HARBOR PORPOISE (*Phocoena phocoena phocoena*): Gulf of Maine/Bay of Fundy Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

This stock is found in U.S. and Canadian Atlantic waters (Figure 1). The distribution of harbor porpoises has been documented by sighting surveys, satellite telemetry data, passive acoustic monitoring, strandings and takes reported by NMFS observers in the Sea Sampling Programs. During summer (July to September), harbor porpoises are concentrated in the northern Gulf of Maine, southern Bay of Fundy and around the southern tip of Nova Scotia, generally in waters less than 150 m deep (Gaskin 1977; Kraus et al. 1983; Palka 1995), with lower densities in the upper Bay of Fundy and on Georges Bank (Palka 2000). During fall (October–December) and spring (April–June), harbor porpoises are widely dispersed from New Jersey to Maine, with lower densities farther north and south. During winter (January to March), intermediate densities of harbor porpoises can be found in waters off New Jersey to North Carolina, and lower densities are found in waters off New York to New Brunswick, Canada. In non-summer months they have been seen from the coastline to deep waters (>1,800 m; Westgate et al. 1998), although the majority are found over the continental shelf. Passive acoustic monitoring detected harbor porpoises regularly during the period January–May offshore of Maryland (Wingfield et al. 2017). There does not appear to be a temporally coordinated migration or a specific migratory route to and from the Bay of Fundy region. However, during the fall, several satellite-tagged harbor porpoises did favor the waters around the 92-m isobath, which is consistent with observations of high rates of incidental catches in this depth range (Read and Westgate 1997). There were two stranding records from Florida during the 1980s (Smithsonian strandings database) and one in 2003 (NE Regional Office/NMFS strandings and entanglement database).

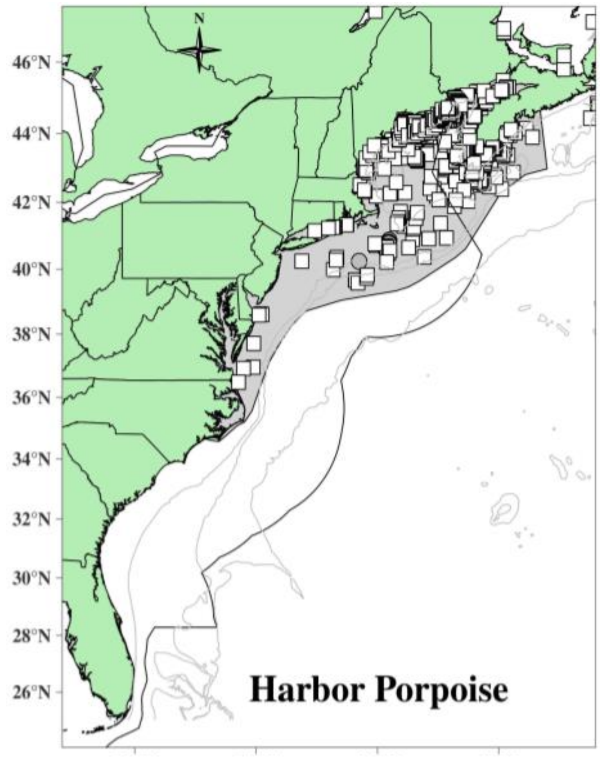

Figure 1. Distribution of harbor porpoises from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010, 2011, 2016, and 2021 and portions of DFO's 2007 TNASS and 2016 NAISS surveys. Circle symbols represent shipboard sightings and squares are aerial sightings. Shaded area represents approximate stock range.

Gaskin (1984, 1992) proposed that there were four separate populations in the western North Atlantic: the Gulf of Maine/Bay of Fundy, Gulf of St. Lawrence, Newfoundland, and Greenland populations. Analyses involving mtDNA (Wang et al. 1996; Rosel et al. 1999a, 1999b), organochlorine contaminants (Westgate et al. 1997; Westgate and Tolley 1999), heavy metals (Johnston 1995), and life history parameters (Read and Hohn 1995) support Gaskin's proposal. Genetic studies using mitochondrial DNA (Rosel et al. 1999a) and contaminant studies using total PCBs (Westgate and Tolley 1999) indicate that the Gulf of Maine/Bay of Fundy females were distinct from females from the other populations in the Northwest Atlantic. Gulf of Maine/Bay of Fundy males were distinct from Newfoundland and Greenland males, but not from Gulf of St. Lawrence males according to studies comparing mtDNA (Palka et al. 1996; Rosel et al. 1999a) and CHLORs, DDTs, PCBs and CHBs (Westgate and Tolley 1999). Nuclear microsatellite markers have also been applied to samples from these four populations, but this analysis failed to detect significant population sub-division in either sex (Rosel et al. 1999a). These patterns may be indicative of female philopatry coupled with dispersal of males. Both mitochondrial DNA and microsatellite analyses indicate that the Gulf of Maine/Bay of Fundy stock is not the sole contributor to the aggregation of porpoises found off the mid-Atlantic states during winter (Rosel et al. 1999a; Hiltunen 2006). Mixed-stock analyses using twelve microsatellite loci in both Bayesian and likelihood frameworks indicate that the Gulf of Maine/Bay of Fundy is the largest contributor (~60%), followed by Newfoundland (~25%) and then the Gulf of St. Lawrence (~12%), with Greenland making a small contribution (<3%). For Greenland, the lower confidence interval of the likelihood analysis includes zero. For the Bayesian analysis, the lower 2.5% posterior quantiles include zero for both Greenland and the Gulf of St. Lawrence. Intervals that reach zero provide the possibility that these populations contribute no animals to the mid-Atlantic aggregation.

This report follows Gaskin's hypothesis on harbor porpoise stock structure in the western North Atlantic, where the Gulf of Maine and Bay of Fundy harbor porpoises are recognized as a single management stock separate from harbor porpoise populations in the Gulf of St. Lawrence, Newfoundland, and Greenland. It is unlikely that the Gulf of Maine/Bay of Fundy harbor porpoise stock contains multiple demographically independent populations (Rosel et al. 1999a; Hiltunen 2006), but a comparison of samples from the Scotian shelf to the Gulf of Maine has not yet been made.

POPULATION SIZE

The best current abundance estimate of the Gulf of Maine/Bay of Fundy harbor porpoise stock was generated from the 2021 NEFSC and SEFSC that covered U.S. and Canadian waters, from Florida to Nova Scotia, Canada surveys: 85,765 (CV=0.53; Table 1; Garrison and Dias 2023; Palka 2023). A key uncertainty in the population size estimate is the precision and accuracy of the availability bias correction factor that was applied. More information on the spatio-temporal variability of the animals' dive profile is needed.

Recent Surveys and Abundance Estimates

An abundance estimate of 75,079 (CV=0.38) harbor porpoises was generated from a U.S. shipboard and aerial survey conducted during 27 June–28 September 2016 (Table 1; Palka 2020) in a region covering 425,192 km^2. The aerial portion included 11,782 km of tracklines that were over waters north of New Jersey from the coastline to the 100-m depth contour, throughout the U.S. waters. The shipboard portion included 4,351 km of tracklines that were in waters offshore of central Virginia to Massachusetts (waters that were deeper than the 100-m depth contour out to beyond the outer limit of the U.S. EEZ). Both sighting platforms used a two-team data collection procedure, which allows estimation of abundance to correct for perception bias of the detected species (Laake and Borchers 2004). The estimates were also corrected for availability bias.

An abundance estimate of 20,464 (CV=0.39) harbor porpoises from the Canadian Bay of Fundy/Scotian shelf region was generated from an aerial survey conducted by the Department of Fisheries and Oceans, Canada (DFO). The entire survey covered Atlantic Canadian shelf and shelf break waters extending from the northern tip of Labrador to the U.S border off southern Nova Scotia in August and September of 2016 (Lawson and Gosselin 2018). A total of 29,123 km were flown over the Gulf of St. Lawrence/Bay of Fundy/Scotian Shelf strata using two Cessna Skymaster 337s and 21,037 km were flown over the Newfound/Labrador strata using a DeHavilland Twin Otter. The harbor porpoise estimate was derived from the Skymaster data using single team multi-covariate distance sampling with left truncation (to accommodate the obscured area under the plane) where size-bias was also investigated. The Otter-based perception bias correction, which used double platform mark-recapture methods, was applied. An availability bias correction factor, which was based on published records of the cetaceans' surface intervals, was also applied.

A more recent abundance estimate of 85,765 (CV=0.53) harbor porpoises was generated from an aerial survey conducted in U.S. and Canadian waters of the western North Atlantic during the summer of 2021 (Table 1; Garrison and Dias 2023; Palka 2023). The aerial survey was conducted during summer in waters north of 38ºN in the Gulf of Maine to the lower Bay of Fundy and consisted of 5,217 km of on-effort primary tracklines. In addition, two vessel surveys were conducted concurrently covering waters from the Gulf of Maine to Florida with 5,659 km of on-effort track lines. No harbor porpoises were detected during the vessel surveys. All three surveys utilized two visual teams and an independent observer approach to estimate detection probability on the trackline (Laake and Borchers 2004). Mark-recapture distance sampling was used to estimate abundance that was then corrected for availability bias (animals missed due to dive patterns). These surveys missed a small portion of the Gulf of Maine/Bay of Fundy habitat that is on the western part of the Scotian Shelf (about 10% of the known habitat).

Table 1. Summary of recent abundance estimates for the Gulf of Maine/Bay of Fundy harbor porpoise (**Phocoena phocoena*****) by month, year, and area covered during each abundance survey and the resulting abundance estimate (N_{est}) and coefficient of variation (CV). The estimate considered best is in bold font.***

Month/Year	Area	N_{est}	CV
Jun–Sep 2016	Central Virginia to Maine	75,079	0.38
Aug–Sep 2016	Gulf of St. Lawrence/Bay of Fundy/Scotian Shelf	20,464	0.39
Jun–Sep 2016	Central Virginia to Gulf of St. Lawrence/Bay of Fundy/Scotian Shelf (COMBINED)	95,543	0.31
Jun–Aug 2021	New Jersey to lower Bay of Fundy	85,765	0.53
Jun–Aug 2021	Central Florida to New Jersey	0	-
Jun–Aug 2021	**Central Florida to lower Bay of Fundy (COMBINED)**	**85,765**	**0.53**

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normal distributed best abundance estimate. This is equivalent to the 20th percentile of the log-normal distribution as specified by Wade and Angliss (1997). The best estimate of abundance for the Gulf of Maine/Bay of Fundy harbor porpoises is 85,765 (CV=0.53). The minimum population estimate for the Gulf of Maine/Bay of Fundy harbor porpoise is 56,420 (Table 2).

Current Population Trend

A trend analysis has not been conducted for this stock. The statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long survey interval. For example, the power to detect a precipitous decline in abundance (i.e., 50% decrease in 15 years) with estimates of low precision (e.g., CV>0.30) remains below 80% (alpha=0.30) unless surveys are conducted on an annual basis (Taylor et al. 2007).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Several attempts have been made to estimate potential population growth rates. Barlow and Boveng (1991), who used a re-scaled human life table, estimated the upper bound of the annual potential growth rate to be 9.4%. Woodley and Read (1991) used a re-scaled Himalayan tahr life table to estimate a likely annual growth rate of 4%. In an attempt to estimate a potential population growth rate that incorporates many of the uncertainties in survivorship and reproduction, Caswell et al. (1998) used a Monte Carlo method to calculate a probability distribution of growth rates. The median potential annual rate of increase was approximately 10%, with a 90% confidence interval of 3–15%. This analysis underscored the considerable uncertainty that exists regarding the potential rate of increase in this population. Moore and Read (2008) conducted a Bayesian population modeling analysis to estimate the potential population growth of harbor porpoise in the absence of bycatch mortality. Their method used fertility data, in combination with age-at-death data from stranded animals and animals taken in gillnets, and was applied under two scenarios to correct for possible data bias associated with observed bycatch of calves. Demographic parameter estimates were ‘model averaged’ across these scenarios. The Bayesian posterior median estimate for potential natural growth rate was 0.046. This last, most recent, value will be the one used for the purpose of this assessment.

Key uncertainties in the estimate of the maximum net productivity rate for this stock were discussed in Moore and Read (2008), which included the assumption that the age structure is stable, and the lack of data to estimate the probability of survivorship to maximum age. The authors considered the effects of these uncertainties on the estimated potential natural growth rate to be minimal.

POTENTIAL BIOLOGICAL REMOVAL

Potential Biological Removal (PBR) is the product of minimum population size, one-half the maximum productivity rate, and a recovery factor (MMPA Sec. 3. 16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size is 56,420. The maximum productivity rate for this stock is 0.046. The recovery factor is 0.5 because stock’s status relative to Optimum Sustainable Population (OSP) is unknown and the CV of the average mortality estimate is less than 0.3 (Wade and Angliss 1997). PBR for the Gulf of Maine/Bay of Fundy harbor porpoise in U.S. and Canadian waters to Nova Scotia is 649(Table 2).

Table 2. Best and minimum abundance estimates for the Gulf of Maine/Bay of Fundy harbor porpoise (*Phocoena phocoena phocoena*) with Maximum Productivity Rate (R_{max}), Recovery Factor (F_r) and PBR.

N_{est}	CV	N_{min}	F_r	R_{max}	PBR
85,765	0.53	56,420	0.5	0.046	649

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

The total annual estimated average human-caused mortality and serious injury is 145 harbor porpoises per year (CV=0.18) from U.S. fisheries using observer data and an annual average of 0.2 animals from non-fishery stranding records (Table 3). Canadian bycatch information is not available.

Table 3. Total annual estimated average human-caused mortality and serious injury for the Gulf of Maine/Bay of Fundy harbor porpoise (*Phocoena phocoena phocoena*) in U.S. waters.

Years	Source	Annual Avg.	CV
2017–2021	U.S. commercial fisheries using observer data	145	0.18
2017–2021	Non-fishery human caused stranding mortalities	0.2	-
2017–2021	Research takes	0.2	
TOTAL		145.4	-

A key uncertainty is the potential that the observer coverage in the Mid-Atlantic gillnet fishery may not be representative of the fishery during all times and places, since the observer coverage was relatively low (0.012–0.130) for some times and areas, especially during the COVID-19 pandemic (2020–2022) . The effect of this is unknown. Another key uncertainty is that mortalities and serious injuries in Canadian waters are largely unquantified. There are no major known sources of unquantifiable human-caused mortality or serious injury for the U.S. waters within the Gulf of Maine/Bay of Fundy harbor porpoise stock's habitat.

United States

Northeast Sink Gillnet

Harbor porpoise bycatch in the northern Gulf of Maine occurs primarily from June to September, while in the southern Gulf of Maine and south of New England, bycatch occurs from January to May and September to December. Annual bycatch is estimated using ratio estimator techniques that account for the use of pingers (Orphanides 2020, 2021; Precoda and Orphanides 2022, Precoda 2023). See Table 4 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Northeast Bottom Trawl

Since 1989, harbor porpoise mortalities have been observed in the northeast bottom trawl fishery, but many of these mortalities were not attributable to this fishery because decomposed animals are presumed to have been dead prior to being taken by the trawl. Those infrequently caught freshly dead harbor porpoises have been caught during January to April on Georges Bank or in the southern Gulf of Maine. Fishery-related bycatch rates were estimated using an annual stratified ratio-estimator (Lyssikatos and Chavez-Rosales 2022). See Table 4 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Mid-Atlantic Gillnet

Harbor porpoise bycatch in Mid-Atlantic waters occurs primarily from December to May in waters off New Jersey and less frequently in other waters ranging farther south, from New Jersey to North Carolina. Annual bycatch is estimated using ratio estimator techniques (Orphanides 2020, 2021; Precoda and Orphanides 2022, Precoda 2023). See Table 4 for bycatch estimates and observed mortality and serious injury for the current 5-year period, and Appendix V for historical bycatch information.

Research Takes

One harbor porpoise was incidentally killed during research conducted during the NEFSC 2021 Bottom Trawl survey.

Table 4. From observer program data, summary of the incidental mortality of Gulf of Maine/Bay of Fundy harbor porpoise (**Phocoena phocoena phocoena*****) by U.S. commercial fishery including the years sampled, the type of data used, the annual observer coverage, the mortalities and serious injuries recorded by on-board observers, the estimated annual serious injury and mortality, the estimated CV of the annual mortality, and the mean annual combined mortality with its CV.***

Fishery	Years	Data Type [a]	Observer Coverage [b]	Obs. Serious Injury[c]	Obs. Mortality	Est. Serious Injury[c]	Est. Mortality	Est. Combined Mortality	Est. CVs	Mean Combined Annual Mortality
Northeast Sink Gillnet	2017 2018 2019 2020 2021	Obs. Data, Trip Logbook, Allocated Dealer Data	0.12 0.11 0.12 0.02 0.11	1 0 0 0 0	18 9 33 10 25	7 0 0 2 2	129 92 195 119 109	136 92 195 121 111	0.28 0.52 0.22 0.22 0.19	131(0.19)
Mid-Atlantic Gillnet	2017 2018 2019 2020 2021	Obs. Data, Weighout	0.09 0.09 0.13 0.03 0.01	0 0 0 0 0	1 0 2 2 0	0 0 0 0 0	9.1 0 13 16 10	9.1 0 13 16 10	0.95 0 0.51 0.63 0.65	10 (0.56)
Northeast Bottom Trawl	2017 2018 2019 2020 2021	Obs. Data, Weighout	0.12 0.12 0.16 0.08 0.19	0 0 0 0 0	0 0 2 0 1	0 0 0 0 0	0 0 11 3.6 5.0	0 0 11 3.6 5.0	0 0 0.63 0.63 0.92	3.9 (0.44)
TOTAL										145 (0.18)

a. Observer data (Obs. Data) are used to measure bycatch rates and the data are collected within the Northeast Fisheries Observer Program. NEFSC collects Weighout (Weighout) landings data that are used as a measure of total effort for the U.S. gillnet fisheries. Mandatory vessel trip report (VTR; Trip Logbook) data are used to determine the spatial distribution of fishing effort in the Northeast sink gillnet fishery.
b. Observer coverage for the U.S. Northeast and mid-Atlantic coastal gillnet fisheries is based on tons of fish landed. Northeast bottom trawl fishery coverages are ratios based on trips.
c. Serious injuries were evaluated for the 2017–2021 period and include both at-sea monitor and traditional observer data (Josephson and Lyssikatos 2023).

Canada

Within the habitat of the Gulf of Maine/Bay of Fundy population, nNo current bycatch estimates exist, but harbor porpoise interactions hadve been documented in the Bay of Fundy sink gillnet fishery and in herring weirs between the years 1998–2001 in the lower Bay of Fundy demersal gillnet fishery (Trippel and Shepherd 2004). That fishery has declined since 2001 and it is assumed current bycatch is very small, if any (H. Stone, Department of Fisheries and Oceans Canada, pers. comm.).

STATUS OF STOCK

Harbor porpoise in the Gulf of Maine/Bay of Fundy stock are not listed as threatened or endangered under the Endangered Species Act, and this stock is not considered strategic under the MMPA. The total U.S. fishery-related mortality and serious injury for this stock is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of harbor porpoises, relative to OSP is unknown. Population trends for this species have not been investigated.

OTHER FACTORS THAT MAY BE AFFECTING THE STOCK

Strandings

United States

Recent harbor porpoise strandings on the U.S. Atlantic coast are documented in Table 5 (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 19 October2022). Of the 305 U.S.stranding mortalities reported during this time period, 18 were coded as having signs of human interaction. Of these, 2 were deemed fishery interactions (assumed to be subsumed in the extrapolated fishery bycatch estimates) and 1 was attributed to a vessel strike. Most of the remaining Human Interaction (HI) cases were harassment, unlikely to have contributed to the stranding or post-mortem interactions. However, in 1 case, the non-fishery human interaction was likely to have been a contributing factor in the animal's mortality.

Stranding data underestimate the extent of mortality and serious injury because all of the marine mammals that die or are seriously injured may not wash ashore, nor will all of those that do wash ashore necessarily show signs of entanglement or other fishery interaction. Finally, the level of technical expertise among stranding network personnel varies widely as does the ability to recognize signs of fishery interaction.

Table 5. Harbor porpoise (**Phocoena phocoena phocoena*****) reported strandings along the U.S. and Canadian Atlantic coast, 2017–2021.***

Area	2017	2018	2019	2020	2021	Total
Maine[a, f]	2	5	8	8	9	40
New Hampshire	0	1	2	0	3	13
Massachusetts[a, b,e, f]	18	8	29	13	14	137
Rhode Island[a, f]	2	2	0	0	0	2
Connecticut	0	0	0	0	0	1
New York[a]	3	1	12	6	0	33
New Jersey[a]	2	5	14	5	1	31
Delaware	0	0	6	0	1	10
Maryland	0	0	2	1	0	9
Virginia	3	2	5	0	0	12
North Carolina	14	1	1	0	0	17
TOTAL U.S.	44	25	79	33	28	305
Nova Scotia/Prince Edward Island[c]	13	16	22	32	37	141
Newfoundland and New Brunswick[d]	2	0	0	0	0	1
GRAND TOTAL	59	41	101	65	65	447

a. Seven HI cases in 2017: 2 in Maine were released alive and another was a neonate with an infected laceration that required euthanization. One dead HI animal in Massachusetts was coded as a fishery interaction and another HI animal was released alive. One HI animal in New York was released alive and one dead animal in New Jersey had evidence of vessel interaction.
b. Two HI cases in 2018; both in Massachusetts. One was coded as a fishery interaction.
c. Data supplied by Nova Scotia Marine Animal Response Society (pers. comm.)..
d. See Ledwell and Huntington (2018, 2019, 2020, 2021a, 2021b).
e. Three Massachusetts stranding mortalities in 2019 were classified as non-fishery human interaction.
f. Four HI cases in 2020, all of them due to activities by the public post-stranding. In 3 of these cases, the animal was released alive.

Canada

Whales and dolphins stranded on the coast of Nova Scotia, New Brunswick and Prince Edward Island are recorded by the Marine Animal Response Society and the Nova Scotia Stranding Network. See Table 3 for details.

Harbor porpoises stranded on the coasts of Newfoundland and Labrador are reported by the Newfoundland and Labrador Whale Release and Strandings Program (Ledwell and Huntington 2018, 2019, 2020, 2021a, 2021b; Table 5).

Habitat Issues

In U.S. waters, harbor porpoise are mostly found in nearshore areas and inland waters, including bays, tidal areas, and river mouths. As a result, in addition to fishery bycatch, harbor porpoise are vulnerable to contaminants, such as PCBs (Hall et al. 2006), ship traffic (Oakley et al. 2017; Terhune 2015) and physical modifications resulting from urban and industrial development activities such as construction of docks and other over-water structures, dredging (Todd et al. 2015), installation of offshore windfarms (Carstensen et al. 2006; Brandt et al. 2011; Teilmann and Carstensen 2012; Dähne et al. 2013; Benjamins et al. 2017), seismic surveys and other sources of anthropogenic noise (Lucke et al. 2009).

Climate-related changes in spatial distribution and abundance, including poleward and depth shifts, have been documented in and predicted for a range of plankton species and commercially important fish stocks (Nye et al. 2009; Head et al. 2010; Pinsky et al. 2013; Poloczanska et al. 2013; Hare et al. 2016; Grieve et al. 2017; Morley et al. 2018) and cetacean species (e.g., MacLeod 2009; Sousa et al. 2019). Chavez-Rosales et al. (2022) documented an overall 178 km northeastward spatial distribution shift of the seasonal core habitat of Northwest Atlantic cetaceans that was related to changing habitat/climatic factors. Results varied by season and species. This study used sightings data collected during seasonal aerial and shipboard line transect abundance surveys during 2010 to 2017. During this time frame, the weighted centroid of harbor porpoise core habitat moved farthest during winter (397 km towards the northeast) and less than 20 km in the other seasons. There is uncertainty in how, if at all, the changes in distribution and population size of cetacean species may interact with changes in distribution of prey species and how the ecological shifts will affect human impacts to the species.

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