DWARF SPERM WHALE (*Kogia sima*): Western North Atlantic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The dwarf sperm whale (*Kogia sima*) is distributed worldwide in temperate to tropical waters (Caldwell and Caldwell 1989; McAlpine 2009). Pygmy sperm whales and dwarf sperm whales (*K. sima*) are difficult to differentiate at sea (Caldwell and Caldwell 1989; Bloodworth and Odell 2008; McAlpine 2009), and sightings of either species are often categorized as *Kogia* sp. Sightings of *Kogia* whales in the western North Atlantic occur in oceanic waters along the continental shelf break and slope from Canada to Florida (Figure 1; Mullin and Fulling 2003; Roberts *et al.* 2015). In addition, stranding records for *Kogia* spp. are common from Canada to Florida (Bloodworth and Odell 2008; Berini *et al.* 2015). Based on the results of passive acoustic monitoring, Hodge *et al.* (2018) reported that *Kogia* are common in the western North Atlantic in continental shelf break and slope waters between Virginia and Florida, and more common than suggested by visual surveys.

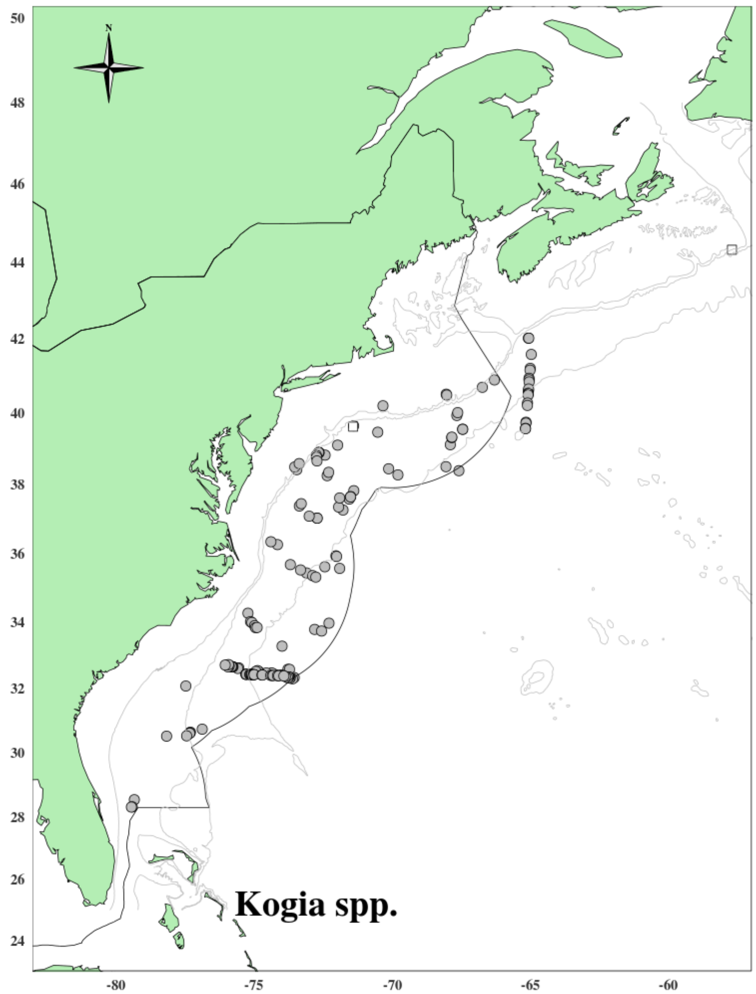

Figure 1. Distribution of Kogia spp. sightings from NEFSC and SEFSC shipboard (circles) and aerial (squares) surveys during 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010, 2011 and 2016. Isobaths are the 200m, 1,000m and 4,000m depth contours. The darker line indicates the U.S. EEZ.

In addition to similarities in appearance, dwarf sperm whales and pygmy sperm whales demonstrate similarities in their foraging ecology as well as their acoustic signals. Staudinger *et al.* (2014) conducted diet and stable isotope analyses on stranded pygmy and dwarf sperm whales from the mid-Atlantic coast and found that the two species shared the same primary prey (cephalopods, primarily squid) and fed in similar habitats. The acoustic signals of dwarf and pygmy sperm whales cannot be distinguished from each other at this time because the signals of the two species are too similar to each other and to other species with narrow-band, high-frequency clicks (Merkens *et al.* 2018).

Across its geographic range, including the western North Atlantic, the population biology of dwarf sperm whales is inadequately known (Staudinger *et al.* 2014). Dwarf sperm whales in the western North Atlantic are managed separately from those in the northern Gulf of Mexico. 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 western North Atlantic and Gulf of Mexico belong to distinct marine ecoregions (Spalding *et al.* 2007; Moore and

Merrick 2011). Within the western North Atlantic, the range of *Kogia* sightings traverses multiple marine ecoregions (Spalding *et al.* 2007) and crosses Cape Hatteras, a known biogeographic break for other marine species, so it is possible that multiple demographically independent populations exist within the western North Atlantic stock. Additional morphological, acoustic, genetic, and/or behavioral data are needed to further delineate population structure within the western North Atlantic and across the broader geographic area.

POPULATION SIZE

Total numbers of dwarf sperm whales off the U.S. Atlantic coast are unknown. Because *K. sima* and *K. breviceps* are difficult to differentiate at sea, the reported abundance estimates are for both species of *Kogia* combined. The best estimate for *Kogia* spp. in the western North Atlantic is 7,750 (CV=0.38; Table 1; Garrison 2020; Palka 2020). This estimate is from summer 2016 surveys covering waters from central Florida to the lower Bay of Fundy. This estimate is almost certainly negatively biased. One component of line transect estimates is *g(0)*, the probability of seeing an animal on the transect line. Estimating *g(0)* is difficult because it consists of accounting for both perception bias (i.e., at the surface but missed) and availability bias (i.e., below the surface while in range of the observers), and many uncertainties (e.g., group size and diving behavior) can confound both (Marsh and Sinclair 1989; Barlow 1999). The long dive times of *Kogia* spp. contribute to a lower probability that animals will be available at the surface and therefore more negative bias. The best estimate was corrected for perception bias (see below) but not availability bias and is therefore an underestimate.

Earlier abundance estimates

Please see Appendix IV for a summary of abundance estimates, including earlier estimates and survey descriptions.

Recent surveys and abundance estimates

An abundance estimate of 1,783 (CV=0.62) *Kogia* spp. was generated from aerial and shipboard surveys conducted during June–August 2011 between central Virginia and the lower Bay of Fundy (Palka 2012). The aerial portion covered 6,850 km of tracklines over waters north of New Jersey between the coastline and the 100-m depth contour through the U.S. and Canadian Gulf of Maine, and up to and including the lower Bay of Fundy. The shipboard portion covered 3,811 km of trackline between central Virginia and Massachusetts in waters deeper than the 100-m depth contour out to beyond the U.S. EEZ. Both sighting platforms used a double-platform data collection procedure, which allowed estimation of abundance corrected for perception bias of the detected species (Laake and Borchers 2004). Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

An abundance estimate of 2,002 (CV=0.69) *Kogia* spp. was generated from a shipboard survey conducted concurrently (June–August 2011) in waters between central Virginia and central Florida (Garrison 2016). This shipboard survey included shelf-break and inner continental slope waters deeper than the 50-m depth contour within the U.S. EEZ. The survey employed two independent visual teams searching with 25x bigeye binoculars. A total of 4,445 km of trackline were surveyed, yielding 290 cetacean sightings. The majority of sightings occurred along the continental shelf break with generally lower sighting rates over the continental slope. Estimation of the abundance was based on the independent observer approach assuming point independence (Laake and Borchers 2004) and calculated using the mark-recapture distance sampling option in the computer program Distance (version 6.0, release 2, Thomas *et al.* 2009).

Abundance estimates of 4,548 (CV=0.49) and 3,202 (CV=0.59) *Kogia* spp. were generated from two non-overlapping vessel surveys conducted in 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 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 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.

Table 1. Summary of abundance estimates for the western North Atlantic* Kogia *spp. with month, year, and area covered during each abundance survey, and resulting abundance estimate (N_{best}) and coefficient of variation (CV).

Month/Year	Area	N_{best}	CV
Jun–Aug 2011	central Virginia to lower Bay of Fundy	1,783	0.62
Jun–Aug 2011	central Florida to central Virginia	2,002	0.69
Jun–Aug 2011	central Florida to lower Bay of Fundy (COMBINED)	3,785	0.47
Jun–Aug 2016	New Jersey to lower Bay of Fundy	4,548	0.49
Jun–Aug 2016	central Florida to New Jersey	3,202	0.59
Jun–Aug 2016	central Florida to lower Bay of Fundy (COMBINED)	7,750	0.38

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 *Kogia* spp. is 7,750 (CV=0.38). The minimum population estimate for *Kogia* spp. is 5,689 animals.

Current Population Trend

There are three available coastwide abundance estimates for *Kogia* spp. from the summers of 2004, 2011, and 2016. Each of these is derived from vessel surveys with similar survey designs and all three used the two-team independent observer approach to estimate abundance. The resulting estimates were 395 (CV=0.4) in 2004, 3,785 (CV=0.47) in 2011, and 7,750 (CV=0.38) in 2016 (Garrison 2020; Palka 2020). While there is an apparent increasing trend in these population estimates, a generalized linear model did not indicate a statistically significant (p=0.071) trend. The high level of uncertainty in these estimates limits the ability to detect a statistically significant trend. In addition, interpretation of trends is complicated by two methodological factors. First, the ability to detect *Kogia* spp. visually is highly dependent upon weather and visibility conditions which may contribute to differences between estimates. Second, during 2016 both surveys did not use scientific echosounders during some survey periods. Changing the use of echosounders may affect the surfacing/diving patterns of the animals and thus have an influence on the availability of animals to the visual survey teams. Finally, a key uncertainty in this assessment of trend is that interannual variation in abundance may be caused by either changes in spatial distribution associated with environmental variability or changes in the population size of the stock. Therefore, the possible increasing trend should be interpreted with caution.

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 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 for *Kogia* spp. is 5,689. The maximum productivity rate is 0.04, the default value for cetaceans. The recovery factor is 0.4 because the CV of the average mortality estimate is greater than 0.8 (Wade and Angliss 1997). PBR for western North Atlantic *Kogia* spp. is 46.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Total annual estimated fishery-related mortality and serious injury to this stock during 2013–2017 was presumed to be zero, as there were no reports of mortalities or serious injuries to dwarf sperm whales or *Kogia* spp. in the western North Atlantic.

Fishery Information

The commercial fisheries that interact, or that could potentially interact, with this stock in the Atlantic Ocean are the Category I Atlantic Highly Migratory Species longline and Atlantic Ocean, Caribbean, Gulf of Mexico large pelagics longline fisheries (Appendix III). Percent observer coverage (percentage of sets observed) for these longline fisheries for each year during 2013–2017 was 9, 10, 12, 15, and 12, respectively.

The Atlantic Highly Migratory Species longline fishery operates outside the U.S. EEZ. No takes of dwarf sperm whales or *Kogia* sp. within high seas waters of the Atlantic Ocean have been observed or reported thus far.

The large pelagics longline fishery operates in the U.S. Atlantic (including Caribbean) and Gulf of Mexico EEZ. Pelagic swordfish, tunas and billfish are the targets of the large pelagics longline fishery. During 2013–2017, there were no observed mortalities or serious injuries of dwarf sperm whales or *Kogia* spp. by this fishery (Garrison and Stokes 2014; 2016; 2017; 2019; 2020). Historically, observed takes of *Kogia* spp. have been rare, and the most recent observed take occurred in 2011. Please see Appendix V for historical estimates of annual mortality and serious injury for *Kogia* spp. by this fishery.

Other Mortality

During 2013–2017, 46 dwarf sperm whales were reported stranded along the U.S. Atlantic coast from New York to Florida (Table 2; Northeast Regional Marine Mammal Stranding Network, Southeast Regional Marine Mammal Stranding Network; NOAA National Marine Mammal Health and Stranding Response Database unpublished data, accessed 13 June 2018 (SER) and 8 June 2018 (NER)). It could not be determined whether there was evidence of human interaction for 20 of these strandings, and for 26 strandings, no evidence of human interaction was detected. In addition, there were 12 records of unidentified stranded *Kogia*. It could not be determined whether there was evidence of human interaction for 10 of these strandings; for one, no evidence of human interaction was detected; and for the remaining stranding, evidence of human interaction was self-reported by a citizen who transported the animal.

Stranding data probably underestimate the extent of human and fishery-related mortality and serious injury because not all of the marine mammals 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, shelf and slope stocks in the western North Atlantic are less likely to strand than nearshore coastal stocks. 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.

Table 2. Dwarf and pygmy sperm whale (**Kogia sima*** ***(Ks),*** **Kogia breviceps** ***(Kb) and*** **Kogia** ***sp. (Sp)) strandings along the Atlantic coast, 2013–2017. Strandings that were not reported to species have been reported as*** **Kogia** ***sp. 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	2013			2014			2015			2016			2017			TOTALS		
	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp	Ks	Kb	Sp
Massachusetts	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0
Rhode Island	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
New York	0	2	0	0	1	0	0	0	0	0	2	0	2	1	0	2	6	0
New Jersey	1	1	0	0	1	0	0	0	0	0	1	0	0	3	0	1	6	0
Delaware	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0
Maryland	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	3	0
Virginia	1	2	0	1	2	0	0	0	0	0	0	0	0	2	0	2	6	0
North Carolina	3	4	0	3	4	1	12	4	0	2	2	0	0	2	1	20	16	2
South Carolina	2	2	0	0	3	0	1	8	0	0	2	0	1	3	0	4	18	0
Georgia	0	5	1	5	1	0	0	3	0	0	3	0	0	2	0	5	14	1
Florida	0	9	6	0	9	0	5	12	2	4	9	0	3	7	1	12	46	9
TOTALS	7	27	7	9	25	1	18	29	2	6	19	0	6	20	2	46	120	12

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., Schwacke *et al.* 2002; Jepson *et al.* 2016; Hall *et al.* 2018). Bryan *et al.* (2012) examined liver and kidney samples from stranded pygmy sperm whales from the U.S. Atlantic and Gulf of Mexico and found that all samples contained mercury concentrations in excess of the USEPA action limits, potentially levels hazardous to the health of whales and putting them at greater risk of disease. Because animals are exposed to mercury through the consumption of their prey, and the foraging ecology of dwarf sperm whales is similar to that of pygmy sperm whales (Staudinger *et al.* 2014), dwarf sperm whales are likely also experiencing potentially hazardous levels of mercury. Reed *et al.* (2015) examined metal concentrations in dwarf sperm whales stranded along the South Carolina coast, and found that levels of mercury for all adults and cadmium for most adults, exceeded FDA historical levels of concern, while concentrations of some metals were low.

Harmful algal blooms have been responsible for large-scale marine mammal mortality events as well as chronic, harmful health effects and reproductive failure (Fire *et al.* 2009). Diatoms of the genus *Pseudo-nitzschia* produce domoic acid, a neurotoxin. Fire *et al.* (2009) sampled pygmy and dwarf sperm whales stranded along the U.S. East Coast from Virginia to Florida, and more than half (59%) of the samples tested positive for domoic acid, indicating year-round, chronic exposure, whereas other cetaceans stranded in the same area had no detectable domoic acid. Harmful algal blooms may be occurring in offshore areas not currently being monitored, and the detection only in *Kogia* species suggests a possible unknown, unique aspect of their foraging behavior or habitat utilization (Fire *et al.* 2009).

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.

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; 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.

STATUS OF STOCK

Dwarf sperm whales 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. 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 U.S. Atlantic EEZ relative to OSP is unknown. There was no statistically significant trend in population size for *Kogia* spp.; however, there are key methodological issues and uncertainty that limit the ability to evaluate trend.

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