SPERM WHALE (*Physeter macrocephalus*): Northern Gulf of Mexico Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Sperm whales are found throughout the world's oceans in deep waters from the tropics to the edge of the ice at both poles (Leatherwood and Reeves 1983, Rice 1989, Whitehead 2002). Sperm whales were commercially hunted in the Gulf of Mexico by American whalers from sailing vessels until the early 1900s (Townsend 1935, Reeves *et al.* 2011). In the northern Gulf of Mexico (i.e., U.S. Gulf of Mexico), systematic aerial and ship surveys indicate that sperm whales inhabit continental slope and oceanic waters where they are widely distributed (Figure 1; Fulling *et al.* 2003, Mullin and Fulling 2004, Mullin *et al.* 2004, Maze-Foley and Mullin 2006, Mullin 2007, Garrison and Aichinger Dias 2020). Seasonal aerial surveys confirm that sperm whales are present in the northern Gulf of Mexico in all seasons (Mullin *et al.* 1994, Hansen *et al.* 1996, Mullin and Hoggard 2000).

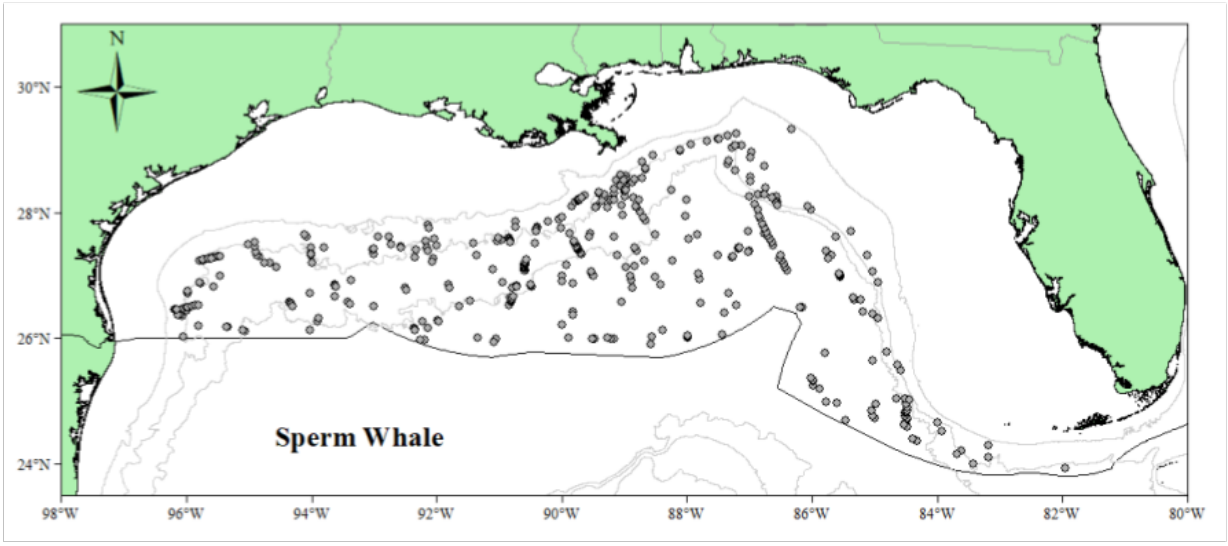

Figure 1. Distribution of sperm whale on-effort sightings from SEFSC vessel surveys during spring 1996–2001, summer 2003, spring 2004, summer 2009, summer 2017, and summer/fall 2018. Isobaths are the 200-m, 1,000-m, and 2,000-m depth contours. The darker line indicates the U.S. EEZ.

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.

Sperm whales throughout the world exhibit a geographic social structure where females and juveniles of both sexes occur in mixed groups and inhabit tropical and subtropical waters. Males, as they mature, initially form bachelor groups but eventually become more socially isolated and more wide-ranging, inhabiting temperate and polar waters as well (Whitehead 2003). While this pattern also applies to the Gulf of Mexico, results of multi-disciplinary research conducted in the Gulf since 2000 confirms speculation by Schmidly (1981) and indicates clearly that Gulf of Mexico sperm whales constitute a stock that is distinct from other Atlantic Ocean stocks (Mullin *et al.* 2003, Jaquet 2006, Jochens *et al.* 2008). Measurements of the total length of Gulf of Mexico sperm whales indicate that they are 1.5–2.0 m smaller on average compared to whales measured in other areas (Jochens *et al.* 2008). Female/immature group size

in the Gulf is about one-third to one-fourth that found in the Pacific Ocean but more similar to group sizes in the Caribbean (Richter *et al.* 2008, Jaquet and Gendron 2009). Tracks from 39 whales satellite tagged in the northern Gulf were monitored for up to 607 days. No discernable seasonal migrations were made, but Gulf-wide movements primarily along the northern Gulf slope did occur. The tracks showed that whales exhibit a range of movement patterns within the Gulf, including movement into the southern Gulf in a few cases, but that only one whale (a male) left the Gulf of Mexico (Jochens *et al.* 2008). This animal moved into the North Atlantic and then back into the Gulf after about two months. Additionally, no matches were found when 285 individual whales photo-identified from the Gulf and about 2500 from the North Atlantic and Mediterranean Sea were compared (Jochens *et al.* 2008).

Gero *et al.* (2007) also suggested that movements of sperm whales between the adjacent areas of the Caribbean Sea, Gulf of Mexico and Atlantic may not be common. No matches were made from animals photo-identified in the eastern Caribbean Sea (islands of Dominica, Guadeloupe, Grenada, St. Lucia and Martinique) with either animals from the Sargasso Sea or the Gulf of Mexico. Engelhaupt *et al.* (2009) conducted an analysis of matrilineally inherited mitochondrial DNA and found significant genetic differentiation between animals from the northern Gulf of Mexico and those from the western North Atlantic Ocean, North Sea and Mediterranean Sea. Analysis of biparentally inherited nuclear DNA showed no significant difference between whales sampled in the Gulf and those from the other areas of the North Atlantic, suggesting that while females show strong philopatry to the Gulf, male-mediated gene flow between the Gulf and North Atlantic Ocean may be occurring (Engelhaupt *et al.* 2009).

Sperm whales make vocalizations called “codas” that have distinct patterns and are apparently culturally transmitted (Watkins and Schevill 1977, Whitehead and Weilgart 1991, Rendell and Whitehead 2001), and based on degree of social affiliation, mixed groups of sperm whales (mixed-sex groups of females/immatures) worldwide can be placed in recognizable acoustic clans (Rendell and Whitehead 2003). Recordings from mixed groups in the Gulf of Mexico compared to those from other areas of the Atlantic indicated that Gulf sperm whales constitute a distinct acoustic clan that is rarely encountered outside of the Gulf. It is assumed from this that groups from other clans enter the northern Gulf only infrequently (Gordon *et al.* 2008). Antunes (2009) used additional data to further examine variation in sperm whale coda repertoires in the North Atlantic Ocean, and found that variation in the North Atlantic is mostly geographically structured as coda patterns were unique to certain regions and a significant negative correlation was found between coda repertoire similarities and geographic distance. His work also suggested sperm whale codas differed between the Gulf of Mexico and the North Atlantic.

Thus, there are now multiple lines of evidence supporting delimitation of separate Gulf of Mexico and western North Atlantic stocks of sperm whales. However, 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 (N_{est}) for the northern Gulf of Mexico sperm whale is 1,180 (CV=0.22; 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).

Earlier Abundance Estimates

Five point estimates of sperm whale 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, including apportioning unidentified

species among identified taxa to address the first issue, applying the model for detection probability on the trackline from the summer 2017 survey to the abundance estimates from the 2003, 2004, and 2009 surveys, and examining relationships between sighting distance and estimated group size (Garrison *et al.* 2020). This resulted in revised abundance estimates of: 2003, N=2,542 (CV=0.34); 2004, N=1,686 (CV=0.41); and 2009, N=2,096 (CV=0.55).

Recent Surveys and Abundance Estimates

An abundance estimate for sperm whales 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, which allowed estimation of the detection probability on the trackline using the independent observer approach assuming point independence (Laake and Borchers 2004). Abundance was calculated using mark-recapture distance sampling implemented in package mrds (version 2.21, Laake *et al.* 2020) in the R statistical programming language. This approach accounted for the effects of covariates (e.g., sea state, glare) on detection probability within the surveyed strip. 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 abundance estimate for this stock included sightings of unidentified large whales that were apportioned among identified species based on their relative density within the survey strata (Garrison *et al*. 2020). The 2017 and 2018 estimates were N=1,078 (CV=0.29) and N=1,307 (CV=0.33), respectively. The inverse variance weighted mean abundance estimate for sperm whales in oceanic waters during 2017 and 2018 was 1,180 (CV=0.22; Table 1; Garrison *et al.* 2020). Unlike previous abundance estimates, this estimate was corrected for the probability of detection on the trackline. There may be a portion of the detection probability that is not accounted for due to long dive times.

Table 1. Most recent abundance estimate (N_{est}) and coefficient of variation (CV) of northern Gulf of Mexico 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	1,180	0.22

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 sperm whales is 1,180 (CV=0.22). The minimum population estimate for the northern Gulf of Mexico sperm whale stock is 983 (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 no significant differences between survey years (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 is 983. The maximum productivity rate is 0.04, the default value for cetaceans. The recovery factor is 0.1 because the sperm whale is an endangered species. PBR for the northern Gulf of Mexico sperm whale is 2.0 (Table 2).

Table 2. Best and minimum abundance estimates for the northern Gulf of Mexico sperm whale with Maximum Productivity Rate (R_{max}), Recovery Factor (F_r) and PBR.

N_{est}	CV	N_{min}	F_r	R_{max}	PBR
1,180	0.22	983	0.1	0.04	2.0

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

The estimated mean annual fishery-related mortality and serious injury for this stock during 2014–2018 was 0.2 sperm whales (CV=1.00) due to interactions with the large pelagics longline fishery (see Fisheries Information sections below; Tables 3–4). Mean annual mortality and serious injury during 2014–2018 due to other human-caused actions (the *Deepwater Horizon* oil spill) was predicted to be 9.4. The minimum total mean annual human-caused mortality and serious injury for this stock during 2014–2018 was, therefore, 9.6.

Table 3. Total annual estimated fishery-related mortality and serious injury for the northern Gulf of Mexico sperm whale.

Years	Source	Annual Avg.	CV
2014–2018	U.S. fisheries using observer data	0.2	1.00

Fisheries Information

There are two commercial fisheries that interact, or that potentially could 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 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 the second quarter of 2015, one sperm whale was observed to be seriously injured (Garrison and Stokes 2017). The average annual serious injury and mortality in the Gulf of Mexico pelagic longline fishery for the five-year period from 2014 to 2018 is 0.2 (CV=1.00; Table 4; Garrison and Stokes 2016, 2017, 2019, 2020a, 2020b).

During the first and second quarters of 2014–2018, observer coverage in the Gulf of Mexico pelagic longline fishery was greatly enhanced to collect more robust information on the interactions between pelagic longline vessels and spawning bluefin tuna. Therefore, the high annual observer coverage rates during 2014–2018 primarily reflect high coverage rates during the first and second quarters of each year. During these quarters, this elevated coverage results in an increased probability that relatively rare interactions will be detected. Species within the oceanic Gulf of Mexico are presumed to be resident year-round; however, it is unknown if the bycatch rates observed during the first and second quarters are representative of that which occurs throughout the year.

A commercial fishery for sperm whales operated in the Gulf of Mexico during the late 1700s to the late 1800s (Reeves *et al.* 2011), but the exact number of whales taken is not known (Townsend 1935, Lowery 1974). Reeves *et al.* (2011) estimated the number of sperm whales removed from the Gulf during the 1780s–1870s as 1,179 (SE=224).

Table 4. Summary of the incidental mortality and serious injury of sperm whales by the pelagic longline commercial fishery including the years sampled (Years), the type of data used (Data Type), the annual observer coverage (Observer Coverage), the annual observed serious injury and mortality recorded by on-board observers, the annual estimated serious injury and mortality, the combined annual estimates of serious injury and mortality (Est. Combined Mortality), the estimated CV of the combined annual mortality estimates (Est. CVs), the mean of the combined annual mortality estimates, and the CV of the mean combined annual mortality estimate (CV of Mean).

Fishery	Years	Data Type[a]	Observer Coverage[b]	Observed Serious Injury[c]	Observed Mortality	Estimated Serious Injury[c]	Est. Mort.	Est. Combined Mortality	Est. CVs	Mean Combined Annual Mortality	CV of Mean
Pelagic Longline	2014	Obs. Data, Trip Logbook	0.18	0	0	0	0	0	-	0.2	1.00
	2015		0.19	1	0	0.94	0	0.94	1		
	2016		0.23	0	0	0	0	0	-		
	2017		0.13	0	0	0	0	0	-		
	2018		0.20	0	0	0	0	0	-		
Total										**0.2**	**1.00**

[a] Number of vessels in the fishery is based on vessels reporting effort to the pelagic longline logbook.
[b] Observer data (Obs. Data) are used to measure bycatch rates, and the data are collected within the Northeast Fisheries Observer Program. Mandatory logbook data were used to measure total effort for the longline fishery. These data are collected at the Southeast Fisheries Science Center (SEFSC). Observer coverage in the GOM is dominated by very high coverage rates during April–June associated with efforts to improve estimates of bluefin tuna bycatch.
[c] Proportion of sets observed.

Other Mortality

There were seven sperm whale strandings in the northern Gulf of Mexico during 2014–2018 (NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 21 May 2019). There was evidence of human interaction for one stranding (healed scarring). No evidence of human interaction was detected for one stranding, and for the remaining five strandings it could not be determined if there was evidence of human interaction. 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). Six sperm whale strandings during 2010–2013 were considered to be part of the UME.

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 this stock experienced a 7% 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 94 sperm whales died during 2010–2013 (four year annual average of 24) due to elevated mortality associated with oil exposure (see Appendix VI). For the 2014–2018 reporting period of this SAR, the population model estimated 47 sperm whales died due to elevated mortality associated with oil exposure. The population model used to predict 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 sperm whales occupying waters outside of the Gulf of Mexico. 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. Also, there was no estimation of uncertainty in model parameters or outputs.

Table 5. Sperm whale strandings along the northern Gulf of Mexico coast, 2014–2018. Data are from the NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 21 May 2019. There were no strandings of sperm whales in Mississippi.

State	2014	2015	2016	2017	2018	Total
Alabama	0	0	1	0	0	1
Florida	0	0	1	0	0	1
Louisiana	0	0	2	1	0	3
Texas	1	0	1	0	0	2
Total	**1**	**0**	**5**	**1**	**0**	**7**

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 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 16% (95%CI: 11–23) of 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 sperm whales suffered adverse health effects (DWH MMIQT 2015). A population model estimated the stock experienced a maximum 7% 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). Seismic vessel operations in the Gulf of Mexico (commercial and academic) now operate with marine mammal observers as part of required mitigation measures. There have been no reported seismic-related or industry ship-related mortalities or injuries to sperm whales. However, disturbance by anthropogenic noise may prove to be an important habitat issue in some areas of this population's range, notably in areas of oil and gas activities and/or where shipping activity is high. Results from very limited studies of northern Gulf of Mexico sperm whale responses to seismic exploration indicate that sperm whales do not appear to exhibit horizontal avoidance of seismic survey activities (Miller *et al.* 2009, Winsor *et al.* 2017). Data did suggest there may be some decrease in foraging effort during exposure to full-array airgun firing, at least for some individuals. Further study is needed as sample sizes are insufficient at this time (Miller *et al.* 2009). Farmer *et al.* (2018a) developed a bio-energetics model to examine the consequences of frequent disruptions to foraging on sperm whales. The simulations suggested that frequent and severe disruptions could lead to terminal starvation. A follow-up study examined the population level effects of acoustic disturbance in combination with the impacts of the DWH oil spill and suggested that acoustic disturbance could have significant population effects, though terminal starvation and fetal abortions were unlikely (Farmer *et al.* 2018b). 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.

Vessel strikes to whales occur world-wide and are a source of injury and mortality. No vessel strikes have been

documented in recent years (2014–2018) for sperm whales in the Gulf of Mexico. Historically, one possible sperm whale mortality due to a vessel strike was documented for the Gulf of Mexico. The incident occurred in 1990 in the vicinity of Grande Isle, Louisiana. Deep cuts on the dorsal surface of the whale indicated the vessel strike was probably pre-mortem (Jensen and Silber 2004).

STATUS OF STOCK

The sperm whale is listed as endangered under the Endangered Species Act, and therefore the northern Gulf of Mexico stock is considered strategic under the MMPA. In addition, the mean modeled annual human-caused mortality and serious injury due to the DWH oil spill exceeds PBR for this stock. Total fishery-related mortality and serious injury for this stock is not less than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate. The status of sperm whales in the northern Gulf of Mexico, relative to OSP, is unknown. There was no statistically significant trend in population size for this stock in the northern Gulf of Mexico.

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