

DWARF SPERM WHALE (*Kogia sima*): Northern Gulf of Mexico Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The dwarf sperm whale is distributed worldwide in temperate to tropical waters (Caldwell and Caldwell 1989). Sightings of these animals in the northern Gulf of Mexico (i.e., U.S. Gulf of Mexico) occur primarily in oceanic waters (Figure 1; Mullin *et al.* 1991, Mullin and Fulling 2004, Maze-Foley and Mullin 2006). Dwarf sperm whales and pygmy sperm whales (*Kogia breviceps*) are often difficult to differentiate at sea (Caldwell and Caldwell 1989, Bloodworth and Odell 2008, McAlpine 2009) unless sighting conditions are ideal, and sightings of either species are usually categorized as *Kogia* spp. In addition, the acoustic signals of dwarf and pygmy sperm whales also cannot be distinguished from each other at this time (Merkens *et al.* 2018) adding to the difficulties of identification at sea.

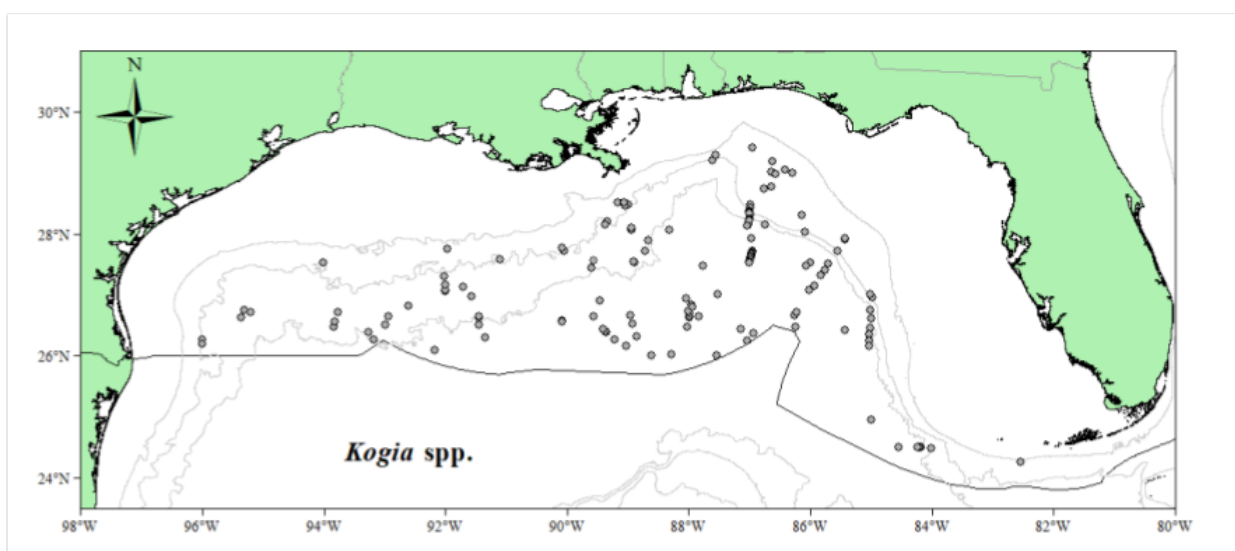


Figure 1. Distribution of *Kogia* spp. on-effort sightings from SEFSC vessel surveys during spring 1996–2001, summer 2003, spring 2004, summer 2009, summer 2017, and summer/fall 2018. Isobaths are the 200-m, 1,000-m, and 2,000-m depth contours. The darker line indicates the U.S. EEZ.

In the northern Gulf of Mexico, *Kogia* spp. are sighted in waters >200 m, over the continental slope and deep basin. They have been seen in all seasons during aerial and vessel surveys of the northern Gulf of Mexico (Hansen *et al.* 1996, Mullin and Hoggard 2000, Maze-Foley and Mullin 2006, Garrison and Aichinger Dias 2020; Figure 1). All the cetacean species found in the oceanic northern Gulf of Mexico almost certainly occur in similar habitat beyond U.S. boundaries in the southern Gulf. There are fewer cetacean sighting and stranding records in the southern Gulf due to more limited effort. Nevertheless there are records for most oceanic species in the southern Gulf (e.g., Jefferson and Schiro 1997; Ortega Ortiz 2002; Ortega-Argueta *et al.* 2005; Jefferson *et al.* 2008; Vázquez Castán *et al.* 2009; Whitt *et al.* 2011). This is therefore likely a transboundary stock with Cuba and/or Mexico. Because U.S. waters only comprise about 40% of the entire Gulf of Mexico and 35% of the oceanic (i.e., >200 m) Gulf of Mexico (Mullin and Fulling 2004), abundance and stock boundaries of oceanic species are poorly known.

Dwarf sperm whales in the northern Gulf of Mexico are managed separately from those in the western North Atlantic. Although there have been no directed studies of the degree of demographic independence between the two areas, this management structure is consistent with the fact that the Gulf of Mexico and western North Atlantic belong to distinct marine ecoregions (Spalding *et al.* 2007, Moore and Merrick 2011). There are insufficient data to determine whether the northern Gulf of Mexico stock comprises multiple demographically independent populations. Additional morphological, acoustic, genetic, and/or behavioral data are needed to further delineate population structure within

the Gulf of Mexico and across the broader geographic area.

POPULATION SIZE

The best abundance estimate (Nest) for northern Gulf of Mexico dwarf and pygmy sperm whales combined is 336 (CV=0.35; Table 1). This estimate is from summer 2017 and summer/fall 2018 oceanic surveys covering waters from the 200-m isobath to the seaward extent of the U.S. EEZ (Garrison *et al.* 2020). This estimate was not corrected for the probability of detection on the trackline, and is likely a severe underestimate because *Kogia* spp. are often difficult to see, present little of themselves at the surface, do not fluke when they dive, and have long dive times. In addition, they exhibit avoidance behavior towards ships and changes in behavior towards approaching survey aircraft (Würsig *et al.* 1998).

Earlier Abundance Estimates

Five point estimates of dwarf and pygmy sperm whale combined abundance have been made based on data from surveys during: 2003 (June–August), 2004 (April–June), 2009 (July–August), 2017 (July–August), and 2018 (August–October). Each of these surveys had a similar design and was conducted using the same vessel or a vessel with a similar observation platform. Surveys in 2003, 2004, and 2009 employed a single survey team while the 2017 and 2018 surveys employed two survey teams. In addition, the 2017 and 2018 surveys were conducted in "passing" mode rather than "closing" mode. Passing mode eliminates the problems of fragmented tracklines associated with using closing mode in areas with high densities of animals. When using the closing mode with the two-team method, both teams must be allowed the opportunity to see a mammal group and allow it to pass behind the ship before turning to close on it, making it difficult to reacquire the group and resulting in long periods spent chasing the group, with the increased potential for off-effort sightings. For passive acoustics, in closing mode the vessel often turns before the acoustic team is able to achieve a good localization. This is especially important for deep-diving species where visual surveys are less optimal for abundance estimates. However, passing mode can result in increased numbers of unidentified sightings and may have affected group size estimation for distant groups of dolphins and small whales. Comparisons of the survey results over the years 2003 through 2009 required adjustments for these differences. This resulted in revised abundance estimates for dwarf and pygmy sperm whales combined of: 2003, N=441 (CV=0.42); 2004, N=38 (CV=0.71); and 2009, N=124 (CV=0.60; Garrison *et al.* 2020).

Recent Surveys and Abundance Estimates

An abundance estimate for dwarf and pygmy sperm whales combined was generated from vessel surveys conducted in the northern Gulf of Mexico from the continental shelf edge (~200-m isobath) to the seaward extent of the U.S. EEZ (Garrison *et al.* 2020). One survey was conducted from 2 July to 25 August 2017 and consisted of 7,302 km of on-effort trackline, and the second survey was conducted from 11 August to 6 October 2018 and consisted of 6,473 km of on-effort trackline within the surveyed strata. Both surveys used a double-platform data-collection procedure to allow estimation of the detection probability on the trackline using the independent observer approach assuming point independence (Laake and Borchers 2004). However, there were too few sightings and too few resightings of these species to allow estimation of detection probability on the trackline. Therefore, abundance estimates were derived using MCDS distance sampling methods that accounted for the effects of covariates (e.g., sea state, glare) on detection probability within the surveyed strip (Thomas *et al.* 2010) implemented in package mrds (version 2.21, Laake *et al.* 2020) in the R statistical programming language. The surveys were conducted in passing mode (e.g., Schwarz *et al.* 2010) while all prior surveys in the Gulf of Mexico have been conducted in closing mode. The 2017 and 2018 estimates were N=293 (CV=0.59) and N=359 (CV=0.42), respectively. The inverse variance weighted mean abundance estimate for dwarf and pygmy sperm whales in oceanic waters during 2017 and 2018 was 336 (CV=0.35; Table 1; Garrison *et al.* 2020). This estimate was not corrected for the probability of detection on the trackline, and is likely a severe underestimate due to the long dive times of these species.

Table 1. Most recent abundance estimate (Nest) and coefficient of variation (CV) of northern Gulf of Mexico dwarf and pygmy sperm whales in oceanic waters (200 m to the offshore extent of the EEZ) based on the inverse variance weighted mean from summer 2017 and summer/fall 2018 vessel surveys.

Years	Area	Nest	CV
2017, 2018	Gulf of Mexico	336	0.35

Minimum Population Estimate

The minimum population estimate (Nmin) is the lower limit of the two-tailed 60% confidence interval of the log-normal distributed abundance estimate. This is equivalent to the 20th percentile of the log-normal distributed abundance estimate as specified by Wade and Angliss (1997). The best estimate of abundance for dwarf and pygmy sperm whales is 336 (CV=0.35). It is not possible to determine the minimum population estimate for only dwarf sperm whales. The minimum population estimate for the northern Gulf of Mexico dwarf and pygmy sperm whales is 253 (Table 2).

Current Population Trend

Using revised abundance estimates for surveys conducted in 2003 (June–August), 2004 (April–June), and 2009 (July–August; see above), and the 2017 (July–August) and 2018 (August–October) estimates, pairwise comparisons of the log-transformed means were conducted between years, and significant differences were assessed at $\alpha=0.10$. P-values were adjusted for multiple comparisons. There were significant differences between the 2003 and 2004 estimates (p.adjusted=0.006) and between the 2004 estimate and both the 2017 (p.adjusted=0.063) and 2018 (p.adjusted=0.014) estimates (Garrison *et al.* 2020).

However, the statistical power to detect a trend in abundance for this stock is poor due to the relatively imprecise abundance estimates and long intervals between surveys. 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). In addition, because these surveys are restricted to U.S. waters, it is not possible to distinguish between changes in population size and Gulf-wide shifts in spatial distribution.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Current and maximum net productivity rates are unknown for this stock. For purposes of this assessment, the maximum net productivity rate was assumed to be 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 the minimum population size, one half the maximum net productivity rate and a recovery factor (MMPA Sec. 3.16 U.S.C. 1362; Wade and Angliss 1997). The minimum population size for dwarf and pygmy sperm whales is 253. The maximum productivity rate is 0.04, the default value for cetaceans. The recovery factor, which accounts for endangered, depleted, threatened stocks, or stocks of unknown status relative to optimum sustainable population (OSP), is assumed to be 0.5 because the stock is of unknown status. PBR for the northern Gulf of Mexico dwarf and pygmy sperm whales is 2.5 (Table 2). It is not possible to determine the PBR for only dwarf sperm whales.

Table 2. Best and minimum abundance estimates for northern Gulf of Mexico dwarf and pygmy sperm whales with Maximum Productivity Rate (Rmax), Recovery Factor (Fr) and PBR.

Nest	CV	Nmin	Fr	Rmax	PBR
336	0.35	253	0.5	0.04	2.5

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Total annual estimated fishery-related mortality and serious injury to this stock during 2014–2018 was presumed to be zero, as there were no reports of mortalities or serious injuries to dwarf or pygmy sperm whales in the Gulf of Mexico (Table 3). Mean annual mortality and serious injury during 2014–2018 for dwarf and pygmy sperm whales due to other human-caused actions (the *Deepwater Horizon* oil spill) was predicted to be 31. The minimum total mean

annual human-caused mortality and serious injury for dwarf and pygmy sperm whales during 2014–2018 was, therefore, 31. The minimum total mean annual human-caused mortality and serious injury for dwarf sperm whales is unknown.

Table 3. Total annual estimated fishery-related mortality and serious injury for northern Gulf of Mexico dwarf and pygmy sperm whales.

Years	Source	Annual Avg.	CV
2014–2018	U.S. fisheries using observer data	0	-

Fisheries Information

There are two commercial fisheries that interact, or that could potentially interact, with this stock in the Gulf of Mexico. These are the Category I Atlantic Highly Migratory Species (high seas) longline fishery and the Category I Atlantic Ocean, Caribbean, Gulf of Mexico large pelagics longline fishery (Appendix III). Percent observer coverage (percentage of sets observed) for these longline fisheries for each year during 2014–2018 was 18, 19, 23, 13 and 20, respectively. There is very little effort within the Gulf of Mexico by the Atlantic Highly Migratory Species (high seas) longline fishery, and no takes of pygmy or dwarf sperm whales within high seas waters of the Gulf of Mexico have been observed or reported thus far. Pelagic swordfish, tunas and billfish are the targets of the large pelagics longline fishery operating in the northern Gulf of Mexico. During 2014–2018 there were no observed mortalities or serious injuries to dwarf or pygmy sperm whales by this fishery (Garrison and Stokes 2016, 2017, 2019, 2020a, 2020b).

Other Mortality

At least nine dwarf sperm whale strandings were documented in the northern Gulf of Mexico during 2014–2018 (Table 4; NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 21 May 2019). No evidence of human interaction was detected for one animal; for the remaining eight animals, it could not be determined if there was evidence of human interaction. An additional 10 *Kogia* spp. stranded during 2014–2018. No evidence of human interaction was detected for one of the *Kogia* spp. strandings; it could not be determined if there was evidence of human interaction for the remaining nine *Kogia* spp. strandings. Stranding data probably underestimate the extent of human and fishery-related mortality and serious injury because not all of the whales that die or are seriously injured in human interactions wash ashore, or, if they do, they are not all recovered (Peltier *et al.* 2012, Wells *et al.* 2015). In particular, oceanic stocks in the Gulf of Mexico are less likely to strand than nearshore coastal stocks or shelf stocks (Williams *et al.* 2011). Additionally, not all carcasses will show evidence of human interaction, entanglement or other fishery-related interaction due to decomposition, scavenger damage, etc. (Byrd *et al.* 2014). Finally, the level of technical expertise among stranding network personnel varies widely as does the ability to recognize signs of human interaction.

An Unusual Mortality Event (UME) was declared for cetaceans in the northern Gulf of Mexico beginning 1 March 2010 and ending 31 July 2014 (Litz *et al.* 2014; <https://www.fisheries.noaa.gov/national/marine-life-distress/2010-2014-cetacean-unusual-mortality-event-northern-gulf-mexico>). It included cetaceans that stranded prior to the *Deepwater Horizon* (DWH) oil spill (see “Habitat Issues” below), during the spill, and after. Exposure to the DWH oil spill was determined to be the primary underlying cause of the elevated stranding numbers in the northern Gulf of Mexico after the spill (e.g., Schwacke *et al.* 2014; Venn-Watson *et al.* 2015; Colegrove *et al.* 2016; DWH NRDAT 2016; see Habitat Issues section). Four dwarf sperm whale strandings were considered to be part of this UME, one of which occurred during 2014.

A population model was developed to estimate the injury and time to recovery for stocks affected by the DWH oil spill, taking into account long-term effects resulting from mortality, reproductive failure, reduced survival rates, and the proportion of the stock exposed to DWH oil (DWH MMIQT 2015). Overall, the model estimated that dwarf and pygmy sperm whale stocks experienced a 6% maximum reduction in population size due to the oil spill (DWH MMIQT 2015). The mortality projected for the years 2010–2013 due to the spill has not been reported previously. Based on the population model, it was projected that 340 dwarf and pygmy sperm whale died during 2010–2013 (four year annual average of 85) due to elevated mortality associated with oil exposure (see Appendix VI). For the 2014–2018 reporting period of this SAR, the population model estimated 154 dwarf and pygmy sperm whales died due to elevated mortality associated with oil exposure. However, this mortality estimate is not comparable to the current abundance estimate derived from visual surveys because the population model included a correction factor for detection probability derived from acoustic density estimates (DWH MMIQT 2015). The population model used to predict dwarf/pygmy sperm whale mortality due to the DWH event has a number of sources of uncertainty. Model

parameters (e.g., survival rates, reproductive rates, and life-history parameters) were derived from literature sources for dwarf/pygmy sperm whales occupying waters outside of the Gulf of Mexico. In addition, proxy values for the effects of DWH oil exposure on both survival rates and reproductive success were applied based upon estimated values for common bottlenose dolphins in Barataria Bay. Finally, there was no estimation of uncertainty in model parameters or outputs.

Table 4. Dwarf and pygmy sperm whale (*Kogia sima* (Ks), *Kogia breviceps* (Kb) and *Kogia* spp. (Sp)) strandings along the northern Gulf of Mexico coast, 2014–2018. Strandings that were not reported to species have been reported as *Kogia* spp. The level of technical expertise among stranding network personnel varies, and given the potential difficulty in correctly identifying stranded *Kogia* whales to species, reports to specific species should be viewed with caution.

State	2014	2014	2014	2015	2015	2015	2016	2016	2016	2017	2017	2017	2018	2018	2018	Total	Total	Total
	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp
Alabama	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Florida	2	0	1	0	2	1	0	3	1	2	1	1	2	1	0	6	7	4
Louisiana	1	0	2	0	0	0	0	0	0	0	1	0	0	1	0	1	2	2
Mississippi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Texas	0	2	1	0	2	1	1	0	0	1	1	2	0	4	0	2	9	4
Total	3	2	4	0	4	2	1	3	1	3	3	3	2	7	0	9	19	10

HABITAT ISSUES

The DWH MC252 drilling platform, located approximately 80 km southeast of the Mississippi River Delta in waters about 1,500 m deep, exploded on 20 April 2010. The rig sank, and over 87 days ~3.2 million barrels of oil and gas were discharged from the wellhead until it was capped on 15 July 2010 (DWH NRDAT 2016). Shortly after the oil spill, the Natural Resource Damage Assessment (NRDA) process was initiated under the Oil Pollution Act of 1990. A variety of NRDA research studies were conducted to determine potential impacts of the spill on marine mammals. These studies estimated that 15% (95%CI: 8–29) of dwarf/pygmy sperm whales in the Gulf were exposed to oil, that 7% (95%CI: 3–10) of females suffered from reproductive failure, and 6% (95%CI: 2–9) of dwarf/pygmy sperm whales suffered adverse health effects (DWH MMIQT 2015). A population model estimated the stocks experienced a maximum 6% reduction in population size (see Other Mortality section above).

Anthropogenic sound in the world’s oceans has been shown to affect marine mammals, with vessel traffic, seismic surveys, and active naval sonars being the main anthropogenic contributors to low- and mid-frequency noise in oceanic waters (e.g., Nowacek *et al.* 2015; Gomez *et al.* 2016; NMFS 2018). The long-term and population consequences of these impacts are less well-documented and likely vary by species and other factors. Impacts on marine mammal prey from sound are also possible (Carroll *et al.* 2017), but the duration and severity of any such prey effects on marine mammals are unknown.

STATUS OF STOCK

Dwarf sperm whales are not listed as threatened or endangered under the Endangered Species Act, and the northern Gulf of Mexico stock is not considered strategic under the MMPA because PBR is likely a severe underestimate due to the long dive times of this species and because the mean modeled annual human-caused mortality and serious injury due to the DWH oil spill is based on all dwarf and pygmy sperm whales combined and cannot be apportioned to individual species. No fishery-related mortality or serious injury has been observed in recent years; therefore, total fishery-related mortality and serious injury can be considered insignificant and approaching the zero mortality and serious injury rate. The status of dwarf sperm whales in the northern Gulf of Mexico, relative to OSP, is unknown. There are insufficient data to determine the population trends for this stock.

REFERENCES CITED

- 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.
- Bloodworth, B.E. and D.K. Odell. 2008. *Kogia breviceps* (Cetacea: Kogiidae). Mamm. Species 819:1–12.
- Byrd, B.L., A.A. Hohn, G.N. Lovewell, K.M. Altman, S.G. Barco, A. Friedlaender, C.A. Harms, W.A. McLellan, K.T. Moore, P.E. Rosel and V.G. Thayer. 2014. Strandings illustrate marine mammal biodiversity and human impacts off the coast of North Carolina, USA. Fish. Bull. 112:1–23.
- Caldwell, D.K. and M.C. Caldwell. 1989. Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838): Dwarf sperm whale *Kogia sima* Owen, 1866. Pages 235–260 in: S.H. Ridgway and R. Harrison (Eds.). Handbook of marine mammals, Vol. 4: River dolphins and the larger toothed whales. Academic Press, San Diego, California.
- Carroll, A.G., R. Przeslawski, A. Duncan, M. Gunning, B. Bruce. 2017. A critical review of the potential impacts of marine seismic surveys on fish & invertebrates. Mar. Pollut. Bull. 114:9–24.
- Colegrove, K.M., S. Venn-Watson, J. Litz, M.J. Kinsel, K.A. Terio, E. Fougères, R. Ewing, D.A. Pabst, W.A. McLellan, S. Raverty, J. Saliki, S. Fire, G. Rappucci, S. Bowen-Stevens, L. Noble, A. Costidis, M. Barbieri, C. Field, S. Smith, R.H. Carmichael, C. Chevis, W. Hatchett, D. Shannon, M. Tumlin, G. Lovewell, W. McFee and T.K. Rowles. 2016. Fetal distress and *in utero* pneumonia in perinatal dolphins during the Northern Gulf of Mexico unusual mortality event. Dis. Aquat. Org. 119(1):1–16.
- DWH MMIQT. 2015. Models and analyses for the quantification of injury to Gulf of Mexico cetaceans from the *Deepwater Horizon* Oil Spill, MM_TR.01_Schwacke_Quantification.of.Injury.to.GOM.Cetaceans. Southeast Fisheries Science Center, Protected Resources and Biodiversity Division, 75 Virginia Beach Dr., Miami, Florida 33140. PRBD Contribution #: PRBD-2020-02.
- DWH NRDAT [*Deepwater Horizon* Natural Resource Damage Assessment Trustees]. 2016. *Deepwater Horizon* oil spill: Final programmatic damage assessment and restoration plan and final programmatic environmental impact statement. Available from: <http://www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan>
- Garrison, L.P. and L. Aichinger Dias. 2020. Distribution and abundance of cetaceans in the northern Gulf of Mexico. NOAA Tech. Memo. NMFS-SEFSC-747. 40pp. Available from: <https://repository.library.noaa.gov/view/noaa/25568>
- Garrison, L.P. and L. Stokes. 2016. Estimated bycatch of marine mammals and sea turtles in the U.S. Atlantic pelagic longline fleet during 2014. NOAA Tech. Memo. NMFS-SEFSC-696. 62pp. Available from: <https://repository.library.noaa.gov/view/noaa/14390>
- Garrison, L.P. and L. Stokes. 2017. Estimated bycatch of marine mammals and sea turtles in the U.S. Atlantic pelagic longline fleet during 2015. NOAA Tech. Memo. NMFS-SEFSC-709. 61pp.
- Garrison, L.P. and L. Stokes. 2019. Estimated bycatch of marine mammals and sea turtles in the U.S. Atlantic pelagic longline fleet during 2016. Southeast Fisheries Science Center, Protected Resources and Biodiversity Division, 75 Virginia Beach Dr., Miami, Florida 33140. PRBD Contribution # PRBD-2019-01. 62pp.
- Garrison, L.P. and L. Stokes. 2020a. 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, Florida 33140. PRD Contribution # PRD-2020-05. 61pp.
- Garrison, L.P. and L. Stokes. 2020b. 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, Florida 33140. PRD Contribution # PRD-2020-08. 56pp.
- Garrison, L.P., J. Ortega-Ortiz and G. Rappucci. 2020. Abundance of marine mammals in the waters of the U.S. Gulf of Mexico in the summer of 2017 and 2018. Southeast Fisheries Science Center, Protected Resources and Biodiversity Division, 75 Virginia Beach Dr., Miami, Florida 33140. PRBD Contribution # PRBD-2020-07. 55pp. Available from: <https://repository.library.noaa.gov/view/noaa/26505>
- Gomez, C., J.W. Lawson, A.J. Wright, A.D. Buren, D. Tollit and V. Lesage. 2016. A systematic review on the behavioural responses of wild marine mammals to noise: The disparity between science and policy. Can. J. Zool. 94:801–819.
- Hansen, L.J., K.D. Mullin, T.A. Jefferson and G.P. Scott. 1996. Visual surveys aboard ships and aircraft. Pages 55–132 in: R.W. Davis and G.S. Fargion (Eds.). Distribution and abundance of marine mammals in the north-central and western Gulf of Mexico: Final report. Volume II: Technical report. OCS Study MMS 96-0027. Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana.
- Jefferson, T.A. and A.J. Schiro. 1997. Distribution of cetaceans in the offshore Gulf of Mexico. Mammal Rev. 27(1): 27–50.
- Jefferson, T.A., M.A. Webber and R.L. Pitman. 2008. Marine mammals of the world. Academic Press, London. 573pp.

- 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.
- Laake, J., D. Borchers, L. Thomas, D. Miller and J. Bishop. 2020. Package ‘mrds’: Mark-recapture distance sampling. Version 2.2.3. Available from: <http://github.com/DistanceDevelopment/mrds/>
- Litz, J.A., M.A. Baran, S.R. Bowen-Stevens, R.H. Carmichael, K.M. Colegrove, L.P. Garrison, S.E. Fire, E.M. Fougères, R. Hardy, S. Holmes, W. Jones, B.E. Mase-Guthrie, D.K. Odell, P.E. Rosel, J.T. Saliki, D.K. Shannon, S.F. Shippee, S.M. Smith, E.M. Stratton, M.C. Tumlin, H.R. Whitehead, G.A.J. Worthy and T.K. Rowles. 2014. Review of historical unusual mortality events (UMEs) in the Gulf of Mexico (1990–2009): Providing context for the complex and long-lasting northern Gulf of Mexico cetacean UME. *Dis. Aquat. Organ.* 112(2):161–175.
- Maze-Foley, K. and K.D. Mullin. 2006. Cetaceans of the oceanic northern Gulf of Mexico: Distributions, group sizes and interspecific associations. *J. Cetacean Res. Manage.* 8(2):203–213.
- McAlpine, D.F. 2009. Pygmy and dwarf sperm whales. Pages 936–938 *in*: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (Eds.). *Encyclopedia of marine mammals*, Second edition. Academic Press, San Diego, California. 1352pp.
- Merkens, K., D. Mann, V.M. Janik, D. Claridge, M. Hill and E. Oleson. 2018. Clicks of dwarf sperm whales (*Kogia sima*). *Mar. Mamm. Sci.* 34(4):963–978.
- Moore, J.E. and R. Merrick (Eds.). 2011. Guidelines for assessing marine mammal stocks: Report of the GAMMS III workshop, February 15–18, 2011, La Jolla, California. Dept. of Commerce, NOAA Tech. Memo. NMFS-OPR-47.
- Mullin, K.D. and G. L. Fulling. 2004. Abundance of cetaceans in the oceanic northern Gulf of Mexico. *Mar. Mamm. Sci.* 20(4):787–807.
- Mullin, K.D. and W. Hoggard. 2000. Visual surveys of cetaceans and sea turtles from aircraft and ships. Pages 111–172 *in*: R.W. Davis, W.E. Evans and B. Würsig (Eds.). *Cetaceans, sea turtles and seabirds in the northern Gulf of Mexico: Distribution, abundance and habitat associations. Volume II: Technical report.* OCS Study MMS 96-0027. Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana.
- Mullin, K., W. Hoggard, C. Roden, R. Lohoefer, C. Rogers and B. Taggart. 1991. Cetaceans on the upper continental slope in the north-central Gulf of Mexico. OCS Study/MMS 91-0027. U.S. Dep. Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, Louisiana. 108pp.
- NMFS [National Marine Fisheries Service]. 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. Commer., NOAA Tech. Memo. NMFS-OPR-59. 167pp. Available from: <https://repository.library.noaa.gov/view/noaa/17892>
- Nowacek, D.P., C.W. Clark, D. Mann, P.J.O. Miller, H.C. Rosenbaum, J.S. Golden, M. Jasny, J. Kraska and B.L. Southall. 2015. Marine seismic surveys and ocean noise: time for coordinated and prudent planning. *Front. Ecol. Environ.* 13:378–386.
- Ortega-Argueta, A., C.E. Perez-Sanchez, G. Gordillo-Morales, O.G. Gordillo, D.G. Perez and H. Alafita. 2005. Cetacean strandings on the southwestern coast of the Gulf of Mexico. *Gulf Mex. Sci.* 2005(2):179–185.
- Ortega Ortiz, J.G. 2002. Multiscale analysis of cetacean distribution in the Gulf of Mexico. Ph.D. dissertation. Texas A&M University, College Station. 170pp.
- Peltier, H., W. Dabin, P. Daniel, O. Van Canneyt, G. Dorémus, M. Huon and V. Ridoux. 2012. The significance of stranding data as indicators of cetacean populations at sea: modelling the drift of cetacean carcasses. *Ecol. Indicators* 18:278–290.
- Schwacke, L.H., C.R. Smith, F.I. Townsend, R.S. Wells, L.B. Hart, B.C. Balmer, T.K. Collier, S. De Guise, M.M. Fry, L.J. Guillette, S.V. Lamb, S.M. Lane, W.E. McFee, N.J. Place, M.C. Tumlin, G.M. Ylitalo, E.S. Zolman and T.K. Rowles. 2014. Health of bottlenose dolphins (*Tursiops truncatus*) in Barataria Bay, Louisiana following the *Deepwater Horizon* oil spill. *Environ. Sci. Technol.* 48(1):93–103.
- Schwarz, L.K., T. Gerrodette and F.I. Archer. 2010. Comparison of closing and passing mode from a line-transect survey of delphinids in the eastern Tropical Pacific Ocean. *J. Cetacean Res. Manage.* 11(3):253–265.
- 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* 57:573–583.
- 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., S.T. Buckland, E.A. Rexstad, J.L. Laake, S. Streindberg, S.L. Hedley, J.R.B. Bishop, T.A. Marques and K.P. Burnham. 2010. Distance software: Design and analysis of distance sampling surveys for estimating population size. *J. Appl. Ecol.* 47(1):5–14.
- Vázquez Castán, L., A. Serrano and J.A. Galindo. 2009. Estudio preliminar sobre la diversidad, distribución y abundancia de cetáceos en aguas profundas del Golfo de México. *Revista UDO Agrícola* 9(4):992–997.
- Venn-Watson, S., K.M. Colegrove, J. Litz, M. Kinsel, K. Terio, J. Saliki, S. Fire, R. Carmichael, C. Chevis, W. Hatchett, J. Pitchford, M. Tumlin, C. Field, S. Smith, R. Ewing, D. Fauquier, G. Lovewell, H. Whitehead, D. Rotstein, W. McFee, E. Fougères and T. Rowles. 2015. Adrenal gland and lung lesions in Gulf of Mexico common bottlenose dolphins (*Tursiops truncatus*) found dead following the *Deepwater Horizon* Oil Spill. *PLoS ONE* 10(5):e0126538.
- Wade, P.R. and R.P. Angliss. 1997. Guidelines for assessing marine mammal stocks: Report of the GAMMS Workshop April 3–5, 1996, Seattle, WA. NOAA Tech Memo. NMFS-OPR-12. 93pp.
- Wells, R.S., J.B. Allen, G. Lovewell, J. Gorzelany, R.E. Delynn, D.A. Fauquier and N.B. Barros. 2015. Carcass-recovery rates for resident bottlenose dolphins in Sarasota Bay, Florida. *Mar. Mamm. Sci.* 31(1):355–368.
- Whitt, A.D., T.A. Jefferson, M. Blanco, D. Fertl and D. Rees. 2011. A review of marine mammal records of Cuba. *Lat. Am. J. Aquat. Mamm.* 9(2):65–122.
- Williams, R., S. Gero, L. Bejder, J. Calambokidis, S.D. Kraus, D. Lusseau, A.J. Read and J. Robbins. 2011. Underestimating the damage: Interpreting cetacean carcass recoveries in the context of the *Deepwater Horizon*/BP incident. *Conserv. Lett.* 4:228–233.
- Würsig, B., S.K. Lynn, T.A. Jefferson and K.D. Mullin. 1998. Behavior of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. *Aquat. Mamm.* 24:41–50.