Dwarf Sperm Whale, *Kogia sima* (Owen, 1866)

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Contents

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Common Names

English	Dwarf sperm whale
German	Kleinpottwal
French	Cachalot nain
Spanish	Cachalote enano
Italian	Cogia di Owen
Russian	Kashalot maliutka

Taxonomy and Systematics

Overview

The dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whale are the only two members of the family Kogiidae, although Chivers et al. (2005) provided evidence that dwarf sperm whales in the Atlantic may represent a different species from those in the Indo-Pacific. Until relatively recently, both species, together with the sperm whale *Physeter macrocephalus,* were included in the family Physeteridae. Currently, the two species are considered members of the family Kogiidae, within the superfamily Physeteroidea (Rice 1998).

The etymology of *Kogia* is unclear. It may be a Latinized form of the English word "codger," which means a "miserly old fellow," or may have been derived from Cogia Effendi, a Turk who observed whales in the Mediterranean (Leatherwood and Reeves 1983; Rice 1998). The specific epithet *sima* is Latin, meaning "flat- or stump-nosed" (Leatherwood and Reeves 1983). Owen (1866) described the type specimen of *K. sima* from Madras, India, which had been hunted by local fishermen, and called it the "snub-nosed cachalot" *Physeter (Euphysetes) simus*.

Gill (1871) recognized differences between the two species of *Kogia* and proposed the name combination *K. sima* (Rice 1998). Ogawa (1936) proposed two species, but it was not until other Japanese authors (e.g., Yamada 1954) adopted that nomenclature that Handley (1966) followed and proposed his account of two definite species.

See ► *Kogia breviceps* account for information on the fossil record of both *Kogia* species.

Subspecies

No subspecies have been suggested.

Current Distribution

Global

Dwarf sperm whales are broadly distributed in slope and offshore tropical and warm temperate waters worldwide. Knowledge of their distribution is based primarily on stranding records, as the species is difficult to detect, given their small body size, typical small group size, undemonstrative behavior at the surface, and relatively long dive times. They appear to prefer slightly warmer waters than pygmy sperm whales (Caldwell and Caldwell 1989; Ross 2006; Willis and Baird 1998; Fig. 1), and gaps in their distribution are likely due to a lack of observer effort in suitable oceanic habitat and difficulties in sighting and identifying this species (Caldwell and Caldwell 1989; Ross 1979).

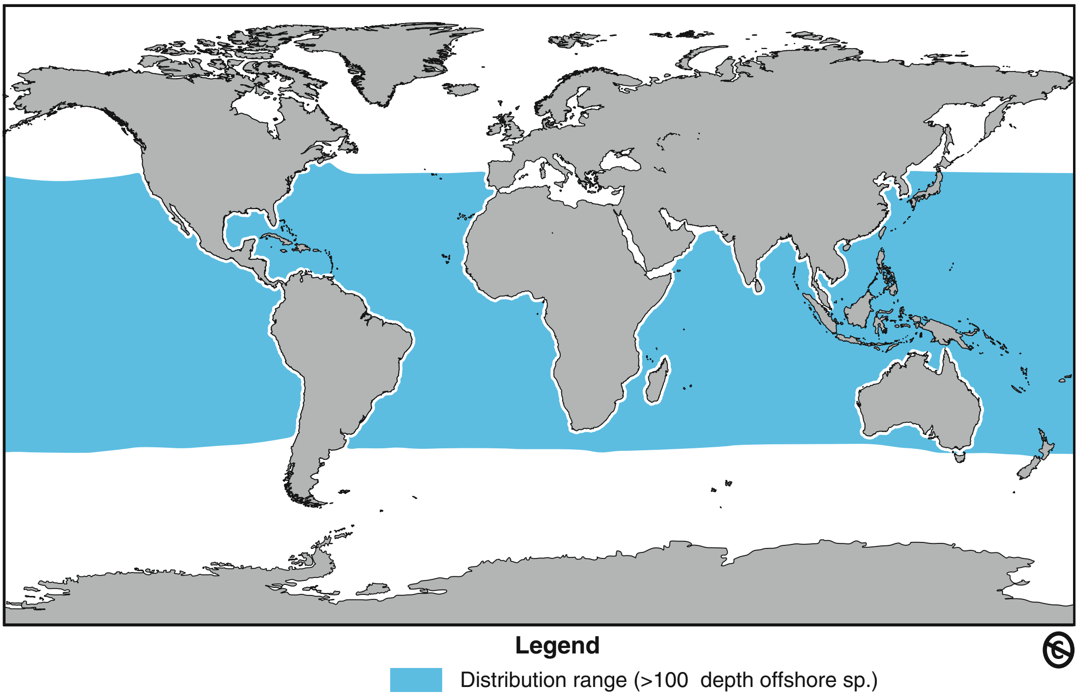

Fig. 1 Worldwide distribution of the dwarf sperm whale. Distribution is based on the IUCN Red List of Threatened Species. Version 2017–2. Areas less than 100 m in depth have been excluded in accordance with the known habitat requirements of the species

European

There have been no directed studies of dwarf sperm whales in Europe, so what is known about this species in European waters primarily comes from reports of single strandings or sightings. In European Atlantic waters (Fig. 2), dwarf sperm whales have been confirmed once each from the Faroe Islands (Bloch and Mikkelsen 2009) and England (Evans and Waggitt 2020). These sightings were in very unusual nearshore waters and were animals considered likely to be in distress. Stranded animals have been documented along the Atlantic coasts of France (Creton et al. 1992; Van Canneyt et al. 2016), and Spain (Gulf of Cádiz – Valverde and Camiñas 1996). There is one confirmed sighting in deep water (>4,000 m) off the coast of Portugal (Santos et al. 2012). In European Macaronesian waters, they have been recorded stranded in the Azores (Gonçalves et al. 1996), Madeira (Freitas et al. 2012), and the Canary Islands (Jaber et al. 2004). There was a sighting of two individuals in 2020 off Lanzarote in the Canary Islands (V. Martin, personal communication) and of two single individuals in 2000 in the Azores (L. Steiner, personal communication). In the Mediterranean, there have been several strandings in Italy (Bortolotto et al. 2003; Maio et al. 2017; Notarbartolo di Sciara 2016; Notarbartolo di Sciara and Birkun 2010), but they are generally considered to be vagrant in that region. Areas off southwestern continental Europe (i.e., Portugal and southwestern Spain) are thought to be within the normal distribution of this species, while records along the continent north of Portugal are likely extralimital (Evans and Waggitt 2020).

Populations

Genetics

Based on mitochondrial cytochrome *b* gene analysis, Chivers et al. (2005) suggested that *Kogia sima* may in fact comprise two separate parapatric

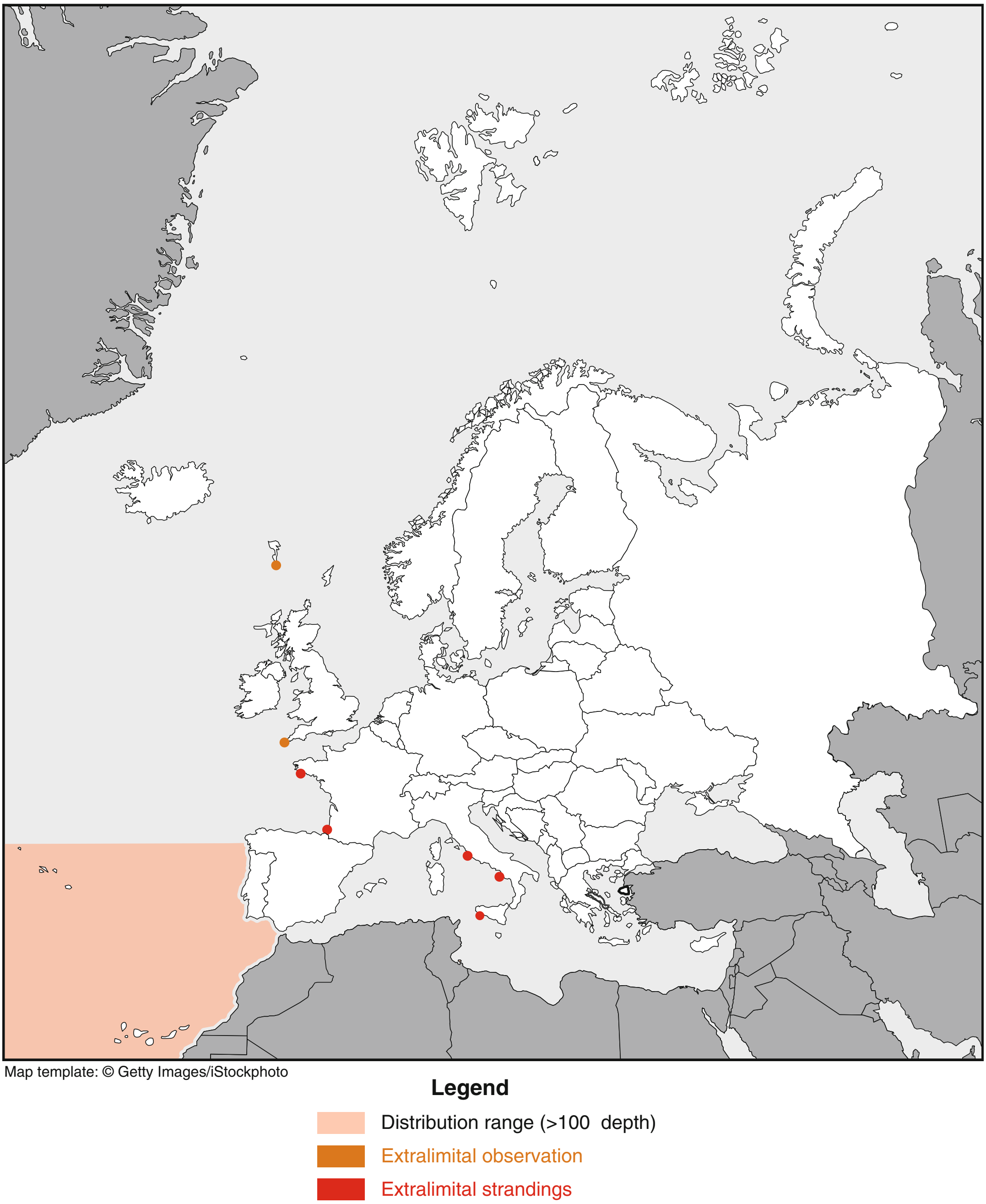

Fig. 2 European distribution of the dwarf sperm whale. Distribution is based on the IUCN Red List of Threatened Species. Version 2017–2. (Map template: ©Copyright Getty Images/iStockphoto)

species occupying the Atlantic and Indo-Pacific Oceans. Whether there is further substructuring in the Atlantic is unknown. The dwarf sperm whale has a 2n = 42 karyotype.

Abundance

There are relatively few abundance estimates available for this species, and none is available for European waters. This reflects the limited amount of survey effort in offshore waters (Rogan et al. 2017) and typically rough sighting conditions offshore, resulting in few, if any, sightings when such surveys have been undertaken. Both *Kogia* species are difficult to detect using visual methods (see ▶ *Kogia breviceps* account). Abundance estimates that do exist for dwarf sperm whales have typically not accounted for the rapid decline in sighting probabilities that occurs with an increase in sea state (Barlow 2015) and, thus, are likely negatively biased. Given challenges in their identification, many sighting surveys aimed at assessing abundance have not attempted to discriminate between the two species, although there are exceptions (e.g., Bradford et al. 2021). In US waters in the western North Atlantic, only a combined estimate for dwarf and pygmy sperm whales exists, of 7,750 individuals (CV = 0.38; Hayes et al. 2020).

In a 2002 survey of Hawaiian waters, dwarf sperm whales had the highest estimated abundance of 18 species for which abundance estimates were made (Barlow 2006), with an estimated 17,519 individuals (CV = 0.74). A revised estimate taking into account changes in sighting probabilities with sea state (Barlow 2015) was 37,440 animals (CV = 0.78) (Bradford et al. 2021). Despite such a high estimated abundance, there were no on-effort sightings during systematic survey efforts from the same area in 2010 or 2017 (Bradford et al. 2021), reflecting the difficulty of sighting this species in anything other than very calm conditions. In the eastern tropical Pacific, dwarf sperm whales were relatively uncommon, with a total estimate of 11,200 animals (CV = 0.29; Wade and Gerrodette 1993), although the above-noted caveats regarding sea state and abundance estimation suggest this estimate is negatively biased. There is no information available on population trends (McAlpine 2017). The frequency with which dwarf sperm whales strand in certain locations, especially along the south-eastern United States and off Japan and South Africa, suggests that in some regions they may be relatively common. However, caution should be taken when interpreting stranding records; in Hawai‘i, dwarf sperm whales strand only about one-fourth as often as pygmy sperm whales, yet represent over 90% of the *Kogia* sightings around the main Hawaiian Islands (Baird 2016; Baird et al. 2021).

Description

Morphology and Coloration

Dwarf sperm whales reach a maximum size of about 2.7 m and a weight of 280 kg, with females possibly reaching larger maximum sizes than males (McAlpine 2017). The body is very robust and tapers rapidly toward the tail. They have a blunt, square-shaped head, underslung jaw, and a single blowhole slightly offset to the left which is characteristic of all sperm whales (Fig. 3). Dwarf sperm whales may have several short longitudinal grooves on the throat (Caldwell and Caldwell 1989; Pinedo 1987), but they are not always present (Leatherwood and Reeves 1983). It has, however, been suggested as a distinguishing feature, as throat grooves are absent in pygmy sperm whales (Baird et al. 1996). The pectoral fins are moderate in size, convex on the upper and lower margins, and tapering evenly to a blunt tip and are situated close to the head. The tailstock is elongated and laterally compressed, and the flukes are broad, notched in the middle, concave along the rear margin, and tapered laterally. The dorsal fin is falcate and located near the midpoint of the back, with a slightly longer base than that of the pygmy sperm whale (Ross 1979). Further differences in species morphological characteristics that can be used to distinguish between the two *Kogia* species are considered in the ▶ *Kogia breviceps* chapter.

The skin of the dwarf sperm whale has a wrinkled appearance (Leatherwood and Reeves 1983). The species is dark gray dorsally, shading to a lighter gray on the sides, and white ventrally (Fig. 4). Wounds from cookie-cutter shark bites repigment to the background coloration (Baird et al. 2021). The animals have a white, crescent-shaped marking on the side of the head, often referred to as a "false-gill" marking (Ross 1979; Fig. 3).

Fig. 3 External features of an adult dwarf sperm whale. (Illustration by ©Uko Gorter)

Fig. 4 (Top) An adult dwarf sperm whale, off Hawai‘i Island, designated HIKs061 in the Cascadia Research Collective photo-identification catalog. This individual has been documented over a 5-year span off the island. (Photo © Robin W. Baird/Cascadia Research). (Bottom) A view of three dwarf sperm whales off Hawai‘i Island taken from an Unoccupied Aerial System. (Photo © Jordan K. Lerma/Cascadia Research)

Skull Characteristics and Dentition

Skull characteristics of both *Kogia* species are covered in the ▶ *K. breviceps* chapter. The teeth are thin and pointed and curved backward into the mouth. Dwarf sperm whales typically have from 7 to 12 pairs and have been reported with 13 pairs (Ross 1979). Between zero and six maxillary teeth may be present.

Life History

Length and weight at birth are estimated to be 103 cm and 14 kg, respectively (Plön 2004). Males reach sexual maturity between 2.6 and 3 years, corresponding to 197 cm of body length, while in females, attainment of sexual maturity occurs at 5 years and 215 m body length (Plön 2004). Approximately 11.5% of females were found to be simultaneously pregnant and lactating, indicating that the species may reproduce annually, but that it is the exception rather than the rule and likely largely dependent on energy requirements and thus resources (Plön 2004; Best 2007). The ovulation rate (0.7/year) suggests an average calving interval of more than a year, with some animals conceiving at postpartum estrus and others after an interval of 2 years (Plön 2004). Records of the size of fetal and juvenile animals indicate that conceptions and births occur between December and March off South Africa (Plön 2004); off Hawai'i, sightings of neonates have been reported in March and October (Baird 2016). Gestation lasts about 12 months, and lactation can last for a year, at which stage the calf is about 1.5 m in length; however, calves can be weaned at 1.3 m (Best 2007). Physical maturity is reached at 249 cm body length in females and 264 cm body length in males, corresponding to 13 and 15 years of age, respectively (Plön 2004). No indications of reproductive senescence have been reported for the species (Best 2007). Maximum recorded ages were 22 years for females and 17 years for males, and the longest reported female measured 274.3 cm versus 260.4 cm for the longest male (Plön 2004), possibly indicating that females may be larger than males; however, Best (2007) suggests little difference in size between the sexes. The maximum combined testis weight is about 2.0% of total body weight, which suggests a polygynous mating system (Plön 2004).

Ecology

Habitat Preferences

Dwarf sperm whales are generally found in tropical and warm temperate areas in slope (>200 m depth) and deep offshore waters. Given the relative lack of sightings in shelf (<200 m) areas where there has been extensive survey effort (Rogan et al. 2017), it is likely that dwarf sperm whales in European waters also primarily use slope and deep offshore waters. Based on the habits of their prey, Ross (1984) noted that juvenile and immature dwarf sperm whales live closer inshore than do adults, with younger animals over the outer part of the continental shelf and upper part of the slope, while adults are found over deeper water. In Hawaiian waters, sighting rates of dwarf sperm whales are highest in depths between 500 and 1000 m, and lower than expected in shallower and deeper waters (Baird et al. 2021). There is some evidence of habitat preferences varying seasonally. Off the Bahamas, Dunphy-Daly et al. (2008) found that groups were found in deeper habitats in summer and predominantly over slope habitats in winter.

Diet and Feeding

Dwarf sperm whales have a diverse diet, with prey documented from 15 families of cephalopods and 16 families of fish, as well as occasionally salps and crustaceans (Clarke 1996; Elwen et al. 2013; Fitch and Brownell 1968; Nagorsen 1985; Ross 1979, 1984; Santos and Haimovici 2001; Sekiguchi et al. 1992; Staudinger et al. 2014). Dwarf sperm whales stranded in Europe have been documented consuming squids (*Histioteuthis bonnellii*, *H. reversa*, *Chiroteuthis veranii*, and *Ctenopteryx sicula),* and the swimming crab *Polybius* spp. (Santoro et al. 2018;

Spitz et al. 2011). Although dwarf sperm whales consume a larger variety of prey items than recorded for most other odontocetes, they appear to have a more specialized diet than pygmy sperm whales (Plön 2004). The two species have a high niche overlap as confirmed by both stomach content and isotope analysis (Staudinger et al. 2014) and dwarf sperm whales consume slightly smaller prey than pygmy sperm whales (Plön 2004; Ross 2006; Staudinger et al. 2014).

Behavior

Migrations and Movements

Dwarf sperm whales appear to be present year-round in areas where they have been studied in detail (e.g., Plön 2004; Dunphy-Daly et al. 2008; Baird et al. 2021). In the Bahamas, there is seasonal variability in spatial use, with animals in higher densities in slope (400–900 m) habitat in winter (Dunphy-Daly et al. 2008). Off Hawai‘i Island, there is a year-round resident population, and resightings of photo-identified individuals suggest ranges are relatively small, with a maximum distance among resightings of identified individuals of 77 km (Baird et al. 2021).

Swimming and Diving

Dwarf sperm whales both slow roll and log at the surface, usually with some forward motion even while logging (Baird et al. 2021). Logging individuals may sink vertically or slow roll out of sight and do not show the flukes (Baird 2016; Baird et al. 2021; Leatherwood and Reeves 1983; Willis and Baird 1998). Individuals tend to surface very slowly, and typically no blow is visible. Breaching or leaping does occur but is rare (Baird et al. 2021; Robert Pitman pers. comm.).

Baird et al. (2021) note that dive times appear to vary based on the age composition of a group: Dives of female dwarf sperm whales with a newborn calf ranged from 2 to less than 5 minutes in duration, dives of females with older calves were up to 9 minutes, and dives of adults and large subadults ranged up to 22 minutes. Dive times reported by Breese and Tershy (1993) for a lone dwarf sperm whale in the Gulf of California ranged from 15 to 43 minutes. Barlow and Sexton (1996) model the duration of long dives as 10.9 minutes on average and the duration of surfacing series as 78 seconds on average, based on 59 dive cycles for dwarf sperm whales. Willis and Baird (1998) note the maximum dive times of up to 53 minutes reported may have resulted from missed surfacings of the animal involved. McCullough et al. (2021) note acoustic evidence of dives lasting over 30 minutes, although they were unable to discriminate whether these were dwarf or pygmy sperm whales.

Foraging

Foraging likely occurs at depth and has not been observed directly in the wild. Based on the shape of their anterior-ventrally flattened snout and their small underslung jaw, Gaskin (1972) suggested that the animals feed at or near the bottom. One live individual in Hawai‘i was documented with abrasions on the head that suggest it was feeding on the bottom (Baird et al. 2021). Dwarf sperm whales primarily use suction-feeding and have one of the widest gape angles and suction abilities of any odontocete (Bloodworth and Marshall 2005). However, observations of feeding behaviors in captivity have shown that dwarf sperm whales can also grasp and manipulate prey (Bloodworth and Marshall 2005).

Social

There have been so few sightings of dwarf sperm whales in European waters that characterizing typical group sizes in the region is not possible, although groups sighted have been small (see Current Distribution). Elsewhere, while groups of up to 12 animals have been reported in the western Atlantic (Dunphy-Daly et al. 2008), mean group sizes are small everywhere they have been reported: 1.7 in the eastern tropical

Pacific (Wade and Gerrodette 1993), 1.6 in the western tropical Indian Ocean (Ballance and Pitman 1998), 2.1 in the Gulf of Mexico (Davis et al. 1995), and 2.7 in Hawai‘i (Baird 2016). Thus, they are likely primarily found in small groups in European waters. In the Bahamas, group size appears to vary seasonally (Dunphy-Daly et al. 2008). In Hawai‘i, lone individuals were sighted most often, representing over a quarter of all groups. However, group size increased with encounter duration (Baird et al. 2021), and thus group size is likely underestimated in many surveys, given the typical short duration of sightings and the fact that some groups contain two or more pairs of individuals that may be somewhat asynchronous in their surfacing times (Baird et al. 2021).

Relatively little is known about social organization. Stranding data from Florida and South Africa suggest that some age/sex segregation may occur, namely solitary adult animals of both sexes, cow/calf pairs and small groups of immature animals, the most common being solitary animals or cow/calf pairs (Credle 1988; Leatherwood and Reeves 1983; Ross 1984). Although the sample size is small, results from a photo-identification study in Hawai‘i have shown that while most animals seen on more than one occasion appear to be linked together in the same social network, repeated associations post-weaning are rare (Baird et al. 2021). Inter-specific interactions are rare; in 94 sightings of dwarf sperm whales in Hawai‘i, they have never been seen associated with another cetacean species (Baird et al. 2021). Scott and Cordaro (1987) note one case where a pair of dwarf sperm whales were encircled in a tuna purse-seine net together with a mixed school of pantropical spotted (*Stenella attenuata*) and spinner (*S. longirostris*) dolphins, although they did not appear to be associated with the group.

Fecal “ink”

Dwarf sperm whales have been observed to emit clouds of reddish-brown feces, often referred to as “inking” (Scott and Cordaro 1987). Scott and Cordaro (1987) noted that a female dwarf sperm whale encircled in a seine net released a cloud of feces into the net about six to eight times and hid herself and her calf inside it whenever a dolphin was approaching the pair. The cloud covered an area of approximately 100 m^2. One individual in Hawai‘i was observed defecating in air while leaping (Baird et al. 2021).

Acoustic

Vocalizations of dwarf sperm whales are characterized by narrow-band, high-frequency clicks with peak frequencies reported at about 123 kHz (Malinka et al. 2021) and 127–129 kHz (Merkens et al. 2018). Clicks localized on an array in an area with water depth of about 400 m were produced at depths ranging from 1 to 392 m (median = 47 m). Inter-click intervals in deep water were relatively long (median of 228 ms) compared to some shallow-water narrow-band high-frequency odontocetes (Malinka et al. 2021). Tonal calls have not been reported for this species.

Parasites and Diseases

Dwarf sperm whales have been recorded documented with a number of parasites, including large numbers of nematodes in the gastrointestinal tract and encysted tapeworms in the blubber (Caldwell and Caldwell 1989; Pinedo 1987; Santoro et al. 2018; Zam et al. 1971). Species of parasites documented include *Phyllobothrium delphini*, *Pseudoterranova kogiae*, *Skrjabinisakis physeteris*, *Anisakis simplex* and *A. typica*, as well as the ectoparasitic copepod *Pennella* sp. (Nagorsen 1985). A stranded dwarf sperm whale in Costa Rica has been documented with brucellosis, a disease caused by *Brucella* bacteria (Hernández-Mora et al. 2021), and stranded individuals in Taiwan have been documented with circulatory disease, respiratory disease, gastrointestinal disease, and hepatobiliary-pancreatic disease, although how many of these cases led to death is unclear (Li et al. 2021). A stranded individual in the Canary Islands was documented with infectious bronchointerstitial pneumonia, hepatitis, nephritis, and endometritis (Díaz-Delgado et al. 2018). Cardiomyopathy (heart failure) is a leading cause of mortality in dwarf sperm whales along the southeast coast of the United States (Bossart et al. 2007; Credle 1988).

Conservation and Management

Human Threats

Small numbers of *Kogia* have been recorded in directed hunts in a number of areas, although it is not always clear which species is involved. Either dwarf or pygmy sperm whales, or possibly both, have been reported to be hunted off St. Vincent in the Lesser Antilles (Caldwell et al. 1973), the Philippines (Leatherwood et al. 1992), southern Japan (Yamada 1954), and Indonesia, and they have been seen occasionally in the fish markets in Sri Lanka (Leatherwood 1985). Bycatch has been reported for the Sri Lankan gillnet fishery (Chantrapornsyl et al. 1991), in a drift gillnet fishery off California (Barlow and Cameron 2003), off Taiwan (Wang et al. 2002), and is likely elsewhere (Klinowska 1991; Tulloch et al. 2020). Several individuals in Hawai‘i have evidence of interactions with hook and line fisheries (Baird et al. 2021). Dwarf sperm whales have been reported to ingest plastic (Caldwell and Caldwell 1989; Ross 1979; Willis and Baird 1998), although how often this leads to mortality is not known.

Dwarf sperm whales appear to be susceptible to the impacts of loud anthropogenic sounds, such as Navy mid-frequency active sonar. In Hawai‘i, one individual live stranded shortly after the start of a US Navy sonar exercise (Baird 2016). In North Carolina, two dwarf sperm whales live stranded together with 33 short-finned pilot whales *Globicephala macrorhynchus* and one minke whale *Balaenoptera acutorostrata* (Hohn et al. 2006). The strandings were potentially related to the exposure to military sonar, although the authors could not conclude a definite causal link (Hohn et al. 2006).

Relatively little is known about contaminant loads. Bachman et al. (2014) reported on persistent organic pollutants for one adult male in Hawai‘i, and levels of dichlorodiphenyltrichloroethane (DDT), polychlorinated biphenyls (PCBs), and other contaminants were all on the low end of the range for the 14 species of odontocetes tested. Based on a study of persistent organic pollutants in pygmy sperm whales (King 1987), and given the similar diets of the two species (Staudinger et al. 2014), dwarf sperm whales are likely to have relatively low levels of contaminants. Reed et al. (2015) documented trace elements in dwarf sperm whales stranded along the south-east coast of the United States and noted that concentrations of some metals associated with anthropogenic contamination were relatively low.

It is unknown what effect climate change may have on dwarf sperm whales, but given their apparent preference for warmer waters, it is possible that their distribution could expand to the north as global ocean temperatures increase.

Natural Impacts

Predators include both large sharks and killer whales (*Orcinus orca*). Predation on dwarf sperm whales by killer whales has been documented twice in the Bahamas (Dunphy-Daly et al. 2008; Dunn and Claridge 2013) and likely occurs in European waters and elsewhere. Evidence of shark predation exists for both great white sharks (*Carcharodon carcharias*) off California (Long and Jones 1996), and tiger sharks (*Galeocerdo cuvier*) in Hawai‘i (Baird 2016; Baird et al. 2021). Individuals have been documented surviving attacks by large sharks (Baird et al. 2021). In European waters, predation by great white sharks likely occurs.

Legislation and Management

The International Union for the Conservation of Nature lists the status of the dwarf sperm whale as “Least Concern” (Kiszka and Braulik 2020), given its wide distribution and apparent relative abundance. Dwarf sperm whales are listed on Appendix II (species for which trade must be controlled in order to avoid utilization incompatible with their survival) of the Convention on International Trade in Endangered Species.

In Europe, ASCOBANS (the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish, and North Seas) and ACCOBAMS (the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea, and contiguous Atlantic area) form the legislative framework for the protection of the species. Both agreements promote the close cooperation between countries to achieve and maintain a favorable conservation status for cetaceans throughout the respective agreement areas. In addition, the Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention) is the legislative mechanism under which 15 Governments and the European Union cooperate to protect the marine environment of the North-East Atlantic, including small cetaceans. Dwarf sperm whales are also included in Appendix III of the Convention on the Conservation of European Wildlife Habitats, and in Annex IV of Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (the Habitats Directive). While in theory these include measures to protect the species and regulate trade and exploitation, for practical purposes they are not actively implemented for dwarf sperm whales.

Future Challenges for Research and Management

Previous research suggests that there may be two different species currently referred to as *K. sima* (Chivers et al. 2005); to ensure appropriate conservation and management in the future, it should be a priority to resolve the number of species in the genus, their status, distribution, and threats.

The general lack of information on dwarf sperm whales in European waters and worldwide stems from the difficulty in detecting individuals during surveys, and in working with groups for extended periods of time, given their long dives, occasional adverse reactions to vessels, and cryptic nature. The recent ability to acoustically detect *Kogia* bodes well for increasing our understanding of their habitat use, abundance, and behavioral patterns (e.g., diel patterns in acoustic behavior), but methods are needed to discriminate between dwarf and pygmy sperm whales acoustically (Hildebrand et al. 2019), since both are found in European waters. Long-term photo-identification off Hawaiʻi has provided invaluable knowledge of site fidelity and association patterns (Baird 2005; Baird et al. 2021) that is not available from other methods; similar field studies of dwarf sperm whales are needed at other sites. Continuation of such work, incorporation of new methods, such as unoccupied aerial systems to document behavior (Fig. 4), and efforts to photo-identify individuals elsewhere (e.g., in European Macaronesian waters) when they are encountered would help broaden knowledge of dwarf sperm whales. Given their oceanic habitats and tendency to react to vessels, such work will require patience and financial resources.

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References

Bachman MJ, Keller JM, West KL, Jensen BA (2014) Persistent organic pollutant concentrations in blubber of 16 species of cetaceans stranded in the Pacific Islands from 1997 through 2011. Sci Total Environ 488-489:115–123

Baird RW (2005) Sightings of dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whales from the main Hawaiian Islands. Pac Sci 59:461–466

Baird RW (2016) The lives of Hawaiʻi's dolphins and whales – natural history and conservation. University of Hawaiʻi Press, Honolulu

Baird RW, Nelson D, Lien J, Nagorsen DW (1996) The status of the pygmy sperm whale, *Kogia breviceps*, in Canada. Can Field-Nat 110:525–532

Baird RW, Mahaffy SD, Lerma JK (2021) Site fidelity, spatial use, and behavior of dwarf sperm whales in Hawaiian waters: using small-boat surveys, photo-identification, and unmanned aerial systems to study a difficult-to-study species. Mar Mamm Sci. https://doi.org/10.1111/mms.12861

Ballance LT, Pitman RL (1998) Cetaceans of the Western Tropical Indian Ocean: distribution, relative abundance, and comparisons with cetacean communities of two other tropical ecosystems. Mar Mamm Sci 14: 429–459

Barlow J (2006) Cetacean abundance in Hawaiian waters estimated from a summer/fall suvey in 2002. Mar Mamm Sci 22:446–464

Barlow J (2015) Inferring trackline detection probabilities, g(0), for cetaceans from apparent densities in different survey conditions. Mar Mamm Sci 31:923–943

Barlow J, Cameron GA (2003) Field experiments show that acoustic pingers reduce marine mammal bycatch in the California drift gill net fishery. Mar Mamm Sci 19: 265–283

Barlow J, Sexton S (1996) The effect of diving and searching behavior on the probability of detecting track-line groups, *g0*, of long-diving whales during line-transect surveys. Southwest Fisheries Science Center, National Marine Fisheries Service, La Jolla

Best PB (2007) Whales and dolphins of the Southern African Subregion. Cambridge University Press, Cape Town

Bloch D, Mikkelsen B (2009) A northernmost record of dwarf sperm whale (*Kogia sima*) (Owen, 1866) from the Faroe Islands. Aquat Mamm 35:306–307

Bloodworth B, Marshall CD (2005) Feeding kinematics of *Kogia* and *Tursiops* (Odontoceti:Cetacea): characterization of suction and ram feeding. J Exp Biol 208: 3721–3730

Bortolotto A, Papini L, Insacco G, Gili C, Tumino G, Mazzariol S, Pavan G, Cozzi B (2003) First record of a dwarf sperm whale, *Kogia sima* (Owen, 1866) stranded alive along the coasts of Italy. Poster presentation at the 31st Symposium of the European Association for Aquatic Mammals, Tenerife, Spain, 14-17 March 2003

Bossart GD, Hensley G, Goldstein JD, Kroell K, Manire CA, Defran RH, Reif JS (2007) Cardiomyopathy and myocardial degeneration in stranded pygmy (*Kogia breviceps*) and dwarf (*Kogia sima*) sperm whales. Aquat Mamm 33:214–222

Bradford AL, Oleson EM, Forney FA, Moore JE, Barlow J (2021) Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. NOAA Technical Memorandum NMFS-PIFSC-115

Breese D, Tershy BR (1993) Relative abundance of cetacea in the Canal de Ballenas, Gulf of California. Mar Mamm Sci 9:319–324

Caldwell DK, Caldwell MC (1989) Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838): dwarf sperm whale *Kogia simus* Owen, 1866. In: Ridgway SH, Harrison R (eds) Handbook of marine mammals. 4. River dolphins and larger toothed whales. Academic Press, London, pp 235–260

Caldwell DK, Caldwell MC, Arrindell G (1973) Dwarf sperm whales, *Kogia simus*, from the lesser Antillean Island of St. Vincent J Mammal 54:515–517

Chantrapornsyl S, Kinze CC, Leatherwood S, Prematunga WP (1991) Notes on the genus *Kogia* in the Northern Indian Ocean. Cetaceans and cetacean research in the Indian Ocean Sanctuary- Marine Mammal Technical Report No. 3. United Nations Environment Programme (UNEP), Nairobi

Chivers SJ, LeDuc RG, Robertson KM, Barros NB, Dizon AE (2005) Genetic variation of *Kogia* spp. with preliminary evidence for two species of *Kogia sima*. Mar Mamm Sci 21:619–634

Clarke MR (1996) Cephalopods as prey. III. Cetaceans. Philos Trans R Soc B 351:1053–1065

Credle VR (1988) Magnetite and magnetoreception in stranded dwarf and pygmy sperm whales, *Kogia simus* and *Kogia breviceps*. MSc thesis, University of Miami. Florida

Creton P, Hussenot E, Ridoux V (1992) A dwarf sperm whale, *Kogia simus*, stranded in Brittany: second record from Atlantic European waters. Eur Res Cetaceans 6:100–102

Davis RW, Scott GP, Würsig B, Fargion GS, Evans WE, Hansen LJ, Benson R, Mullin KD, Leming TD, May N, Mate BR, Norris JC, Jefferson TA, Peake DE, Lynn SK, Sparks TD, Schroeder C (1995) Distribution and abundance of cetaceans in the north-central and western Gulf of Mexico, final report. U. S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans

Díaz-Delgado J, Fernández A, Sierra E, Sacchini S, Andrada M, Vela AI, Quesada-Canales Ó, Paz Y, Zucca D, Broch K, Arbelo M (2018) Pathologic findings and causes of death of stranded cetaceans in the Canary Islands (2006-2012). PLoS One 13:e0204444

Dunn C, Claridge D (2013) Killer whale (*Orcinus orca*) occurrence and predation in the Bahamas. J Mar Biol Assoc UK 94(6):1305–1309

Dunphy-Daly MM, Heithaus MR, Claridge DE (2008) Temporal variation in dwarf sperm whale (*Kogia sima*) habitat use and group size off Great Abaco Island, Bahamas. Mar Mamm Sci 24:171–182

Elwen SH, Gridley T, Roux J-P, Best PB, Smale MJ (2013) Records of kogiid whales in Namibia, including the first record of the dwarf sperm whale (*Kogia sima*). Mar Biodivers Recs 6:e45

Evans PGH, Waggitt JJ (2020) Dwarf sperm whale *Kogia sima*. In: Crawley D, Coomber F, Kubasiewicz L, Harrower C, Evans P, Waggitt J, Smith B, Mathews F (eds) Atlas of the mammals of Great Britain and Northern Ireland. Pelagic Publishing, Exeter

Fitch JE, Brownell RL (1968) Fish otoliths in cetacean stomachs and their importance in interpreting feeding habits. J Fish Res 25:2561–2574

Freitas L, Dinis A, Nicolau C, Ribeiro C, Alves F (2012) New records of cetacean species for Madeira archipelago with an updated checklist. Bol Mus Mun Funchal 62:25–43

Gaskin DE (1972) The sperm whales family Physeteridae. In: Gaskin DE (ed) Whales, dolphins and seals. Heinemann, London

Gill T (1871) The sperm whales, giant and pygmy. Am Nat 4:723–743

Gonçalves JM, Barreriros JP, Azevedo JMN, Norberto R (1996) Cetaceans stranded in the Azores during 1992–1996. Arquipelago, Life and Marine Sciences 14A:57–65

Handley CO (1966) A synopsis of the genus *Kogia* (pygmy sperm whales). In: Norris K (ed) Whales, dolphins and porpoises. University of California Press, Berkeley, pp 62–69

Hayes SA, Josephson E, Maze-Foley K, Rosel PE (2020) US Atlantic and Gulf of Mexico marine mammal stock assessments – 2019. NOAA technical memorandum NMFS-NE-264

Hernández-Mora G, González-Barrientos R, Viquez-Ruíz P-A, Bettoni-Rodríguez GM, Vincent C, Roca-Monge-K, Ruiz-Villalobos N, Suárez-Esquivel M, Cordero-Chavarría M, Chaves-Olarte E, Thomson NR, Barquero-Calvo E, Moreno E, Guzmán-Verri (2021) Brucella sp. sequence-type 27 associated with abortion in dwarf sperm whale *Kogia sima*. Eur J Wildl Res 67:63

Hildebrand JA, Frasier KE, Baumann-Pickering S, Wiggins SM, Merkens KP, Garrison LP, Soldevilla MS, McDonald MA (2019) Assessing seasonality and density from passive acoustic monitoring of signals presumed to be from pygmy and dwarf sperm whales in the Gulf of Mexico. Front Mar Sci 6:66

Hohn AA, Rotstein DS, Harms CA, Southall BL (2006) Report on marine mammal unusual mortality event UMESE0501Sp: multispecies mass stranding of pilot whales (*Globicephala macrorhynchus*), minke whale (*Balaenoptera acutorostrata*), and dwarf sperm whales (*Kogia sima*) in North Carolina on 15-16 January 2005. NOAA technical memorandum NMFS-SEFSC-537

Jaber JR, Pérez J, Arbelo M, Andrada M, Hidalgo M, Gómez-Vallamandos JC, Van Den Ingh T, Fernández A (2004) Hepatic lesions in cetaceans stranded in the Canary Islands. Vet Path 41:147–153

King CA (1987) Organochlorines in bottlenose dolphins (*Tursiops truncatus*) and pygmy sperm whales (*Kogia breviceps*) from southeastern Florida. MSc thesis, University of Miami, Florida

Kiszka J, Braulik G (2020) *Kogia sima*, dwarf sperm whale. The IUCN red list of threatened species 2020: e.T11048A50359330

Klinowska M (1991) Dolphins, porpoises and whales of the world-the IUCN red data book. Gland

Leatherwood S (1985) Further notes on cetaceans of Sri Lanka. Cetology 50:1–12

Leatherwood S, Reeves RR (1983) The Sierra Club handbook of whales and dolphins. Sierra Club Books, San Francisco

Leatherwood S, Dolar MLL, Wood CJ, Aragones LV, Hill CL (1992) Marine mammal species confirmed from Philippine waters. Silliman Journal 36(1):65–81

Li W-T, Chou L-S, Chiou H-Y, Chen I-H, Yang W-C (2021) Analyzing 13 years of cetacean strandings: multiple stressors to cetaceans in Taiwanese waters and their implications for conservation and future research. Front Mar Sci 8:606722

Long DJ, Jones RE (1996) White shark predation and scavenging on cetaceans in the eastern North Pacific Ocean. In: Klimley AP, Ainley DG (eds) Great white sharks, the biology of *Carcharodon carcharias*. Academic Press

Maio N, Pollaro F, Gasparro A, Petraccioli A, Mezzasalma M, Guariglia M, Galiero G, Di Nocera F, Iaccarino D, Santoro M, Insacco G, Guarino FM (2017) New record of dwarf sperm whale *Kogia sima* (Owen, 1866) from the Mediterranean Sea (Cetacea Kogiidae). Biodivers J 8:947–950

Malinka CE, Tonnesen P, Dunn CA, Claridge DE, Gridley T, Elwen SH, Madsen PT (2021) Echolocation click parameters and biosonar behaviour of the dwarf sperm whale (*Kogia sima*). J Exp Biol 224, jeb240689

McAlpine DF (2017) Pygmy and dwarf sperm whales. In: Perrin WF, Würsig B, Thewissen JGM (eds) Encyclopedia of marine mammals, 2nd edn. Academic Press, San Diego, pp 786–787

McCullough JKL, Oleson EM, Barlow J, Allen AN, Merkens K (2021) An acoustic survey in the main Hawaiian Islands using drifting recorders. NOAA Administrative Report H-21-04

Merkens K, Mann D, Janik VM, Claridge D, Hill M (2018) Clicks of dwarf sperm whales (*Kogia sima*). Mar Mamm Sci 34:963–978

Nagorsen D (1985) Kogia simus. Mamm Species 239:1–6

Notarbartolo di Sciara G (2016) Marine mammals in the Mediterranean Sea: an overview. Adv Mar Biol 75: 1–36

Notarbartolo di Sciara G, Birkun A (2010) Conserving whales, dolphins and porpoises in the Mediterranean and Black Seas. An ACCOBAMS status report. ACCOBAMS, Monaco

Ogawa T (1936) Studien über die Zahnwale in Japan. Pt VI, *Cogia*. Botany Zoology 4:2017–2024

Owen R (1866) On some Indian cetacea collected by Walter Elliot, Esq. Trans Zool Soc London 6(1):17–47

Pinedo MC (1987) First record of a dwarf sperm whale from southwest Atlantic, with reference to osteology, food habits and reproduction. Sci Rep Whales Res Inst 38:171–186

Plön S (2004) The status and natural history of pygmy (*Kogia breviceps*) and dwarf (*K. sima*) sperm whales off Southern Africa. Dissertation, Rhodes University

Reed LA, McFee WE, Pennington PL, Wirth EF, Fulton MH (2015) A survey of trace element distribution in tissues of the dwarf sperm whale (*Kogia sima*) stranded along the South Carolina coast from 1990–2011. Mar Poll Bull 100(1):501–506

Rice DW (1998) Marine mammals of the world – Systematics and distribution. Society for Marine Mammalogy, Lawrence

Rogan E, Cañadas A, Macleod K, Benoña Santos M, Mikkelsen B, Uriarte A, Van Canneyt O, Vázquez JA, Hammon PS (2017) Distribution, abundance and habitat use of deep diving cetaceans in the North-east Atlantic. Deep-Sea Res II 141:8–19

Ross GJB (1979) Records of pygmy and dwarf sperm whales, genus *Kogia*, from southern Africa, with biological notes and some comparisons. Ann Cape Prov Mus (Nat Hist) 11(14):259–327

Ross GJB (1984) The smaller cetaceans of the south east coast of Southern Africa. Ann Cape Prov Mus (Nat Hist) 15(2):173–410

Ross GJB (2006) Review of the conservation status of Australia's smaller whales and dolphins. In: Consultancy report to the Threatened Species Scientific Committee. Department of the Environment and Heritage, Canberra

Santoro M, Di Nocera F, Iaccarino D, Cipriani P, Guadano Procesi I, Maffucci F, Hochscheid S, Blanco C, Cerrone A, Galiero G, Nascetti G, Mattiucci S (2018) Helminth parasites of the dwarf sperm whale *Kogia sima* (Cetacea: Kogiidae) from the Mediterranean Sea, with implications on host ecology. Dis Aquat Org 129:175–182

Santos RA, Haimovici M (2001) Cephalopods in the diet of marine mammals stranded or incidentally caught along southeastern and southern Brazil (21-34 S). Fish Res 52:99–112

Santos J, Araújo H, Ferreira M, Henriques A, Miodonski J, Monteiro S, Oliveira I, Rodrigus P, Duro G, Olivira F, Pinto N, Sequeira M, Eira C, Vingada J (2012) Chapter I: Baseline estimates of abundance and distribution of target species. MARPRO Conservaçåo de especies marinhas protegidas em Portugal continental. Project LIFE09/NAT/PT/000038

Scott MD, Cordaro JG (1987) Behavioral observations of the dwarf sperm whale, *Kogia simus*. Mar Mamm Sci 3: 353–354

Sekiguchi K, Klages NTW, Best PB (1992) Comparative analysis of the diets of smaller odontocete cetaceans along the coast of Southern Africa. S Afr J Mar Sci 12: 843–861

Spitz J, Cherel Y, Bertin S, Kiszka J, Dewez A, Ridoux V (2011) Prey preferences among the community of deep-diving odontocetes from the Bay of Biscay, Northeast Atlantic. Deep Sea Res I 58(3):273–282

Staudinger MD, McAlarney RJ, McLellan WA, Pabst DA (2014) Foraging ecology and niche overlap in pygmy (*Kogia breviceps*) and dwarf (*Kogia sima*) sperm whales from waters of the U.S. mid-Atlantic coast. Mar Mamm Sci 30:626–655

Tulloch V, Pirotta V, Grech A, Crocetti S, Double M, How J, Kemper C, Meager J, Peddemors V, Waples K, Watson M, Harcourt R (2020) Long-term trends and a risk analysis of cetacean entanglements and bycatch in fisheries gear in Australian waters. Biodivers Conserv 29:251–282

Valverde JA, Caminas JA (1996) On a dwarf sperm whale *Kogia simus* (Owen, 1866), Physeteroidea. In: Spain: a correction. European Research on Cetaceans-10 Proceedings of the tenth annual conference of the European Cetacean Society, Lisbon, pp 168–171

Van Canneyt O, Dars C, Authier M, Dabin W, Demaret F, Dorémus G, Peltier H, Spitz J (2016) Les échouages de mammifères marins sur le littoral français en 2015. Réseau National Echouages, La Rochelle

Wade PR, Gerrodette T (1993) Estimates of cetacean abundance and distribution in the Eastern tropical Pacific. Rep Int Whaling Comm (Spec Iss 6) 43:477–493

Wang M-C, Walker WA, Shao K-T, Chou LS (2002) Comparative analysis of the diets of pygmy sperm whales and dwarf sperm whales in Taiwanese waters. Acta Zool Taiwanica 13:53–62

Willis PM, Baird RW (1998) Status of the dwarf sperm whale, *Kogia simus*, with special reference to Canada. Can Field-Nat 112:114–125

Yamada M (1954) Some remarks on the pygmy sperm whale *Kogia*. Sci Rep Whales Res Inst 9:37–58

Zam SG, Caldwell DK, Caldwell MC (1971) Some endoparasites from small odontocete cetaceans collected in Florida and Georgia. Cetology 2:1–11