Revised 05/14/2024

BLUE WHALE (*Balaenoptera musculus musculus*): Eastern North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

North Pacific blue whales were once thought to belong to as many as five separate populations (Reeves *et al.* 1998), but acoustic evidence suggests only two populations, in the eastern and western North Pacific, respectively (Stafford *et al*. 2001, Stafford 2003, McDonald *et al*. 2006, Monnahan *et al*. 2014). North Pacific blue whales produce two distinct acoustic calls, referred to as "northwestern" and "northeastern" types. Stafford *et al.* 2001, Stafford 2003, and Monnahan *et al.* 2014 have proposed that these represent distinct populations with some geographic overlap. The northeastern call predominates in the Gulf of Alaska, along the U.S. West Coast, and in the eastern tropical Pacific, and the northwestern call predominates from south of the Aleutian Islands to Russia's Kamchatka Peninsula, though both call types have been recorded concurrently in the Gulf of Alaska (Stafford *et al*. 2001, Stafford 2003). Both call types occur in lower latitudes in the central North Pacific, but differ in seasonal patterns (Stafford *et al*. 2001). Blue whales satellite-tagged off California in summer have traveled to the eastern tropical Pacific and the Costa Rica Dome in winter (Mate *et al*. 1999, Bailey *et al.* 2009). Blue whales photographed off California have been matched to individuals photographed off the Queen Charlotte Islands in northern British Columbia and to one individual photographed in the northern Gulf of Alaska (Calambokidis *et al*. 2009a). Barlow (2010, 2016) noted a northward shift in blue whale distribution within the California Current, based on a series of vessel-based line-transect surveys between 1991 and 2014. Gilpatrick and Perryman (2008) reported that blue whales from California to Central America (the Eastern North Pacific stock) are on average, two meters shorter than blue whales measured from historic whaling records in the central and western North Pacific.

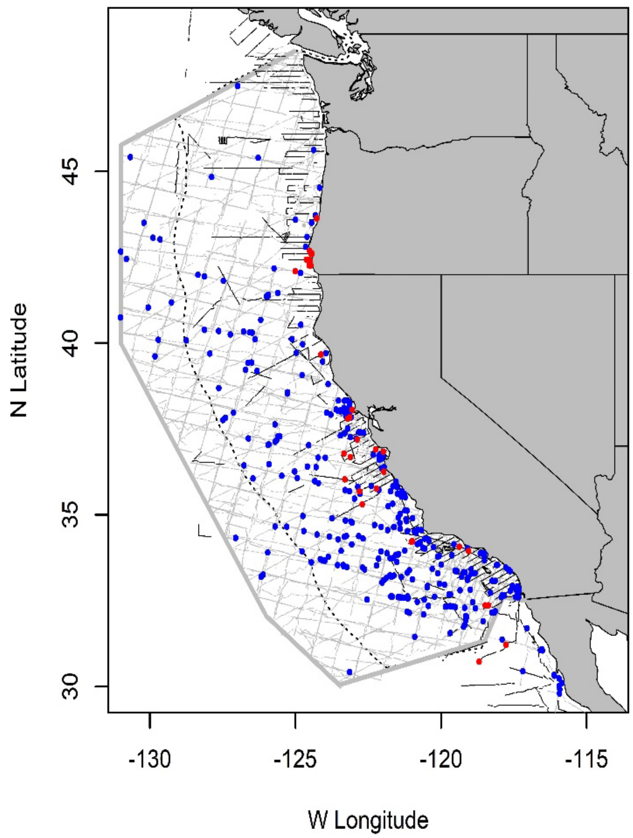

Figure 1. Blue whale sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2018. Dashed line represents U.S. EEZ, thin lines indicate completed transect effort (gray = 1991-2014, black = 2018). Sightings from the 2018 survey are shown in red.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, two stocks are currently recognized in the North Pacific: 1) the Eastern North Pacific Stock, and 2) the Central North Pacific Stock. Based on northeastern call type locations, some whales in the Eastern North Pacific stock may range as far west as Wake Island and as far south as the Equator (Stafford *et al*. 1999, 2001). The U.S. West Coast is an important feeding area in summer and fall (Fig. 1), but, increasingly, blue whales from the Eastern North Pacific stock are found feeding north and south of this area in summer and fall. Nine important areas for blue whale feeding have been identified off the California coast (Calambokidis *et al*. 2015), including six areas in southern California and three in central California.

Most of this stock is believed to migrate south to spend the winter and spring in high productivity areas off Baja California, the Gulf of California, and on the Costa Rica Dome.

POPULATION SIZE

The size of the feeding stock of blue whales off the U.S. West Coast has been estimated by line-transect and mark-recapture methods. Because some fraction of the population is always outside the survey area, the line-transect and mark recapture estimation methods provide different measures of abundance for this stock. Line transect estimates reflect the average density and abundance of blue whales in the study area during summer and autumn surveys, while mark-recapture estimates can provide an estimate of total population size if differences in capture heterogeneity are addressed.

Abundance estimates from line-transect surveys have been highly-variable (Fig. 2), and this variability is attributed to northward distributional shifts of blue whales out of U.S. waters linked to warming ocean temperatures (Barlow and Forney 2007, Calambokidis *et al.* 2009a, Barlow 2010, 2016). Mark-recapture estimates of abundance are considered the more reliable and precise of the two methods for this transboundary population of blue whales because not all animals are within the U.S. Exclusive Economic Zone (EEZ) during summer and autumn line-transect surveys and mark-recapture estimates can be corrected for heterogeneity in sighting probabilities. Generally, the highest abundance estimates from line-transect surveys occurred in the mid-1990s, when ocean conditions were colder than present-day (Fig. 2). Since that time, line-transect abundance estimates within the California Current have declined, while estimates from mark-recapture studies have increased (Fig. 2). Evidence for a northward shift in blue whale distribution includes increasing numbers of blue whales found in Oregon and Washington waters during 1996-2014 line-transect surveys (Barlow 2016) and satellite tracks of blue whales in Gulf of Alaska and Canadian waters between 1994 and 2007 (Bailey *et al.* 2009). Calambokidis and Barlow (2020) estimated blue whale abundance for the U.S. West Coast based on updated photographic ID data through 2018 using mark-recapture methods. They reported that the best estimate of current abundance for CA/OR/WA waters is based the most-recent 4 years (2015-2018) of capture-recapture data and a Chao model that accounts for heterogeneity of capture probabilities, resulting in an estimate of 1,898 (CV=0.085) whales. Becker *et al*. (2020) also estimated blue whale abundance with habitat-based species distribution models from line-transect data collected between 1991 to 2018, using fixed and dynamic ocean variables (Becker *et al.* 2016, 2017). The most-recent species distribution model-based estimate is 670 (CV=0.43) blue whales for 2018 (Fig. 2). The mark-recapture estimate (1,898) is considered the best estimate of abundance for 2018 due to its higher precision and because estimates based on line-transect data reflect only animal densities within the study area at the time surveys are conducted.

Minimum Population Estimate

The minimum population estimate of blue whales is calculated as the lower 20th percentile of the 2018 mark-recapture estimate, or 1,767 whales.

Current Population Trend

Mark-recapture estimates provide the best gauge of population trends for this stock, because of recent northward shifts in blue whale distribution that negatively bias line-transect estimates. Based on mark-recapture estimates shown in Fig. 2, there may be evidence of a population size increase since the 1990s, but a formal trend analysis is lacking and the current population trend is unknown. Monnahan *et al*. (2015) used a population dynamics model to estimate that the eastern Pacific blue whale population was at 97% of carrying capacity in 2013 and suggested that density dependence, and not vessel strike impacts, explained the observed lack of a population size increase since the early 1990s. Monnahan *et al.* (2015) also estimated that the eastern North Pacific population likely did not drop below 460 whales during the last century, despite being targeted by commercial whaling. Monnahan *et al*. (2014) estimated that 3,411 blue whales (95% range 2,593 - 4,114) were removed via commercial whaling from the eastern North Pacific between 1905 and 1971.

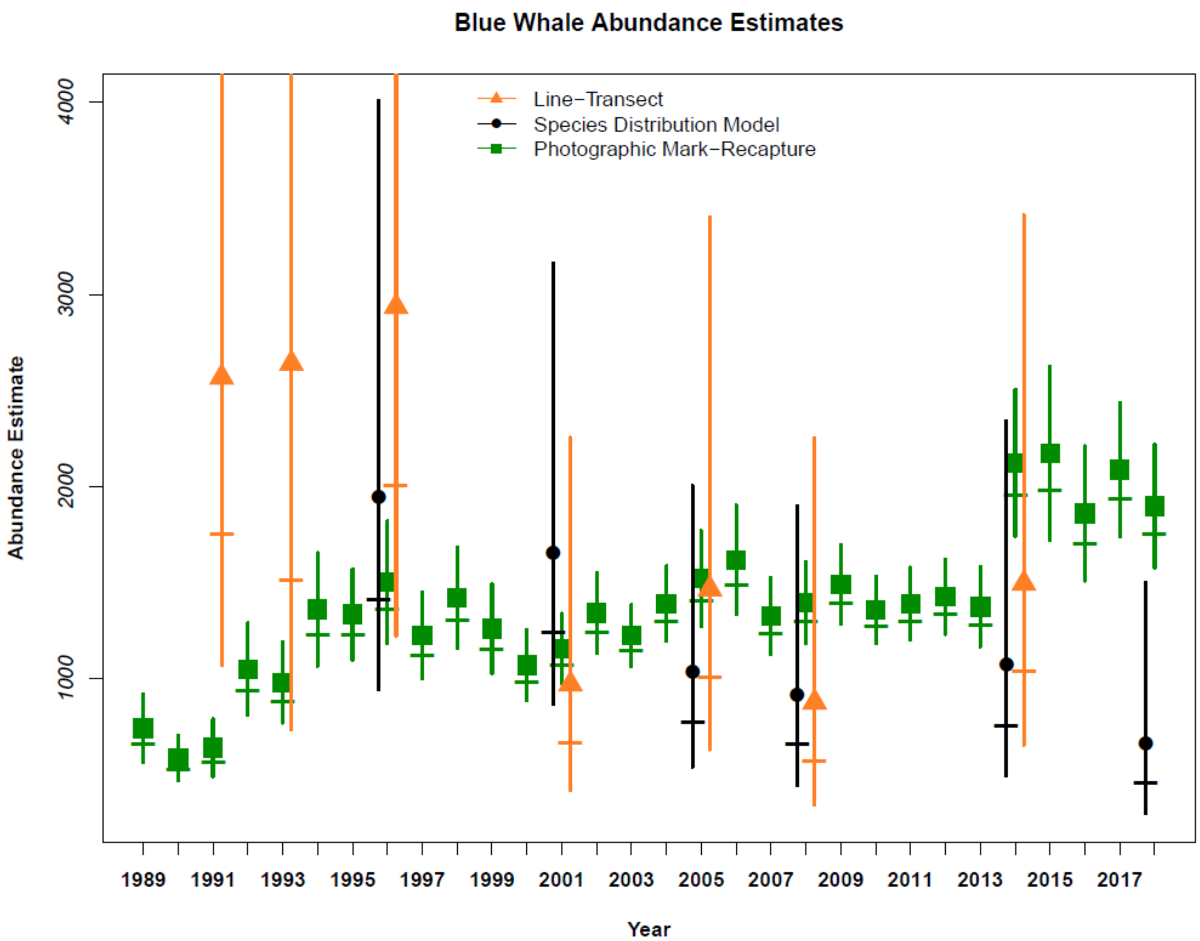

Figure 2. Estimated abundance of blue whales based on three methods (standard vessel-based line transect surveys, habitat-based species distribution models, and a photographic mark-recapture model). The line-transect estimates are based on surveys reported by Barlow (2016). Species distribution model estimates are based on the same line-transect surveys, but use fixed and dynamic ocean variables to model whale density (Becker *et al.* 2020). The mark recapture estimates reflects a Chao model that uses rolling 4-year periods and accounts for heterogeneity of capture probability (Calambokidis and Barlow 2020). Vertical bars indicate approximate 95% log-normal confidence limits for line-transect estimates, 95% confidence limits reported from species distribution model estimates, and ±2 standard errors of mark-recapture abundance estimates. Horizontal hatch marks represent minimum population size estimates based on 20th percentiles of mean estimates. Line-transect surveys in 1991 and 1993 did not include the waters of Oregon and Washington. The y-axis has been truncated to better show the variability in mean estimates between methods. Upper 95% confidence limits for line-transect surveys in 1991, 1993 and 1995 not visible in this plot ranged between 6,000 and 9,500 whales.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Based on mark-recapture estimates from the U.S. West Coast and Baja California, Mexico, Calambokidis *et al*. (2009b) estimated an approximate rate of increase of 3% per year. This estimate is not considered a maximum net productivity rate because it does not account for the effects of anthropogenic mortality and serious injury on the population and therefore likely represents an underestimate of the maximum net productivity rate. For this reason and because an estimate of maximum net productivity is lacking for any blue whale population, the default rate of 4% is used for all blue whale stocks, based on NMFS guidelines for preparing stock assessments (NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (1,767) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.2 (for an endangered species with a minimum abundance greater than 1,500 and unknown population trend), resulting in a PBR of 7 whales. Satellite telemetry deployments (Hazen *et al*. 2016) indicate that most blue whales are outside U.S. West Coast waters from November to March (5 months), so the PBR for U.S. waters is 7/12 of the total PBR, or 4.1 whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Blue whales are occasionally documented entangled in pot/trap fisheries and other unidentified fishery gear on the U.S. West Coast (Table 1). The annual entanglement rate of blue whales (observed) during 2017-2021 is the sum of observed annual entanglements (0.60/yr), plus species probability assignments (Carretta 2018) from 4 unidentified whale entanglements (0.014/yr), totaling 0.61 blue whales annually (Table 1). Observed totals represent a negatively-biased accounting of the serious injury and mortality of blue whales in the region, because not all cases are detected and there is no correction factor available to account for undetected events.

Table 1. Summary of available information on observed incidental mortality and injury of blue whales (Eastern North Pacific stock) from commercial fisheries (Carretta *et al.* 2023, Carretta 2022). Values in this table represent observed deaths and serious injuries and totals are negatively-biased because not all cases are detected.

Fishery Name	Year(s)	Data Type	Observer Coverage	Observed Mortality + Serious Injury	Estimated mortality and/or serious injury (CV in parentheses)	Mean Annual Mortality and Serious Injury (CV in parentheses)
CA Dungeness crab pot	2017-2021	Strandings + sightings	n/a	0 + 0.75	n/a	≥ 0.15 (n/a)
Unidentified fishery interactions involving identified blue whales	2017-2021	Strandings + sightings	n/a	0 + 2.25	n/a	≥ 0.45 (n/a)
Unidentified fishery interactions involving *unidentified whales* prorated to blue whale	2017-2021	Strandings + Sightings	n/a	n/a	0.07	≥ 0.014
CA/OR thresher shark/swordfish drift gillnet fishery	2017 2018 2019 2020 2021	observer	0.186 0.251 0.226 0.222 0.228	0	0	0 (n/a)
Total Annual Takes						≥ 0.61(n/a)

Vessel Strikes

Three blue whale vessel strike deaths were observed during 2017-2021 (Carretta *et al*. 2023), resulting in an observed annual average of 0.6 vessel strike deaths. Observations of blue whale vessel strikes have been highly-variable in previous 5-year periods, with as many as 10 observed (9 deaths + 1 serious injury) during 2007-2011 (Carretta *et al*. 2013). The highest number of blue whale vessel strikes observed in a single year (2007) was 5 whales (Carretta *et al*. 2013). Since 2007, documented vessel strikes have totaled 14 blue whales and 10 unidentified whales (Carretta *et al*. 2013, 2023). Methods to prorate the number of unidentified whale vessel strike cases to species are not available, because observed sample sizes are small and identified cases are likely biased towards species that are large, easy to identify, and more likely to be detected, such as blue and fin whales. Most observed blue whale vessel strikes have been in southern California or off San Francisco, CA, where blue whales seasonally occur close to shipping ports (Berman-Kowalewski *et al*. 2010). Documented vessel strike deaths and serious injuries are derived from observed whale carcasses and at-sea sightings and are considered minimum values. Where evaluated, estimates of detection rates of cetacean carcasses are consistently quite low across different regions and species (<1% to 36%), highlighting that observed numbers are unrepresentative of true impacts (Kraus *et al*. 2005, Pace *et al*. 2021, Perrin *et al*. 2011, Williams *et al*. 2011, Prado *et al*. 2013). Due to this negative bias, Redfern *et al*. (2013) noted that the number of observed vessel strike deaths of blue whales in the U.S. West Coast EEZ likely exceeds PBR.

Vessel strike mortality was estimated for blue whales in the U.S. West Coast EEZ (Rockwood *et al*. 2017), using an encounter theory model (Martin *et al.* 2016) that combined species distribution models of whale density (Becker *et al*. 2016), vessel traffic characteristics (size + speed + spatial use), along with whale movement patterns obtained from satellite-tagged whales in the region to estimate encounters that would result in mortality. The estimated number of annual vessel strike deaths was 18 blue whales, though this includes only the period July – November when whales are most likely to be present in the U.S. West Coast EEZ and was based on cetacean habitat models generated from line-transect surveys (Becker *et al*. 2016, Rockwood *et al*. 2017). This estimate was also based on an assumption of a moderate level of vessel avoidance (55%) by blue whales, as measured by the behavior of satellite-tagged whales in the presence of vessels (McKenna *et al*. 2015). The estimated mortality of 18 blue whales annually due to vessel strikes represents approximately 1% of the most recent estimated population size of the stock (18 deaths / 1,898 whales). The results of Rockwood *et al*. (2017) also include a no-avoidance encounter model that results in a worst-case estimate of 40 annual blue whale vessel strike deaths, which represents 2.1% of the estimated population size. The authors note that 74% of blue whale vessel strike mortalities occur within 10% of the study area, implying that vessel avoidance mitigation measures can be effective if applied over relatively small regions. Using the moderate level of avoidance model from Rockwood *et al*. (2017), estimated vessel strike deaths of blue whales are 18 annually. A comparison of average annual vessel strikes observed over the period 2017-2021 (0.6/yr) versus estimated vessel strikes (18/yr) indicates that the rate of detection for blue whale vessel strikes is approximately 3%. Comparing the highest number of vessel strikes observed in a single year (5 in 2007) with the estimated annual number (18) implies that vessel strike detection rates have not exceeded 28% (5/18) in any single year.

Impacts of vessel strikes on population recovery of the eastern North Pacific blue whale population were assessed by Monnahan *et al*. (2015). Their population dynamics model incorporated data on historic whaling removals, vessel strike levels, and projected numbers of vessels using the region through 2050. The authors concluded (based on 10 vessel strike deaths per year) that this stock was at 97% of carrying capacity in 2013. These authors also analyzed the status of the blue whale stock based on a 'high case' of annual vessel strike deaths (35/yr) and concluded that under that scenario, the stock would have been at approximately 91% of carrying capacity in 2013. Caveats to the carrying capacity analysis include the assumption that the population was already at carrying capacity prior to commercial whaling of this stock in the early 20th century and that carrying capacity has not changed appreciably since that time (Monnahan *et al*. 2015).

Vessel strikes within the U.S. West Coast EEZ impact all large whale populations (Redfern *et al*. 2013; 2019; Moore *et al*. 2018). (Redfern *et al*. 2013; 2019; Moore *et al*. 2018). However, diverse vessel types, speeds, and destination ports all contribute to variability in vessel traffic and these factors may be influenced by economic and regulatory changes. For example, Moore *et al*. (2018) found that primary routes travelled by vessels changed when emission control areas (ECAs) were established off the U.S. West Coast. They also found that large vessels typically reduced their speed by 3-6 kts in ECAs between 2008 and 2015. The speed reductions are thought to be a strategy to reduce operating costs associated with more expensive, cleaner burning fuels required within the ECAs. In contrast, Moore *et al*. (2018) noted that some vessels increased their speed when they transited longer routes to avoid the ECAs. Further research is ongoing to understand how variability in vessel traffic affects vessel strike risk and mitigation strategies, though Redfern *et al*. (2019) note that a combination of vessel speed reductions and expansion of areas to be avoided should be considered.

STATUS OF STOCK

As a result of commercial whaling, blue whales were listed as "endangered" under the U.S. Endangered Species Conservation Act of 1969. This protection was transferred to the U.S. Endangered Species Act in 1973. Despite an analysis suggesting that the Eastern North Pacific population was at 91%-97% of carrying capacity in 2013 (Monnahan *et al*. 2015), blue whales are listed as "endangered", and consequently the Eastern North Pacific stock is automatically considered a "depleted" and "strategic" stock under the MMPA. Conclusions about the population's current status relative to carrying capacity depend upon assumptions that the population was already at carrying capacity before commercial whaling impacted the population in the early 1900s, and that carrying capacity has remained relatively constant since that time (Monnahan *et al*. 2015). If carrying capacity has changed significantly in the last century, conclusions regarding the status of this population would necessarily change (Monnahan *et al*. 2015).

The sum of observed and assigned annual incidental mortality and serious injury due to commercial fisheries (≥0.61/yr), plus estimated vessel strike deaths (18/yr), is 18.6 whales annually for 2017-2021. This exceeds the calculated PBR of 4.1 for this stock. Monnahan *et al*. (2015) proposed that estimated vessel strike levels of 10 – 35 whales annually did not pose a threat to the status of this stock, but estimates of carrying capacity of this blue whale stock differed depending on the level of vessel strikes: 97% of K with 10 annual strikes and 91% of K with 35 annual strikes. The highest estimates of blue whale vessel strike mortality (35/yr; Monnahan *et al*. (2015); 40/yr; Rockwood *et al*. (2017)) are similar, and annually represent approximately 2% of the estimated population size. Observed and assigned levels of serious injury and mortality due to commercial fisheries (≥ 0.61) exceed 10% of the stock's PBR (4.1), thus, commercial fishery take levels are not approaching zero mortality and serious injury rate.

OTHER FACTORS THAT MAY BE CAUSING A DECLINE OR IMPEDING RECOVERY

Increasing levels of anthropogenic sound in the world's oceans is a habitat concern for blue whales (Reeves *et al*. 1998, Andrew *et al*. 2002). Tagged blue whales exposed to simulated mid-frequency sonar and pseudo-random noise demonstrated a variety of behavioral responses, including no change in behavior, termination of deep dives, directed travel away from sound sources, and cessation of feeding (Goldbogen *et al*. 2013, Southall *et al.* 2019). Behavioral responses were highly dependent upon the type of sound source, distance from sound sources, and the behavioral state of the animal at the time of exposure. Deep-feeding and non-feeding whales reacted more strongly to experimental sound sources than surface-feeding whales that typically showed no change in behavior (Goldbogen *et al.* 2013, Southall *et al.* 2019). Both studies noted that behavioral responses to such sounds are influenced by a complex interaction of behavioral state, environmental context, and prior exposure of individuals to such sound sources. One concern expressed in both studies is if blue whales did not habituate to such sounds near feeding areas, that chronic cessation of feeding behavior could affect the fitness of individual whales, which could impact population fitness (Goldbogen *et al.* 2013, Southall *et al.* 2019). Currently, no evidence indicates that such reduced population health exists, but such evidence would be difficult to differentiate from natural sources of reduced fitness or mortality in the population. Nine blue whale feeding areas identified off the California coast by Calambokidis *et al*. (2015) represent a diversity of nearshore and offshore habitats that overlap with a variety of anthropogenic activities, including shipping, oil and gas extraction, and military activities.

REFERENCES

Andrew, R. K., B. M. Howe, J. A. Mercer, and M. A. Dzieciuch. 2002. Ocean ambient sound: comparing the 1960's with the 1990's for a receiver off the California coast. Acoustic Research Letters Online 3:65-70.

Bailey, H., Mate, B.R., Palacios, D.M., Irvine, L., Bograd, S.J. and Costa, D.P., 2009. Behavioural estimation of blue whale movements in the Northeast Pacific from state-space model analysis of satellite tracks. Endangered Species Research, 10(93-106).

Barlow, J. 2016. Cetacean abundance in the California Current estimated from ship-based line-transect surveys in 1991-2014. NOAA Southwest Fisheries Science Center Administrative Report LJ-16-01. 63p.

Becker, E.A., Forney, K.A., Fiedler, P.C., Barlow, J., Chivers, S.J., Edwards, C.A., Moore, A.M. and Redfern, J.V., 2016. Moving Towards Dynamic Ocean Management: How Well Do Modeled Ocean Products Predict Species Distributions? Remote Sensing, 8(2), p.149.

Becker E.A., Forney K.A., Thayre B.J., Debich A.J., Campbell G.S., Whitaker K., Douglas A.B., Gilles A, Hoopes R., Hildebrand J.A. 2017. Habitat-based density models for three cetacean species off southern California illustrate pronounced seasonal differences. Frontiers in Marine Science. 4(121):1–14.

Becker, E.A., Karin A. Forney, David L. Miller, Paul C. Fiedler, Jay Barlow, and Jeff 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.

Berman-Kowalewski, M., F. Gulland, S. Wilkin, J. Calambokidis, B. Mate, J. Cordaro, D. Rotstein *et al*. 2010. Association between blue whale (*Balaenoptera musculus*) mortality and ship strikes along the California coast. Aquatic Mammals 36, no. 1: 59-66.

Calambokidis, J., J. Barlow, J.K.B. Ford, T.E. Chandler, and A.B. Douglas. 2009a. Insights into the population structure of blue whales in the Eastern North Pacific from recent sightings and photographic identification. Marine Mammal Science 25:816-832.

Calambokidis, J., E. Falcone, A. Douglas, L. Schlender, and J. Huggins. 2009b. Photographic identification of humpback and blue whales off the U.S. West Coast: results and updated abundance estimates from 2008 field season. Final Report for Contract AB133F08SE2786 from Southwest Fisheries Science Center. 18pp.

Calambokidis, J. and J. Barlow. 2013. Updated abundance estimates of blue and humpback whales off the US west coast incorporating photo-identifications from 2010 and 2011. Document PSRG-2013-13 presented to the Pacific Scientific Review Group, April 2013. 7 p.

Calambokidis, J., G.H. Steiger, C. Curtice, J. Harrison, M.C. Ferguson, E. Becker, M. DeAngelis, and S.M. Van Parijs. 2015. Biologically Important Areas for Selected Cetaceans Within U.S. Waters – West Coast Region. Aquatic Mammals 41(1):39-53.

Calambokidis, J. and J. Barlow. 2020. Updated abundance estimates for blue and humpback whales along the U.S. West Coast using data through 2018, U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-634. https://repository.library.noaa.gov/view/noaa/27104

Carretta, J.V., S. Wilkin, M.M. Muto, and K. Wilkinson. 2013. Sources of human-related injury and mortality for U.S. Pacific West Coast marine mammal stock assessments, 2007-2011. NOAA-TM-NMFS-SWFSC-514. 91 p.

Carretta, J.V. 2018. A machine learning approach to assign species to 'unidentified' entangled whales. Endangered Species Research. Vol. 36:89-98.

Carretta, J.V. 2022. Estimates of marine mammal, sea turtle, and seabird bycatch in the California large-mesh drift gillnet fishery: 1990-2021. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-671. https://doi.org/10.25923/kh19-sk22

Carretta, J.V., Justin Greenman, Kristin Wilkinson, Lauren Saez, Dan Lawson, and Justin Viezbicke. 2023. Sources of human-related injury and mortality for U.S. Pacific West Coast marine mammal stock assessments, 2017-2021. NOAA Technical Memorandum NMFS-SWFSC-690. https://doi.org/10.25923/qwf2-9b97

Gilpatrick, J.W., Jr. and W. L. Perryman. 2008. Geographic variation in external morphology of North Pacific and Southern Hemisphere blue whales (*Balaenoptera musculus*). Journal of Cetacean Research and Management 10(1):9-21.

Goldbogen, J.A., Southall B.L., DeRuiter S.L., Calambokidis J., Friedlaender A.S., Hazen E.L., Falcone E.A., Schorr G.S., Douglas A., Moretti D.J., Kyburg C., McKenna M.F., Tyack P.L. 2013. Blue whales respond to simulated mid-frequency military sonar. Proc. R. Soc. B 280:20130657.

Hazen, E.L., D.M. Palacios, K.A. Forney, E.A. Howell, E. Becker, A.L. Hoover, L. Irvine, M. DeAngelis, S.J. Bograd, B.R. Mate, H. Bailey. 2016. WhaleWatch: a dynamic management tool for predicting blue whale density in the California Current. Journal of Applied Ecology, doi: 10.1111/1365-2664.12820

Kraus. S.D., M.W. Brown, H. Caswell, C.W.Clark, M. Fujiwara, P.K. Hamilton, R.D. Kenney, A.R. Knowlton, S. Landry, C.A.Mayo, W.A. McLellan, M.J. Moore, D.P. Nowacek, D.A. Pabst, A.J. Read, R. M. Rolland. 2005. North Atlantic Right Whales in crisis. Science 309:561-562.

Martin, J., Sabatier, Q., Gowan, T.A., Giraud, C., Gurarie, E., Calleson, C.S., Ortega-Ortiz, J.G., Deutsch, C.J., Rycyk, A. and Koslovsky, S.M., 2016. A quantitative framework for investigating risk of deadly collisions between marine wildlife and boats. Methods in Ecology and Evolution, 7(1), pp.42-50.

Mate, B. R., B. A. Lagerquist, and J. Calambokidis. 1999. Movements of North Pacific blue whales during their feeding season off southern California and their southern fall migration. Mar. Mamm. Sci. 15(4):1246-1257.

McDonald M.A., Hildebrand J.A., Mesnick S.L. 2006. Biogeographic characterization of blue whale song worldwide: using song to identify populations. Journal of Cetacean Research and Management 8: 55–65.

McKenna M., Calambokidis J., Oleson E., Laist D., Goldbogen J. 2015. Simultaneous tracking of blue whales and large ships demonstrates limited behavioral responses for avoiding collision. Endangered Species Research 27: 219-232. https://doi.org/10.3354/esr00666

Monnahan, C. C., Branch, T. A., Stafford, K. M., Ivashchenko, Y. V., & Oleson, E. M. 2014. Estimating historical eastern North Pacific blue whale catches using spatial calling patterns. *PloS one*, *9*(6), e98974.

Monnahan, C. C., Branch, T. A., and Punt, A. E. 2015. Do ship strikes threaten the recovery of endangered eastern North Pacific blue whales? Marine Mammal Science, 31(1), 279-297.

Moore, T.J, J.V. Redfern, M. Carver, S. Hastings, J.D. Adams, and G.K. Silber. Exploring ship traffic variability off California. 2018. Ocean and Coastal Management 163:515-527.

NMFS. 2016. Guidelines for Preparing Stock Assessment Reports Pursuant to the 1994 Amendments to the MMPA.

Pace III, R.M., Williams, R., Kraus, S.D., Knowlton, A.R. and Pettis, H.M., 2021. Cryptic mortality of North Atlantic right whales. Conservation Science and Practice, 3(2), p.e346.

Perrin, W.F., Thieleking, J.L., Walker, W.A., Archer, F.I. and Robertson, K.M. 2011. Common bottlenose dolphins (Tursiops truncatus) in California waters: Cranial differentiation of coastal and offshore ecotypes. Marine Mammal Science, 27:769-792.

Prado, J.H.F., Secchi, E.R., & Kinas, P.G. 2013. Mark-recapture of the endangered franciscana dolphin (Pontoporia blainvillei) killed in gillnet fisheries to estimate past bycatch from time series of stranded carcasses in southern Brazil. Ecological Indicators, 32, 35-41.

Reeves, R. R., P. J. Clapham, R. L. Brownell, Jr., and G. K. Silber. 1998. Recovery plan for the blue whale (*Balaenoptera musculus*). Office of Protected Resources, NMFS, NOAA, Silver Spring, Maryland. 30 pp.

Redfern, J. V., M. F. McKenna, T. J. Moore, J. Calambokidis, M. L. DeAngelis, E. A. Becker, J. Barlow, K. A. Forney, P. C. Fiedler, and S. J. Chivers. 2013. Assessing the risk of ships striking large whales in marine spatial planning. Conservation Biology, 27:292-302.

Redfern, J.V., T.J. Moore, E.A. Becker, J. Calambokidis, S.P. Hastings, L.M. Irvine, B.R. Mate, D.M. Palacios. 2019. Evaluating stakeholder-derived strategies to reduce the risk of ships striking whales. Diversity and Distributions.

Rockwood C.R., 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).

Southall, B.L., DeRuiter, S.L., Friedlaender, A., Stimpert, A.K., Goldbogen, J.A., Hazen, E., Casey, C., Fregosi, S., Cade, D.E., Allen, A.N. and Harris, C.M., 2019. Behavioral responses of individual blue whales (Balaenoptera musculus) to mid-frequency military sonar. Journal of Experimental Biology, 222(5), p.jeb190637.

Stafford, K. M., S. L. Nieukirk, and C. G. Fox. 1999. An acoustic link between blue whales in the eastern tropical Pacific and the Northeast Pacific. Mar. Mamm. Sci. 15(4):1258-1268.

Stafford, K. M., S. L. Nieukirk, and C. G. Fox. 2001. Geographic and seasonal variation of blue whale calls in the North Pacific. Journal Cetacean Research and Management. 3:65-76.

Stafford, K.M. 2003. Two types of blue whale calls recorded in the Gulf of Alaska. Marine Mammal Science 19(4):682-693.