities that work, live, or otherwise have a social, economic, or cultural connection there” (NMFS 2023a).
Macroalgae Marine Algae/Seaweed	“‘Seaweed’ is the common name for countless species of marine plants and algae that grow in the ocean as well as in rivers, lakes, and other water bodies” (NOAA 2024e).
Marine Aquaculture	See Chapter 1, Section A for characterization of this term.

Term	Definition
Marine Debris	"Any persistent, manufactured, or processed solid material that is directly or indirectly, intentionally or unintentionally, disposed of, or abandoned in, the marine environment. Marine debris can include a wide variety of objects (e.g., lost fishing gear, lost vessel cargo, plastics, metal military debris) from multiple sources (e.g., stormwater runoff, landfills, recreational and commercial activities, military activities)" (ONMS 2019).
Marine Heatwave	"Times when normalized SSTa >1.29 s.d. (90th percentile) of the long-term SSTa time series at a location, and 2) lasts for >5 days; these are analogous to the thresholds suggested in Hobday et al. (2016); large heatwaves are defined as those with an area >400,000 km^2 (these denote the top 20% of all heatwaves by area as measured since 1982 when satellite data became available for tracking)" (Harvey et al. 2023).
Marine Wildlife	For the purpose of this DPEIS, this term includes all marine mammals, sea turtles, seabirds, sharks and rays, benthic organisms, other invertebrates and/or other lower trophic levels that may or may not be protected under state and federal regulations but contribute to the natural, baseline biological communities within the area of interest.
Market Values (see also, "Non-market Values")	"Economic values based on items that are bought and sold" (Lovett 2022).
Mass Mortality Event	"Strandings of multiple animals (sea turtles or marine mammals, excluding cetacean cow/calf pairs) simultaneously within a defined area" (NMFS 2024a).
Maximum Sustainable Yield	"MSY is the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological, environmental conditions and fishery technological characteristics (e.g., gear selectivity), and the distribution of catch among fleets"(50 C.F.R. § 600.310(e)(1)(i)(A)).

Term	Definition
Mitigation	"Mitigation means measures that avoid, minimize, or compensate for effects caused by a proposed action or alternatives as described in an environmental document or record of decision and that have a nexus to those effects. While NEPA requires consideration of mitigation, it does not mandate the form or adoption of any mitigation. Mitigation includes: (1) Avoiding the impact altogether by not taking a certain action or parts of an action. (2) Minimizing impacts by limiting the degree or magnitude of the action and its implementation. (3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment. (4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action. (5) Compensating for the impact by replacing or providing substitute resources or environments" (40 C.F.R. § 1508.1 (s)).
National Consistency	A common framework for processes, products, or timelines that contribute to the overall outcome of successful AOA selection, with the purpose of (1) Leads to a common understanding of AOAs (2) Creates predictability in the process for external stakeholders and for internal coordination (3) Ensures the value of AOAs is consistent for industry and other targeted stakeholders across regions (4) Promotes efficiencies in implementing AOAs across regions (OAQ unpublished internal notes 2021) (https://docs.google.com/document/d/1wg57lkhzInTBhc4EplKItpf0LwbcBy40HojdQun_oVM/edit)
Non-market Values (see also, "Market Values")	"Value of goods and services that are not bought or sold, but still have economic value" (Lovett 2022).
Nondestructive	"Actions that do not result in permanent physical alteration of a component of the human environment. Passive acoustics, ground penetrating radar, and air quality sampling are examples of nondestructive methods to collect environmental data" (NOAA 2017).
Ocean-related Matters	"Management, science, and technology matters involving the ocean, coastal, and Great Lakes waters of the US (including its territories and possessions), and related seabed, subsoil, waters superadjacent to the seabed, and natural resources" (83 FR 29431).

Term	Definition
Offshore Aquaculture	See Chapter 1, Section A for characterization of this term.
Operating Area (OPAREA)	An area "where national defense training exercises and system qualification tests are routinely conducted. OPAREA boundaries are formally established by national designation and by international treaty for national defense training purposes. OPAREAs allow for specific exercises and training events to be coordinated with other federal, state, and local agencies, and also the general public using the Local Notice to Mariners" (OCM 2024).
Opportunity Cost (see also, "Travel Cost")	What people give up to go somewhere or participate in something (Lovett 2022).
Optimum Yield	"The amount of fish that will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities and taking into account the protection of marine ecosystems; that is prescribed on the basis of the Maximum Sustainable Yield (MSY) from the fishery, as reduced by any relevant economic, social, or ecological factor; and, in the case of an overfished fishery, that provides for rebuilding to a level consistent with producing the MSY in such fishery" (50 C.F.R. § 600.310 (e)(3)(i)(A)).
Participating Agency	"A Federal, State, Tribal, or local agency participating in an environmental review or authorization of an action" (40 C.F.R. § 1508.1(w)).
Pathogen	Viruses (intracellular pathogens and are wholly dependent upon the host cell for persistence and replication), bacteria (opportunistic organisms that replicate independently of a host, colonize a host that cannot limit or eliminate the bacteria, usually due to injury, stress, other illnesses, or a compromised immune system), and parasites (e.g., protozoa, fungi, worms) (Rhodes et al. 2023a).
Point Source (see also, source)	"Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged" (33 U.S.C. § 1362(14)).

Term	Definition
Pollutant	“Any substances in water, soil, or air that degrade the natural quality of the environment, offend the senses of sight, taste, or smell, or cause a health hazard. The usefulness of the natural resource is usually impaired by the presence of pollutants and contaminants” (EPA 2024c). Additionally, the Clean Water Act § 502(6) defines a “pollutant” as “dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water. This term does not mean (A) "sewage from vessels" within the meaning of section 1322 of this title; or (B) water, gas, or other material which is injected into a well to facilitate production of oil or gas, or water derived in association with oil or gas production and disposed of in a well, if the well-used either to facilitate production or for disposal purposes is approved by authority of the State in which the well is located, and if such State determines that such injection or disposal will not result in the degradation of ground or surface water resources.”
Principal Port	“Principal Ports are politically defined by port limits or US Army Corps of Engineers (USACE) projects, excluding non-USACE projects not authorized for publication. The determination for the published Principal Ports is based upon the total tonnage for the port for the particular year; therefore the top 150 list can vary from year to year” (USGCRP 2013).
Private Aids to Navigation (PATON)	“Includes all marine aids to navigation operated in the navigable waters of the United States other than those operated by the Federal Government or those operated in State waters for private aids to navigation” (33 C.F.R. § 66.01(b)).
Project Sponsor	“Means an entity, including any private, public, or public-private entity that seeks an authorization for an aquaculture project” (85 FR 28471).

Term	Definition
Reasonable Alternatives	"Means a reasonable range of alternatives that are technically and economically feasible, and meet the purpose and need for the proposed action" (40 C.F.R. § 1508.1 (z)).
Reasonably Foreseeable Future Actions	40 C.F.R. § 1508.1(aa) defines "Reasonably foreseeable" as "sufficiently likely to occur such that a person of ordinary prudence would take it into account in reaching a decision." In addition, 43 C.F.R. § 46.30 defines "Reasonably foreseeable future actions" as "those federal and non-federal activities not yet undertaken, but sufficiently likely to occur, that a Responsible Official of ordinary prudence would take such activities into account in reaching a decision. These federal and non-federal activities that must be taken into account in the analysis of cumulative impact include, but are not limited to, activities for which there are existing decisions, funding, or proposals identified by the bureau. Reasonably foreseeable future actions do not include those actions that are highly speculative or indefinite."
Regenerative	Methods of producing food "whether on land or at sea in ways that actively restore habitat and protect biodiversity in and around production areas while reducing greenhouse gas emissions" (Doane 2020).
Region/Regional (see also, "Local")	"Considered to be the marine waters of the Southern California Bight Ecosystem (SCB), from Point Conception to the north, to the United States/Mexico border to the south, encompassing the Channel Islands. Local/regional is also considered to include the coastal Counties of Santa Barbara, Ventura, and Los Angeles, agencies that serve constituents within those counties, and the communities that work, live, or otherwise have a social, economic, or cultural connection there" (NMFS 2023a).
Regional Ocean Partnership	"A regional organization of coastal or Great Lakes States, territories, or possessions voluntarily convened by governors to address cross-jurisdictional ocean matters, or the functional equivalent of such a regional ocean organization designated by the governor or governors of a State or States" (83 FR 29431).

Term	Definition
Replacement Costs (see also, “Benefit Transfer,” and “Damages Avoided”)	Economic impact method of study that measures the “amount of money that an entity would have to pay to replace an asset at the present time, according to its current worth” (Lovett 2022).
Risk Assessment	“A process of evaluation including the identification of the attendant uncertainties, of the likelihood and severity of an adverse effect(s)/ event(s) occurring to man or the environment following exposure under defined conditions to a risk source(s). A risk assessment comprises hazard identification, hazard characterization, exposure assessment, and risk characterization” (FAO 2020b).
Sanitary Survey	“A sanitary survey is a comprehensive review and inspection to evaluate the adequacy of the water system to provide safe drinking water. The comprehensive evaluation and inspection must include: 1) sources of supply, 2) treatment facilities, 3) distribution system, 4) finished water storage, 5) pumps, pump facilities, and controls, 6) monitoring, reporting, and data verification, 7) system management and operation, and 8) operator compliance with State requirements. The sanitary survey includes an in-office file review and a physical field visit inspection” (SWRCB 2017).
Scoping	CEQ describes scoping as agencies using “an early and open process to determine the scope of issues for analysis in an environmental impact statement, including identifying the significant issues and eliminating from further study non-significant issues. Scoping may begin as soon as practicable after the proposal for action is sufficiently developed for agency consideration. Scoping may include appropriate pre-application procedures or work conducted prior to publication of the notice of intent" (40 C.F.R. §1501.9(a)).
Shellfish	For the purposes of this DPEIS, the term shellfish refers to marine invertebrates that have hard exoskeletons, including species of mollusks, crustaceans, or echinoderms.

Term	Definition
Short-term	"A potential impact of short duration, relative to the proposed project and the environmental resource. Short-term impacts occur while the activity is underway, and do not persist once the activity ends. Noise produced by temporary construction activities are an example of short-term impacts" (NOAA 2017).
Small Business, Small-Scale, Artisan	The NAICS US industry size standards for subsector 112 (includes finfish farming, fish hatcheries, shellfish farming, and other aquaculture) as having maximum annual receipts of $3.75 million. The size standards for subsector 114 (includes finfish, shellfish, and other marine fishing) as having maximum annual receipts of $25 million (13 C.F.R. § 121.201).
Social Acceptance	"A process of learning about, accepting, and adapting to an innovation. Social acceptance for aquaculture represents the willingness of a community, however that community is defined, to support the growing industry and their overall approval of its growth... gauged through public comments on pending farm permits, as well as evaluation of messages in publicly available media such as newspapers… influenced by the perception of aquaculture's benefits, which varies according to community characteristics, individual viewpoints, and scale of operation... regionally focused by necessity and frameworks must account for community-specific nuances" approaches stakeholder communities as partners, rather than receivers of information - in contrast to social license (2021 ICAF proposal); "collective community-based evaluation that reinforces participatory democracy, aiming at implementing governance processes based on deliberation and public involvement... a social construction based on a trade-off between pros and cons" (Knauss et al. 2021).
Social License	Exists when a project or industry has ongoing approval within the local community and other stakeholders, or broad social acceptance; communication oriented, fostering best practices for better acceptance (Knauss et al 2021); "Social license extends from the resource extraction sector and describes the ongoing approval of a company's practices and procedures by employees, stakeholders, and the public. With social license, local communities are frequently framed as receivers of information." (2021 ICAF proposal).

Term	Definition
Societal Goals	"Relevant economic, social, and ecological factors in the context of Ecosystem-Based Fishery Management" (NMFS 2016b).
Species	"A fundamental group of related organisms similar in certain morphologic and physiologic characteristics and capable of interbreeding; a genetically distinct population of organisms with very similar physical characteristics, which interbreed and occupy a limited geographic region, share a common gene pool, and are reproductively isolated from all other such groups. The term includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species or vertebrate fish or wildlife which interbreeds when mature" (NOAA 2017).
Structure	"Includes without limitation, any pier, boat dock, boat ramp, wharf, dolphin, weir, boom, breakwater, bulkhead, revetment, riprap, jetty, artificial island, artificial reef, permanent mooring structure, power transmission line, permanently moored floating vessel, piling, aid to navigation, or any other obstacle or obstruction" (33 C.F.R. § 322.2 (b)).
Substantive	Substantive language is interpreted to include a comment that addresses a specific aspect of AOA identification as it may be used to inform the draft PEIS. In addition, substantive language is unique: interpreted to include uncopied, unduplicated language that may be used to identify a single submission (NMFS 2023a).
Sustainable Aquaculture	Aquaculture developed within the context of the DOC goals of encouraging economic growth and employment opportunities as well as in the context of NOAA goals of integrating environmental, social and economic considerations in management decisions concerning aquaculture (NOAA 2011).
Sustainable Diets	"Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources" (Burlingame and Dernini 2010).

Term	Definition
Take	Under the MMPA, “take” means “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal” (16 U.S.C. § 1362(13)). The MMPA defines “harassment” as “any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild” (defined as ‘Level A harassment’); “or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (defined as ‘Level B harassment’) (16 U.S.C. § 1362(18)). Section 9 of the ESA defines “take” as to “harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct” (16 U.S.C. § 1532(19)). Authorization for incidental takes are granted if NMFS finds that the taking would have a negligible impact on the species or stock(s), would not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant), and if the permissible methods of taking and requirements pertaining to the mitigation, monitoring and reporting of such takings are set forth (NMFS 2024g).
Toxic Chemical	“Any substance, other than an allowable chemical, that, when introduced into the water, can stun, immobilize, or take marine life” (50 C.F.R § 622.2).
Traditional Ecological Knowledge (TEK)	“A rich body of knowledge, accumulated over generations through repeated interaction within tightly associated social and environmental systems” (NOAA 2019). Additionally, the NOAA Consultation Handbook defines TEK as "a cumulative body of knowledge, practice and belief evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment." (NOAA 2023b).
Travel Cost (see also, “Opportunity Cost”)	How much money people pay to travel somewhere or participate in something (Lovett 2022).

Term	Definition
Tribe (Federally Recognized Tribe)	"Any Indian tribe, band, nation, or other organized group or community of Indians, including any Alaska Native village or regional or village corporation as defined in or established pursuant to the Alaska Native Claims Settlement Act [43 U.S.C. 1601 et seq.], that is recognized as eligible for the special programs and services provided by the United States to Indians because of their status as Indians pursuant to the Indian Self-Determination and Education Assistance Act (25 U.S.C. 450 et seq.)"(25 U.S.C. § 4103(13)(B)).
Tribal Rights	"Those rights legally accruing to a tribe or tribes by virtue of inherent sovereign authority, unextinguished aboriginal title, treaty, statute, judicial decisions, executive order or agreement, and which give rise to legally enforceable remedies" (DOI 1997, Sec. Order 3206).
Tribal Trust Resources	"Those natural resources, either on or off Indian lands, retained by, or reserved by or for Indian tribes through treaties, statutes, judicial decisions, and executive orders, which are protected by a fiduciary obligation on the part of the United States" (DOI 1997, Sec. Order 3206).
Unusual Mortality Event	"Under the Marine Mammal Protection Act, an unusual mortality event (UME) is defined as a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response" (NMFS 2024b). See also "Mass Mortality Event".
Upwelling	"A process in which deep, cold water rises towards the surface. Winds blowing across the ocean surface push water away. Water then rises up from beneath the surface to replace the water that was pushed away" (NOAA 2023e).
Vertically-Integrated Business Pathway (see also, Collaborative Business pathway)	An existing business with capital investments available, and possibly with aquaculture operations already underway elsewhere (NCCOS 2022).

Appendix 4: Potential Effects of Climate Change on Federally Protected Species

C. Sea Turtles

Changes to climate and oceanographic processes may lead to decreased productivity in different patterns of prey distribution and availability. Such changes could affect sea turtles that are dependent on those affected prey. Sea turtle migration, feeding, and breeding locations may be influenced by factors such as ocean currents and water temperature (Patrício et al. 2021).

D. Marine Mammals

Climate and oceanographic change may affect habitat availability, food availability, and home range of cetaceans (Evans and Bjorge 2013). Changes to climate and oceanographic processes may lead to decreased prey productivity and different patterns of prey distribution and availability (Gulland et al. 2022). Site selection for whale migration, feeding, and breeding may be influenced by factors such as ocean currents and water temperature. For example, there is some evidence from Pacific equatorial waters that sperm whale feeding success and, in turn, calf production rates are negatively affected by increases in sea surface temperature (Smith and Whitehead 1993). Such changes could affect whales that are dependent on affected prey, such as Southern Resident killer whales that may be affected by changes in salmon prey. Different species will likely react to these changes differently. For example, range size, location, and whether or not specific range areas are used for different life history activities (e.g., feeding, breeding) are likely to affect how each species responds to climate change (Learmonth et al. 2006). Stranding patterns of cetaceans in the Pacific Northwest from 2000-2019 have been linked to increasing sea-surface temperatures, and stranding is linked to patterns of disease and food availability (Warlick et al. 2022). Some changes may be positive, such as new suitable habitat availability for some species (Learmonth et al. 2006).

Climate change may affect pinnipeds and sea otters at sea where they forage as well. Changes in ocean currents, ocean acidification, and other alterations in climate cycles, such as changes in the frequency of El Niño events, are likely to alter ocean food webs and affect the abundance and diversity of prey items (Adame et al. 2020). These changes may also affect susceptibility to diseases (Gulland et al. 2022).

E. White and Black Abalone

Abalone in southern California are heavily dependent on kelp for both habitat and food, and kelp forests are sensitive to oceanographic conditions associated with nutrients within the water column. Warming ocean temperatures are causing declines in nutrients available to kelp forests and also causing increased incidence of disease. NMFS (2020c) concluded that elevated water temperatures can affect black abalone by reducing survival and growth and influencing disease transmission, kelp growth, and harmful algal blooms. NMFS (2008) found that the potential for climate change to affect white abalone was unclear, but warmer water could result in increased incidence of withering syndrome and decreased kelp growth. The effects of climate impacts on oceanographic conditions, including temperature, have strong implications for abalone aquaculture. Warmer temperatures, hypoxic conditions, and changes in ocean salinity and pH have similar effects on abalone culture, resulting in reduced growth and reproductive rates, and greater frequency of disease (Morash and Alter 2015).

F. Birds

A recent global assessment of threats to seabirds concluded the top three threats to seabird populations were invasive species, fisheries interactions resulting in mortality as bycatch, and climate change (Dias et al. 2019). Similar to other animal groups, birds may experience shifts in or contractions of habitat availability and food availability as a result of climate change. Within the CCE, increased variability of forage availability, including krill and anchovies, driven by warming ocean temperatures and changes in upwelling has been associated with declines in abundance of 23 species-groups of seabirds (Sydeman et al. 2015). These declines have been observed since at least the late 1980s (Veit et al. 1996). A recent analysis showed that seabird biodiversity in CCE marine sanctuaries increased with latitude and decreased with greater distance from shore, with the Channel Islands near the proposed AOAs showing lower seabird density relative to other marine sanctuaries further north in the CCE (Russel et al. 2023).

G. ESA-listed Fish

The CCE includes a variety of ESA-listed fish, including some populations of salmon and steelhead, oceanic whitetip sharks, and scalloped hammerhead sharks. Salmon and steelhead breed in freshwater rivers, which are being affected by climate change, which in turn is affecting salmon and steelhead. Siegel and Croizer (2020) conducted a review of the literature on Pacific salmon and climate change and found changes in steelhead age and size composition that may be related to climate change. They also reported some salmon prey species are changing in abundance and distribution. Increases in stream temperature, sea surface temperature, and ocean acidification were climate-related stressors reported to be likely to impact populations (Siegel and Crozier 2020).

Oceanic whitetip and scalloped hammerhead sharks are oceanic species. NMFS (2020d) reported that the CCE is a hotspot for scalloped hammerheads in the Pacific Ocean. A study of several chondrichthyes species that occur on the Great Barrier Reef suggested that hammerheads were less vulnerable to climate change than most of the species evaluated (Chin et al. 2010). Based on this and other evidence, NOAA concluded that there is not evidence to suggest a present or threatened destruction, modification, or curtailment of the scalloped hammerhead's habitat or range as a result of climate change (Miller et al. 2014b). For oceanic whitetip sharks, NOAA's draft recovery plan concludes that climate change may affect these sharks but there is not enough information about their sensitivity to climate factors and the species resilience to conclude that climate change is a threat at this time, though the potential effects are highly uncertain (NMFS 2024h).

Appendix 5: Sea Grant's Integrated Financial Model for Kelp Aquaculture

A collaboration with Keene State College, series of YouTube videos

Video 1: Introduction, Business Model https://youtu.be/cCE6YA6nIyA

Video 2: Start up nursery https://youtu.be/gYsdvEwarKc

Video 3: Start up farm https://youtu.be/OV8aQJ213ec

Video 4: Operating expenses https://youtu.be/B7mCz6G0Hkk

Video 5: Beginning balance sheet and funding https://youtu.be/leQJeKBywGk

Video 6: Financial statements https://youtu.be/wVMxZJyAPjA

Video 7: Enterprise budget, breakeven, sensitivity analysis https://youtu.be/bZ8LwWn0wP0

Video 8: What-if analysis https://youtu.be/hlKrdAc23p8