RISSO'S DOLPHIN (*Grampus griseus*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Risso's dolphins are distributed worldwide in tropical and temperate seas (Jefferson et al. 2008, 2014), and in the Northwest Atlantic represent a transboundary stock which occurs from Florida to eastern Newfoundland (Leatherwood et al. 1976; Baird and Stacey 1991). Off the northeastern U.S. coast, Risso's dolphins are distributed along the continental shelf edge from Cape Hatteras northward to Georges Bank during spring, summer, and autumn (Figure 1; CETAP 1982; Payne et al. 1984). In winter, the range is in the mid-Atlantic Bight and extends outward into oceanic waters (Payne et al. 1984). In general, the population occupies the mid-Atlantic continental shelf edge year round, and is rarely seen in the Gulf of Maine (Payne et al. 1984). During 1990, 1991 and 1993, spring/summer surveys conducted along the continental shelf edge and in deeper oceanic waters concluded that Risso's dolphins were associated with strong bathymetric features, Gulf Stream warm-core rings, and the Gulf Stream north wall (Waring et al. 1992, 1993; Hamazaki 2002). Sightings during 2016 surveys were concentrated along the shelf break (Figure 1; NEFSC and SEFSC 2018, 2022).

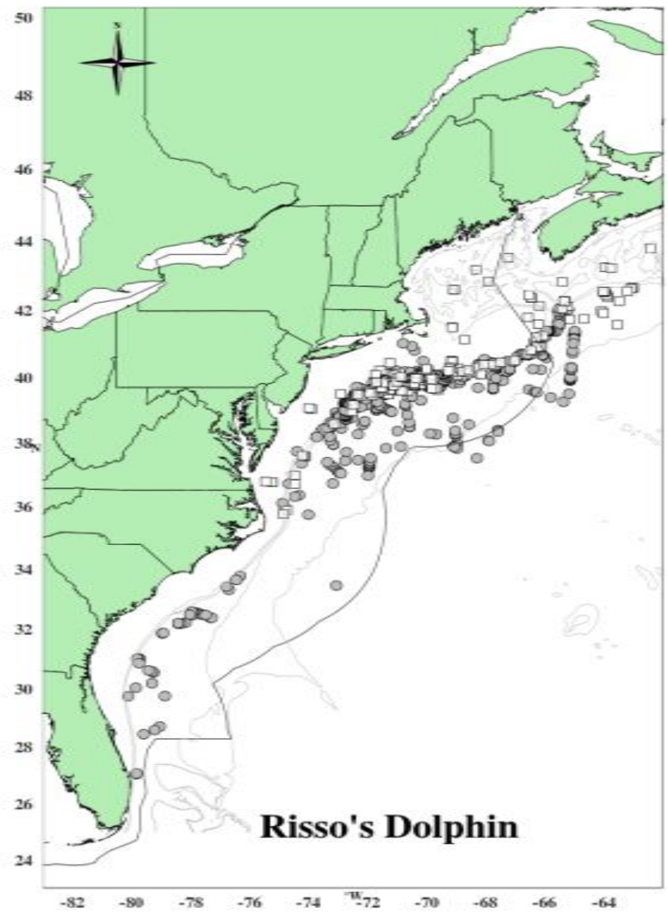

Figure 1. Distribution of Risso's dolphin sightings from NEFSC and SEFSC shipboard and aerial surveys during the summers of 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010, 2011, 2016 and 2021 and Department of Fisheries and Oceans Canada 2007 TNASS and 2016 NAISS surveys. Isobaths are the 100-m, 1000-m and 4000-m depth contours. Circle symbols represent shipboard sightings and squares are aerial sightings.

There is no information on the stock structure of Risso's dolphin in the western North Atlantic, or to determine if separate stocks exist in the Gulf of Mexico and Atlantic. Thus, it is plausible that the stock could actually contain multiple demographically independent populations that should themselves be stocks, because the current stock spans multiple eco-regions (Longhurst 1998; Spalding et al. 2007). In 2006, a rehabilitated adult male Risso's dolphin stranded and released in the Gulf of Mexico off Florida was tracked via satellite-linked tag to waters off Delaware (Wells et al. 2009). The Gulf of Mexico and Atlantic stocks are currently being treated as two separate stocks.

POPULATION SIZE

The best abundance estimate for Risso's dolphins is the sum of the estimates from the 2021 NEFSC and SEFSC surveys—44,067 (CV=0.45; Table 1). Because the survey areas did not overlap, the estimates from the two surveys were added together and the CVs pooled using a delta method to produce a species abundance estimate for the stock area. While some Canadian waters were covered in the aerial portion of the 2021 survey, the full Canadian portion of the species' range was not as well represented in the 2021 survey compared to the 2016 survey. Nevertheless, the 2021 estimate is considered best for this stock.

Earlier Abundance Estimates

Please see Appendix IV for a summary of abundance estimates, including earlier estimates and survey descriptions. As recommended in the GAMMS II Workshop Report (Wade and Angliss 1997), estimates older than eight years are deemed unreliable for the determination of the current PBR.

Recent Surveys and Abundance Estimates

The Department of Fisheries and Oceans, Canada (DFO) generated Risso's dolphin estimates from a large-scale aerial survey of Atlantic Canadian shelf and shelf break habitats, 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 of effort was flown over the Gulf of St. Lawrence/Bay of Fundy/Scotian Shelf strata and 21,037 over the Newfound/Labrador strata. The Bay of Fundy/Scotian shelf portion of the Risso's dolphin population was estimated as 6,073 (CV=0.445).

Abundance estimates of 21,897 (CV=0.23) and 7,245 (CV=0.44) Risso's dolphins were generated from vessel surveys conducted in U.S. waters of the western North Atlantic during the summer of 2016 (Table 1; Garrison 2020; Palka 2020). One survey was conducted from 27 June to 25 August in waters north of 38ºN latitude and consisted of 5,354 km of on-effort trackline along the shelf break and offshore to the outer limit of the U.S. EEZ (NEFSC and SEFSC 2018). The second vessel survey covered waters from Central Florida to approximately 38ºN latitude between the 100-m isobaths and the outer limit of the U.S. EEZ during 30 June–19 August. A total of 4,399 km of trackline was covered on effort (NEFSC and SEFSC 2018). Both 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. Estimates from the two surveys were combined and CVs pooled to produce a species abundance estimate for the stock area.

More recent abundance estimates of 39,612 (CV=0.50) and 4,455 (CV=0.45) Risso's dolphins were generated from vessel surveys conducted in U.S. waters of the western North Atlantic during the summer of 2021 (Table 1; Garrison and Dias 2023; Palka 2023). One survey was conducted from 16 June to 23 August in waters north of 36ºN latitude and consisted of 5,871 km of on-effort trackline along the shelf break and offshore to the outer edge of the U.S. EEZ (NEFSC and SEFSC 2022). The second vessel survey covered waters from central Florida (25ºN latitude) to approximately 38ºN latitude between the 200-m isobaths and the outer edge of the U.S. EEZ during 12 June–31 August. A total of 5,659 km of trackline was covered on effort (NEFSC and SEFSC 2022). Both 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. Estimates from the two surveys were combined and CVs pooled to produce a species abundance estimate for the stock area.

Table 1. Summary of recent abundance estimates for the western North Atlantic Risso's dolphin (*Grampus griseus*), by month, year, and area covered during each abundance survey, resulting abundance estimate (Nest) and coefficient of variation (CV). The estimate considered best is in bold font.

Month/Year	Area	N_{est}	
Jun–Sep 2016	Central Florida to Central Virginia	7,245	0.44
Jun–Sep 2016	Central Virginia to lower Bay of Fundy	21,897	0.23
Aug–Sep 2016	Gulf of St. Lawrence/Bay of Fundy/Scotian Shelf	6,073	0.445
Jun–Sep 2016	Central Florida to Gulf of St. Lawrence/Bay of Fundy/Scotian Shelf -COMBINED	35,215	0.19
Jun–Aug 2021	New Jersey to lower Bay of Fundy	39,612	0.50
Jun–Aug 2021	Central Florida to New Jersey	4,455	0.45
Jun–Aug 2021	**Central Florida to lower Bay of Fundy (COMBINED)**	**44,067**	**0.45**

Minimum Population Estimate

The minimum population estimate is the lower limit of the two-tailed 60% confidence interval of the log-normally 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 Risso's dolphins is 44,067 (CV=0.45), obtained from the 2021 surveys. The minimum population estimate for the western North Atlantic Risso's dolphin is 30,662. This estimate covers U.S. waters and a portion of the range in Canadian waters.

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). There is current work to standardize the strata-specific previous abundance estimates to consistently represent the same regions and include appropriate corrections for perception and availability bias. These standardized abundance estimates will be used in state-space trend models that incorporate environmental factors that could potentially influence the process and observational errors for each strata.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. Due to uncertainties about the stock-specific life history parameters, the maximum net productivity rate was assumed to be the default value of 0.04. This value is based on theoretical modeling showing that cetacean populations may not grow at rates much greater than 4% given the constraints of their reproductive life history (Barlow et al. 1995).

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 30,662. The maximum productivity rate is 0.04, the default value for cetaceans (Barlow et al. 1995). The recovery factor is 0.5, the default value for stocks of unknown status relative to Optimum Sustainable Population (OSP), and the CV of the average mortality estimate is less than 0.3 (Wade and Angliss 1997). PBR for the western North Atlantic stock of Risso’s dolphin is 368 (Table 2). As noted above, the surveys upon which this estimate and PBR are based did not cover all of the species’ range in Canadian waters, however, the estimate is still considered the best estimate for the entire stock.

Table 2. Best and minimum abundance estimates for the western North Atlantic Risso’s dolphin (**Grampus griseus*****) with Maximum Productivity Rate (R_{max}), Recovery Factor (F_r) and PBR.***

N_{est}	CV	N_{min}	F_r	R_{max}	PBR
44,067	0.45	30,662	0.5	0.04	307

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Total annual estimated average human-caused mortality or serious injury to this stock during 2017–2021 was 18 Risso’s dolphins, derived from estimated mortalities and serious injuries in observed U.S. fisheries (CV=0.09; Tables 3, 4). Key uncertainties include the potential that the observer coverage was not representative of the fishery during all times and places.

Table 3. Total annual estimated average human-caused mortality and serious injury for the western North Atlantic Risso’s dolphin (**Grampus griseus*****).***

Years	Source	Annual Avg.	CV
2017–2021	U.S. fisheries using observer data	18	0.09
2017–2021	Non-fishery human caused stranding mortalities	0	-
TOTAL		18	0.09

Fishery Information

Detailed fishery information is reported in Appendix III.

Earlier Interactions

See Appendix V for more information on historical takes.

Pelagic Longline

Pelagic longline bycatch estimates of Risso's dolphins for 2017–2021 are documented in Garrison and Stokes (2019, 2020a, 2020b, 2021, 2023a, 2023b). Most of the estimated marine mammal bycatch was from U.S. Atlantic EEZ waters between South Carolina and Cape Cod. There is a high likelihood that dolphins released alive with ingested gear or gear wrapped around appendages will not survive (Wells et al. 2008). 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 Sink Gillnet

In the northeast sink gillnet fishery, Risso's dolphin interactions have historically been rare, but in 2019 one animal was observed in the waters south of Massachusetts (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

One Risso's dolphin wasobserved taken in northeast bottom trawl fisheries in 2021(Table 4). Annual Risso's dolphin mortalities were estimated using annual stratified ratio-estimator methods (Lyssikatos and Chavez-Rosales 2021). 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 Bottom Trawl

Risso's dolphins have been observed taken in mid-Atlantic bottom trawl fisheries (Table 4). Annual Risso's dolphin mortalities were estimated using annual stratified ratio-estimator methods (Lyssikatos and Chavez-Rosales 2021). 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.

Table 4. Summary of the incidental serious injury and mortality of Risso's dolphin (**Grampus griseus*****) by commercial fishery including the years sampled, the type of data used, the annual observer coverage, the observed mortalities and serious injuries recorded by on-board observers, the estimated annual mortality and serious injury, the combined annual estimates of mortality and serious injury, the estimated CV of the combined estimates and the mean of the combined estimates (CV in parentheses).***

Fishery	Years	Data Type [a]	Observer Coverage [b]	Observed Serious Injury[c]	Observed Mortality	Estimated Serious Injury[e]	Estimated Mortality	Estimated Combined Mortality	Estimated CVs	Mean Combined Annual Mortality
Pelagic Longline	2017 2018 2019 2020 2021	Obs. Data, Logbook	0.12 0.10 0.10 0.09 0.08	1 1 0 2 0	0 0 0 0 0	0.2 0.2 0 12.2 0	0 0 0 0 0	0.2 0.2 0 12.2 0	1 0.94 0 0.71 0	2.5 (0.68)
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	0 0 0 0 0	0 0 1 0 3	0 0 0 0 0	0 0 5 2 3	0 0 5 2 3	0 0 0.7 1.01 0	2 (1.81)
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 0 0 1	0 0 0 0 0	0 0 0 0 3.8	0 0 0 0 3.8	0 0 0 0 0.88	0.75 (0.88)
Mid-Atlantic Bottom Trawl	2017 2018 2019 2020 2021	Obs. Data, Dealer Data	0.14 0.12 0.12 0.02 0.04	2 0 0 0 0	5 0 0 2 0	12 0 0 4 0	31 0 0 14 0	43 0 0 18 0	0.51 0 0 0.51 0	12 (0.39)
TOTAL										18 (0.09)

a. Observer data (Obs. Data) are used to measure bycatch rates and the data are collected within the Northeast Fisheries Observer Program. NEFSC collects landings data (Unallocated Dealer Data and Allocated Dealer Data) which are used as a measure of total landings and mandatory Vessel Trip Reports (VTR; Trip Logbook) are used to determine the spatial distribution of landings and fishing effort. Total landings are used as a measure of total effort for the coastal gillnet fishery.

b. The observer coverages for the northeast and mid-Atlantic sink gillnet fishery are ratios based on tons of fish landed. Northeast bottom trawl, mid-Atlantic bottom trawl, northeast mid-water and mid-Atlantic mid-water trawl fishery coverages are ratios based on trips. Total observer coverage reported for gillnet and bottom trawl gear include samples collected from traditional fisheries observers in addition to fishery at-sea monitors through the Northeast Fisheries Observer Program (NEFOP).

c. Serious injuries were evaluated for the 2017–2021 period and include both at-sea monitor and traditional observer data (Josephson and Lyssikatos 2023).

STATUS OF STOCK

Risso's dolphins are not listed as threatened or endangered under the Endangered Species Act, and the Western North Atlantic stock is not considered strategic under the Marine Mammal Protection Act. The 2017–2021 average annual human-related mortality does not exceed PBR. The total U.S. fishery 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 a zero mortality and serious injury rate. The status of Risso's dolphins relative to OSP is unknown. Population trends for this species have not been investigated. Based on the low levels of uncertainties described in the above sections, it is expected that these uncertainties will have little effect on the designation of the status of this stock.

OTHER FACTORS THAT MAY BE CAUSING A DECLINE OR IMPEDING RECOVERY

Strandings

From 2017 to 2021, 2931 Risso's dolphin strandings were recorded along the U.S. Atlantic coast (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 197 OctoberNovember 20220). None of the animals had indications of human interaction.

Table 5. Risso's dolphin (**Grampus griseus*****) reported strandings along the U.S. Atlantic coast and Puerto Rico, 2017–2021.***

STATE	2017	2018	2019	2020	2021	TOTALS
Massachusetts	141	02	014	00	00	1714

STATE	2017	2018	2019	2020	2021	TOTALS
Rhode Island	10	0	01	00	01	12
New York[a]	02	0	30	00	30	53
New Jersey	10	0	01	00	01	12
Maryland[b]	00	0	10	00	10	11
Virginia	0	0	0	0	1	1
North Carolina	10	10	1	12	10	35
Florida	10	02	01	00	00	41
TOTAL	**184**	**14**	**54**	**12**	**53**	**3129**

a. One animal in 2019 released alive.
b. One animal in 2019 alive, left at site.

Stranding data probably 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.

Habitat Issues

The chronic impacts of contaminants (polychlorinated biphenyls [PCBs] and chlorinated pesticides [DDT, DDE, dieldrin, etc.]) on marine mammal reproduction and health are of concern (e.g., Storelli and Macrotrigiano 2000; Pierce et al. 2008; Jepson et al. 2016; Hall et al. 2018; Murphy et al. 2018), but research on contaminant levels for the western north Atlantic stock of Risso's dolphins is lacking.

Climate-related changes in spatial distribution and abundance, including poleward and depth shifts, have been documented in or predicted for plankton species and commercially important fish stocks (Nye et al. 2009; 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). There is uncertainty in how, if at all, the distribution and population size of this species will respond to these changes and how the ecological shifts will affect human impacts to the species.

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 sighting data collected during seasonal aerial and shipboard line transect abundance surveys during 2010 to 2017. During this time frame, the weighted centroid of Risso's dolphin core habitat moved farthest during spring (232 km towards the northeast) and least during summer (89 km). 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.

REFERENCES CITED

Baird, R.W. and P.J. Stacey. 1990. Status of Risso's dolphin, *Grampus griseus*, in Canada. Can. Field-Nat. 105:233–242.

Barlow, J., S.L. Swartz, T.C. Eagle and P.R. Wade. 1995. U.S. marine mammal stock assessments: Guidelines for preparation, background, and a summary of the 1995 assessments. NOAA Tech. Memo. NMFS-OPR-6. 73pp.

CETAP [Cetacean and Turtle Assessment Program]. 1982. A characterization of marine mammals and turtles in the mid- and North Atlantic areas of the U.S. outer continental shelf, final report. University of Rhode Island. Bureau of Land Management, Washington, DC. #AA551-CT8-48. 576pp.

Chavez-Rosales S., E. Josephson, D. Palka and L. Garrison. 2022. Detection of habitat shifts of cetacean species: a comparison between 2010 and 2017 habitat suitability conditions in the northwest Atlantic Ocean. Front. Mar. Sci. 9:877580. doi: 10.3389/fmars.2022.877580

Garrison, L.P. and L. Stokes. 2020. Estimated bycatch of marine mammals and sea turtles in the U.S. Atlantic pelagic longline fleet during 2017. Southeast Fisheries Science Center, Protected Resources and Biodiversity

Division, 75 Virginia Beach Dr., Miami, FL 33140. PRBD Contribution #PRD-2020-05. 61pp. DOI: 10.25923/a3hs-ea60

Garrison, L.P. and L. Stokes. 2020. Estimated bycatch of marine mammals and sea turtles in the U.S. Atlantic pelagic longline fleet during 2018. Southeast Fisheries Science Center, Protected Resources and Biodiversity Division, 75 Virginia Beach Dr., Miami, FL 33140. PRBD Contribution #2020-08. 56pp. DOI: 10.25923/777n-w316

Garrison, L.P. and L. Stokes. 2021. Estimated bycatch of marine mammals and sea turtles in the U.S. Atlantic pelagic longline fleet during 2019. NOAA Tech Memo NMFS-SEFSC 750. 59pp. DOI: 10.25923/asb3-6q44

Garrison, L.P. 2020. Abundance of cetaceans along the southeast U.S. east coast from a summer 2016 vessel survey. Southeast Fisheries Science Center, Protected Resources and Biodiversity Division, 75 Virginia Beach Dr., Miami, FL 33140. PRD Contribution # PRD-2020-04. 17pp.

Garrison, L.P. and L. Stokes. 2023a. Estimated bycatch of marine mammals and sea turtles in the U.S. Atlantic pelagic longline fleet during 2020. NOAA Tech. Memo. NMFS-SEFSC-764. 66 pp.

Garrison, L.P. and L. Stokes. 2023b. Estimated bycatch of marine mammals and sea turtles in the U.S. Atlantic pelagic longline fleet during 2021. NOAA Tech. Memo. NMFS-SEFSC-765. 65 pp.

Garrison, L.P. and L.A. Dias. 2023. Abundance of marine mammals in waters of the southeastern U.S. Atlantic during summer 2021. SEFSC MMTD Contribution: #MMTD-2023-01. 23 pp. https://repository.library.noaa.gov/view/noaa/49152

Grieve, B.D., J.A. Hare and V.S. Saba. 2017. Projecting the effects of climate change on *Calanus finmarchicus* distribution within the US Northeast continental shelf. Sci. Rep. 7:6264.

Hare, J.A., W.E. Morrison, M.W. Nelson, M.M. Stachura, E.J. Teeters, R.B. Griffis, M.A. Alexander, J.D. Scott, L. Alade, R.J. Bell, A.S. Chute, K.L. Curti, T.H. Curtis, D. Kurcheis, J.F. Kocik, S.M. Lucey, C.T. McCandless, L.M. Milke, D.E. Richardson, E. Robillard, H.J. Walsh, M.C. McManus, K.E. Maranick, C.A. Griswold. 2016. A vulnerability assessment of fish and invertebrates to climate change on the Northeast U.S. continental shelf. 2016. PLoS ONE 11 e0146756. https://doi.org/10.1371/journal.pone.0146756.s014

Hall, A.J., B.J. McConnell, L.J. Schwacke, G.M. Ylitalo, R. Williams and T.K. Rowles. 2018. Predicting the effects of polychlorinated biphenyls on cetacean populations through impacts on immunity and calf survival. Environ. Poll. 233:407–418.

Head, E.J.H. and P. Pepin. 2010. Spatial and inter-decadal variability in plankton abundance and composition in the Northwest Atlantic (1958–2006). J. Plankton Res. 32:1633–1648.

Hamazaki, T. 2002. Spatiotemporal prediction models of cetacean habitats in the mid-western North Atlantic Ocean (from Cape Hatteras, No. Carolina, USA to Nova Scotia, Canada). Mar. Mamm. Sci. 18(4):920-939.

Hatch, J.M. and C.D. Orphanides. 2015. Estimates of cetacean and pinniped bycatch in the 2013 New England sink gillnet and mid-Atlantic gillnet fisheries. Northeast Fish. Sci. Cent. Ref. Doc. 15-15. 33pp.

Jefferson, T.A., M.A. Webber and R.L. Pitman. 2008. Marine mammals of the world. Elsevier, Amsterdam. 573pp.

Jefferson, T.A., C.R. Weir, R.C. Anderson, L.T. Balance, J. Barlow, R.D. Kenney and J.J. Kiszka. 2014. Global distribution of Risso's dolphin *Grampus griseus*: A review and critical evaluation. Mamm. Rev. 44:56–68.

Jepson, P.D., R. Deaville, J.L. Barber, A. Aguilar, A. Borrell, S. Murphy, J. Barry, A. Brownlow, J. Barnett, S. Berrow and A.A. Cunningham. 2016. PCB pollution continues to impact populations of orcas and other dolphins in European waters. Sci. Rep.-U.K. 6:18573.

Josephson, E., F. Wenzel and M.C. Lyssikatos. 2023. Serious injury determinations for small cetaceans and pinnipeds caught in commercial fisheries off the northeast U.S. coast, 2017–2021. Northeast Fish. Sci. Cent. Ref. Doc. 23-03. 26pp.

Lawson J. and J.-F. Gosselin. 2018. Estimates of cetacean abundance from the 2016 NAISS aerial surveys of eastern Canadian waters, with a comparison to estimates from the 2007 TNASS NAAMCO SC/25/AE/09. 40pp.

Laake, J.L. and D.L. Borchers. 2004. Methods for incomplete detection at distance zero. Pages 108-189 *in*: Advanced distance sampling, S.T. Buckland, D.R. Andersen, K.P. Burnham, J.L. Laake, and L. Thomas (eds). Oxford University Press, New York.

Leatherwood, S., D.K. Caldwell and H.E. Winn. 1976. Whales, dolphins, and porpoises of the western North Atlantic. A guide to their identification. NOAA Tech. Rep. NMFS Circ. 396. 176pp.

Longhurst, A.R. 1998. Ecological geography of the sea, Second Edition., Elsevier Academic Press. 560pp.

Lucas, Z.N. and S.K. Hooker. 2000. Cetacean strandings on Sable Island, Nova Scotia, 1970–1998. Can. Field-Nat. 114(1):46–61.

Lyssikatos, M. S. Chavez-Rosales. 2022. Estimation of cetacean and pinniped bycatch in northeast and mid-Atlantic bottom trawl fisheries, 2015–2019. NOAA Tech. Memo. NMFS-NE-281.

MacLeod, C.D. 2009. Global climate change, range changes and potential implications for the conservation of marine cetaceans: A review and synthesis. Endang. Species Res. 7:125–136.

Morley, J.W., R.L. Selden, R.J. Latour, T.L. Frolicher, R.J. Seagraves and M.L. Pinsky. 2018. Projecting shifts in thermal habitat for 686 species on the North American continental shelf. PLoS ONE 13(5):e0196127.

Murphy, S., R.J. Law, R. Deaville, J.Barnett, M W. Perkins, A. Brownlow, R. Penrose, N.J. Davison, J.L. Barber and P.D. Jepson. 2018. Organochlorine contaminants and reproductive implication in cetaceans: A case study of the common dolphin. Pages 3–38 *in:* M.C. Fossi and C. Panti (eds). Marine mammal ecotoxicology: Impacts of multiple stressors on population health. Academic Press, New York, New York.

NEFSC [Northeast Fisheries Science Center] and SEFSC [Southeast Fisheries Science Center]. 2018. Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean. Northeast Fish. Sci. Cent. Ref. Doc. 18-04. 141pp. https://www.fisheries.noaa.gov/resource/publication-database/atlantic-marine-assessment-program-protected-species.

NEFSC [Northeast Fisheries Science Center] and Southeast Fisheries Science Center [SEFSC]. 2022. 2021 Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the Western North Atlantic Ocean – AMAPPS III. 125 pp. https://repository.library.noaa.gov/view/noaa/41734

Orphanides, C.D. and J. Hatch. 2017. Estimates of cetacean and pinniped bycatch in the 2015 New England Sink Gillnet fishery and mid-Atlantic gillnet fisheries. Northeast Fish. Sci. Cent. Ref. Doc. 317-18. 21pp.

Orphanides, C.D. 2019. Estimates of cetacean and pinniped bycatch in the 2016 New England Sink Gillnet fishery and mid-Atlantic gillnet fisheries. Northeast Fish. Sci. Cent. Ref. Doc.19-04. 12pp.

Orphanides, C.D. 2020. Estimates of cetacean and pinniped bycatch in the 2017 New England Sink Gillnet fishery and mid-Atlantic gillnet fisheries. Northeast Fish. Sci. Cent. Ref. Doc. 20-03. 16pp.

Orphanides, C.D. 2021. Estimates of cetacean and pinniped bycatch in the 2018 New England sink and mid-Atlantic Gillnet fisheries. Northeast Fish. Sci. Cent. Ref. Doc. 21-01. 16pp.

Precoda, K. and C.D. Orphanides. 2022. Estimates of cetacean and pinniped bycatch in the 2019 New England sink and mid-Atlantic Gillnet fisheries. Northeast Fish. Sci. Cent. Ref. Doc. 22-05. 21pp

Palka, D. 2020. Cetacean abundance estimates in US northwestern Atlantic Ocean waters from summer 2016 line transect surveys conducted by the Northeast Fisheries Science Center. Northeast Fish. Sci. Cent. Ref. Doc. 20-05.

Palka, DL. 2023. Cetacean abundance in the US Northwestern Atlantic Ocean, Summer 2021. Northeast Fish. Sci. Cent. Ref. Doc. 23-08.

Palka, D.L. and P.S. Hammond. 2001. Accounting for responsive movement in line transect estimates of abundance. Can. J. Fish. Aquat. Sci 58: 777–787.

Payne, P.M., L.A. Selzer and A.R. Knowlton. 1984. Distribution and density of cetaceans, marine turtles and seabirds in the shelf waters of the northeast U.S., June 1980–Dec. 1983, based on shipboard observations. National Marine Fisheries Service, Woods Hole. NA81FAC00023:245.

Pierce, G.J., M.B. Santos, S. Murphy, J.A. Learmonth, A.F. Zuur, E. Rogan, P. Bustamante, F. Caurant, V. Lahaye, V. Ridoux, B.N. Zegers, A. Mets, M. Addink, C. Smeenk, T. Jauniaux, R.J. Law, W. Dabin, A. López, J.M. Alonso Farré, A.F. González, A. Guerra, M. García-Hartmann, R.J. Reid, C.F. Moffat, C. Lockyer and J.P. Boon. 2008. Bioaccumulation of persistent organic pollutants in female common dolphins (*Delphinus delphis*) and harbour porpoises (*Phocoena phocoena*) from western European seas: Geographical trends, causal factors and effects on reproduction and mortality. Environmental Pollution. 153:401–415.

Pinsky, M.L., B. Worm, M.J. Fogarty, J.L. Sarmiento and S.A. Levin. 2013. Marine taxa track local climate velocities, Science 341:1239–1242.

Poloczanska, E.S., C.J. Brown, W.J. Sydeman, W. Kiessling, D.S. Schoeman, P.J. Moore, K. Brander, J.F. Bruno, L.B. Buckley, M.T. Burrows, C.M. Duarte, B.S. Halpern, J. Holding, C.V. Kappel, M.I. O'Connor, J.M. Pandolfi, C. Parmesan, F. Schwing, S.A. Thompson and A.J. Richardson. 2013. Global imprint of climate change on marine life. Nat. Clim. Change 3:919–925.

Sousa, A., F. Alves, A. Dinis, J. Bentz, M.J. Cruz and J.P. Nunes. 2019. How vulnerable are cetaceans to climate change? Developing and testing a new index. Ecol. Indic. 98:9–18.

Storelli, M. and G. Macrotrigiano. 2000. Persistent organochlorine residues in Risso's dolphins (*Grampus griseus*) from the Mediterranean Sea. Mar. Pol. Bull. 40:555–558.

Spalding, M.D., H.E. Fox, G.R. Allen, N. Davidson, Z.A. Ferdaña, M. Finlayson, B.S. Halpern, M.A. Jorge, A. Lombana, S.A. Lourie, K.D. Martin, E. McManus, J. Molnar, C.A. Recchia and J. Robertson. 2007. Marine ecoregions of the world: A bioregionalization of coastal and shelf areas. BioScience. 57(7):573–583.

Taylor, B.L., M. Martinez, T. Gerrodette, J. Barlow and Y.N. Hrovat. 2007. Lessons from monitoring trends in abundance in marine mammals. Mar. Mamm. Sci. 23(1):157–175.

Thomas, L., J.L. Laake, E. Rexstad, S. Strindberg, F.F.C. Marques, S.T. Buckland, D.L. Borchers, D.R. Anderson, K.P. Burnham, M.L. Burt, S.L. Hedley, J.H. Pollard, J.R.B. Bishop and T.A. Marques. 2009. Distance 6.0. Release 2. [Internet]. University of St. Andrews (UK): Research Unit for Wildlife Population Assessment. http://distancesampling.org/Distance/

Wade, P.R. and R.P. Angliss. 1997. Guidelines for assessing marine mammal stocks: Report of the GAMMS Workshop April 3–5, 1996, Seattle, Washington. NOAA Tech. Memo. NMFS-OPR-12. 93pp. https://repository.library.noaa.gov/view/noaa/15963

Waring, G.T., C.P. Fairfield, C.M. Ruhsam and M. Sano. 1992. Cetaceans associated with Gulf Stream features off the northeastern USA Shelf. ICES [Int. Counc. Explor. Sea] C.M. 1992/N:12.

Waring, G.T., C.P. Fairfield, C.M. Ruhsam and M. Sano. 1993. Sperm whales associated with Gulf Stream features off the northeastern USA shelf. Fish. Oceanogr. 2(2):101–105.

Wells, R.S., J.B. Allen, S. Hofmann, K. Bassos-Hull, D.A. Fauquier, N.B. Barros, R.E. DeLynn, G. Sutton, V. Socha and M.D. Scott. 2008. Consequences of injuries on survival and reproduction of common bottlenose dolphins (*Tursiops truncatus*) along the west coast of Florida. Mar. Mamm. Sci. 24:774–794.

Wells, R.S., C.A. Manire, L. Byrd, D.R. Smith, J.G. Gannon, D. Fauquier and K.D. Mullin. 2009. Movements and dive patterns of a rehabilitated Risso's dolphin, *Grampus griseus*, in the Gulf of Mexico and Atlantic Ocean. Mar. Mamm. Sci. 25(2):420–429.

Yeung, C. 2001. Estimates of marine mammal and marine turtle bycatch by the U.S. Atlantic pelagic longline fleet in 1999–2000. NOAA Tech. Memo. NMFS-SEFSC-467. 43pp.

Yeung, C., S. Epperly and C.A. Brown. 2000. Preliminary revised estimates of marine mammal and marine turtle bycatch by the U.S. Atlantic pelagic longline fleet, 1992–1999. PRD Contribution Number 99/00-13. National Marine Fisheries Service, Miami, FL. 58pp.