

## *Kogia breviceps* (Cetacea: Kogiidae)

BRIAN E. BLOODWORTH AND DANIEL K. ODELL

National Marine Fisheries Service, Office of Protected Resources, 1315 East–West Highway (SSMC3), Suite 13758, Silver Spring, MD 20910-3282, USA; brian.bloodworth@noaa.gov (BEB)  
Hubbs-SeaWorld Research Institute, 6295 Sea Harbor Drive, Orlando, FL 32821-8043, USA (DKO)

**Abstract:** *Kogia breviceps* (de Blainville, 1838) is a cetacean commonly called the pygmy sperm whale. A diminutive relative of the sperm whale and difficult to identify in the field, it is 1 of only 2 members of the genus *Kogia*. It is endemic to offshore waters of the Pacific, Atlantic, and Indian oceans in temperate and tropical regions. It is considered solitary and deep-diving in pursuit of cephalopod prey. Abundance is poorly known, although it is protected under U.S. federal and international law. No specimens have ever been maintained permanently in captivity, and, temporary holding of stranded individuals has rarely been nonlethal. DOI: 10.1644/819.1.

**Key words:** asymmetrical skull, cetacean, marine mammal, Odontoceti, pygmy sperm whale, whale biology

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### *Kogia breviceps* (de Blainville, 1838) Pygmy Sperm Whale

*Physeter breviceps* de Blainville, 1838:337. Type locality “cap de Bonne-Espérance,” Cape Province, South Africa.

*Kogia breviceps* Gray, 1846:22. First use of current name combination.

*Euphysetes Grayii* Wall, 1851:46. Type locality “Maroobrah Beach, half way between Coojee and Botany,” New South Wales, Australia; see “Remarks.”

*Euphysetes macleayi* Krefft, 1866:713. Type locality “Manly Beach,” New South Wales, Australia.

*Kogia grayii* Gray, 1866:218. Name combination.

*Kogia macleayii* Gray, 1866:391. Name combination and incorrect subsequent spelling of *Euphysetes macleayi* Krefft.

*Euphysetes grayi* Gill, 1871:737, 739. Incorrect subsequent spelling of *Euphysetes grayii* Wall.

*Kogia floweri* Gill, 1871:738. Type locality “a short distance from Mazatlan,” Sinaloa, Mexico.

*Kogia grayi* Gill, 1871:738. Incorrect subsequent spelling of *Euphysetes grayii* Wall.

*Kogia macleayi* Gill, 1871:737. Name combination.

*Euphysetes pottsii* Haast, 1873:100. Type locality “Governor Bay,” New Zealand.

*Kogia goodie* True, 1884:641. Type locality “Monmouth,” New Jersey.

**CONTEXT AND CONTENT.** Order Cetacea, suborder Odontoceti, superfamily Physeteroidea, family Kogiidae, subfamily Kogiinae, genus *Kogia* (Rice 1998). Two species constitute

the genus, *K. breviceps* and *K. sima* (Handley 1966; Rice 1998). *K. breviceps* is monotypic.

### DIAGNOSIS

Externally, stranded *Kogia breviceps* is readily identified from *K. sima* by the distance between the snout and anterior insertion of the dorsal fin, which is greater than 50% of total body length. In addition, dorsal fin height is less than 5% of total body length (Handley 1966; Ross 1979). *K. breviceps* grows to a larger size than *K. sima*, with adults reaching



**Fig. 1.**—Male *Kogia breviceps* (SWF-KB-8614-B) calf during rehabilitation after stranding in Indian River County, Florida. Photo courtesy SeaWorld of Florida.



4.25 m (Caldwell et al. 1971b) and 417 kg (Tomilin 1957) versus the 2.7-m (Handley 1966; Ross 1979) and 280-kg (Leatherwood et al. 1988) maxima known for *K. sima*. However, at sea identification is difficult, with dorsal fin location, height, and total body length as possible characters to identify *Kogia* to species.

Diagnostic characteristics rely upon dental and cranial morphometrics established by Handley (1966) and Ross (1979) for adult specimens. Maxillary teeth may (Ross 1979) or may not (Handley 1966) be found in *K. breviceps*. Twelve to 16 mandibular teeth (rarely 10 or 11) are present (7–12, rarely 13 in *K. sima*). Teeth are longer than 30 mm and wider than 4.5 mm in diameter (smaller measures are consistent with *K. sima*). Condylbasal length is greater than 350 mm, the mandibular symphysis is ventrally keeled (not so in *K. sima*) and longer than 64 mm. Additionally, features of *K. breviceps* include a dorsal cranial fossa that is not cupped caudally, a left fossa that is distinctively longer and narrower than the right, and elongated pterygoid–basisphenoid “wings.”

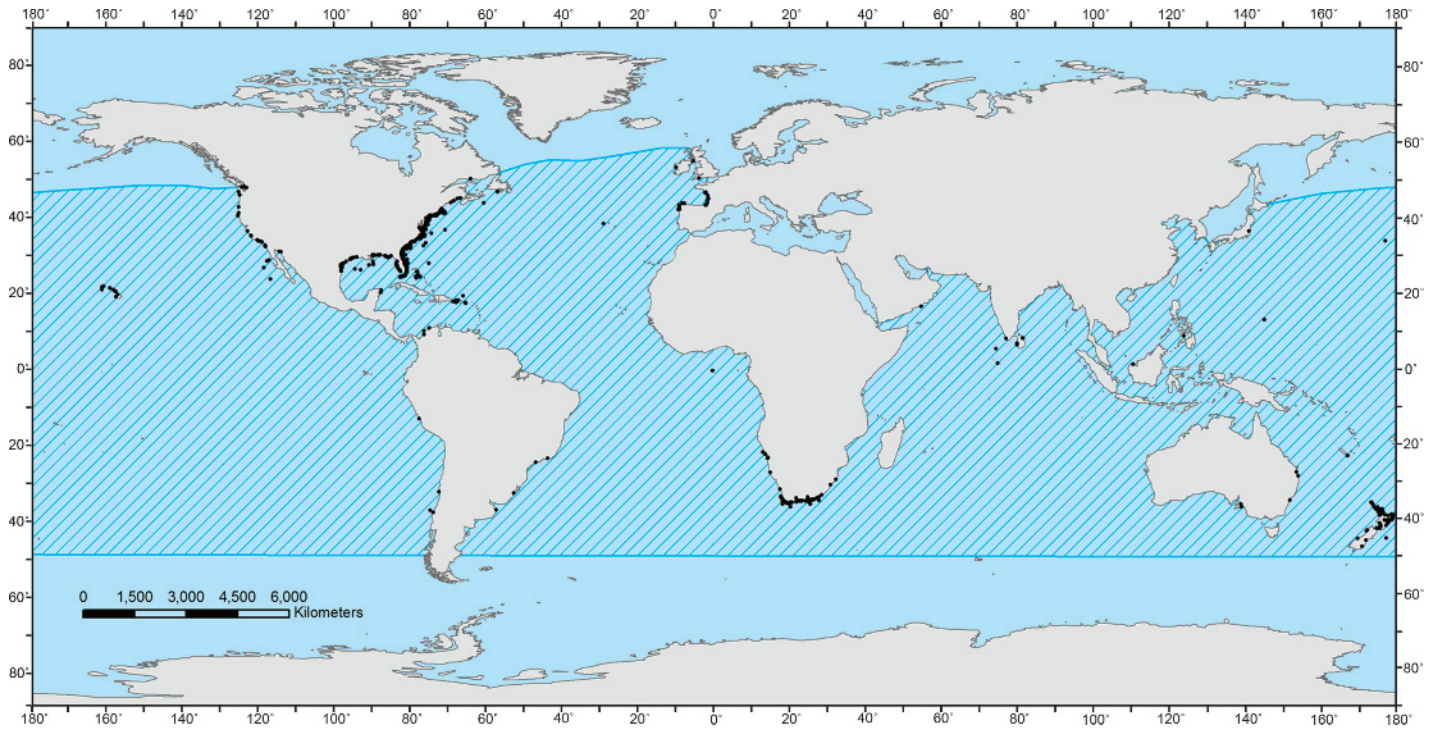
### GENERAL CHARACTERS

*Kogia breviceps* has been described as having a “porpoise-like” or “shark-like” appearance (Fig. 1), likely stemming from the blunt, squared or conical head shape (Ross 1979; Wall 1851; Wynne and Schwartz 1999), presence of a “false-gill” marking (white bracket pigmentation) along either lateral meatus (Hale 1963; Hubbs 1951; Ross 1979), and an inferior mouth (Wynne and Schwartz 1999). The dorsal fin is diminutive, but strongly falcate, as are both flukes (Hale 1963; Wall 1851). Pectoral flippers fit snugly against the body. Coloration is variable between dark and bluish gray dorsally; blue-gray laterally; and cream, ivory, or a similar white color ventrally (Hale 1963; Hubbs 1951; Ross 1979). The gray coloration extends caudally to encompass the ventrum caudal to the anus (Hubbs 1951). Postmortem discoloration occurs as darkening dorsally and pink or purplish mottling ventrally.

*Kogia* cranial morphology (Fig. 2) exhibits dramatic deviations from terrestrial mammals and most cetaceans, with only the sperm whale (*Physeter catodon*) and beaked whales having a comparable asymmetry and dorsal fossa

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**Fig. 2.**—Dorsal, ventral, and lateral views of a skull of *Kogia breviceps* and lateral perspective of the mandible. Adult male specimen collected from Saint Catherine’s Island, Georgia, United States, on 20 February 1996 (field ID GA92-02-22-01), archived at the Museum of Osteology, Oklahoma City (collection number 13592). Condylbasal length, or greatest length of the skull, is 485 mm. Photos courtesy of Jay Villemarette, Museum of Osteology.



**Fig. 3.**—Worldwide locations of roughly 1,700 known sightings, strandings, or bycatch records of *Kogia breviceps* (dots) and probable distribution of *K. breviceps* in marine habitats (hatching). Distribution encompasses regions generally between 45°N and 45°S, with additional extralimital records up to 54°N.

shape. Relative to terrestrial mammals, pronounced derivation is most obvious in maxilla and premaxilla telescoping and narial architecture. However, *K. breviceps* has the shortest rostrum (Handley 1966) and greatest asymmetrical skewness of any cetacean (Haast 1873; Ness 1967). The mesorostral canal contains cartilage that ossifies with age, the rate of which increases significantly at sexual maturity (Ross 1979). Maxillaries and premaxillaries dominate the dorsal cranium's rostral aspect (Handley 1966; Wall 1851). These elements extend caudally to near the supraoccipitals (separated by the frontals—Schulte 1917) along the occipital crest, which forms a large C-shaped cup. This cup is divided into 2 “bowl shaped” cavities by the dorsal sagittal septum, which is composed of the maxillary, premaxillary, and nasal bones, and through which the left naris passes (Clarke 2003; Schulte 1917). The dorsal sagittal septum is formed from the left maxilla and right premaxilla (Schulte 1917; Wall 1851). The left naris is 7–15 times larger than the right (Haast 1873; Schenckan and Purves 1973; Wall 1851) and is the primary respiratory passage, whereas the right likely functions in vocalization (Clarke 2003; Handley 1966). Nasal bones are highly reduced (Wall 1851). Interparietals appear absent in adults but are highly reduced and fused to the frontals in immature specimens (Schulte 1917). Frontals are displaced by the maxillaries laterally and form part of the orbit with the jugals (Wall 1851). A zygomatic arch does not connect to the preorbitals but leaves a large gap along the orbit's

ventral border (Schulte 1917). It has been suggested that the width between occipital condyles could be diagnostic (Handley 1966), but overlap with *K. sima* has been observed in this measure (Ross 1979).

The ventral aspect of the skull is less derived than the dorsal. Maxillaries still dominate the rostrum, with 2 vestigial slits that may house rudimentary teeth. Premaxillae are visible along the midsagittal plane (Hale 1963; Wall 1851). Palatine bones are reduced, whereas pterygoids are enlarged to form much of the nasal foramen (Wall 1851).

Mandibles of *K. breviceps* (Fig. 2) are exceptionally thin and delicate (Haast 1873; Handley 1966; Schulte 1917; Wall 1851), to the point of being translucent along the caudal body. Mandibular condyles are reduced (Schulte 1917; Wall 1851). A dental canal is present rostrally, but it only extends slightly over one-third of mandibular length. The mandibular symphysis is not fused (Schulte 1917).

## DISTRIBUTION

*Kogia breviceps* is cosmopolitan in temperate and tropical waters (Fig. 3; Handley 1966; Leatherwood et al. 1983). This includes the Pacific from Peru and Chile (Huckstadt 2005; Sanino and Yanez 1997; Van Waerebeek et al. 1987) north to Canada (Gulf of California [Brownell 1969; Vidal et al. 1987], California [Hubbs 1951], Washing-

ton State [Rice 1998; Roest 1970], and British Columbia [J. Ford, in litt.]), west to Hawai'i (Baird 2005; Sylvestre 1983; Thomas et al. 1990), Guam (Eldredge 1991, 2003), New Caledonia (Sylvestre 1988), Japan (Omura and Takahashi 1981), Taiwan (Wang et al. 2002), New Zealand, and Australia (Borneo [Harrison and Jamuth 1958], New Zealand [Sylvestre 1983], and South Australia [Hale 1962]). In the Atlantic, *K. breviceps* is found from Argentina (Castello et al. 1986) and Brazil (Carvalho 1966, 1967; Geise and Borobia 1987; Secchi et al. 1994), the Azores (Martins et al. 1985), Europe (Great Britain [Brown 1975], and The Netherlands, France, and Spain [Caldwell and Caldwell 1989; Heintzelman 1981; Santos et al. 2006; Van Canneyt et al. 1998]), eastern Canada (McAlpine et al. 1997; Measures et al. 2004; Nelson et al. 1991), the Caribbean Sea (Cardona-Maldonado and Mignucci-Giannoni 1998, 1999), the eastern United States (Massachusetts to Florida—Sylvestre 1983), and Gulf of Mexico (Texas—Gunther et al. 1955; Huckstadt and Antezana 2001; Hysmith et al. 1976; Raun et al. 1970). In the Indian Ocean, *K. breviceps* occurs along South Africa (Plön 2004; Ross 1979, 1984), off eastern Africa (Ballance and Pitman 1998), Oman, and Sri Lanka (Leatherwood and Reeves 1989).

### FOSSIL RECORD

Information regarding Kogiinae is sparse, but a revision of a prior review (Nagorsen 1985) is appropriate. Three members of Kogiinae are currently known: the 2 extant species *Kogia breviceps* and *K. sima*, and the extinct species *K. pusilla* (Kazar 2002). Teeth of *K. breviceps* are known to exist from Miocene sediments in Italy and later deposits in Japan and southeast Africa (Pilleri 1986). Teeth of *K. sima* have been recovered from Pliocene deposits in Italy as well. Additional Italian finds include fossils of *K. pusilla* from the Piacenzian (Bianucci 1997; Kazar 2002). However, unclassified *Kogia* fossils have been found as old as 13.65 million years (Pilleri and Cigala-Fulgosi 1989). Predating these are cranial fragments assigned to the extinct species *Praekogia cedrosensis* from the late Miocene Almejas Formation in Mexico, which may represent an ancestor to *Kogia* (Barnes 1973). An ancestral link between *Praekogia* and Physeteridae has been suggested based upon a late Miocene mandibular fragment of *Kogiopsis floridana* found in Florida (Barnes 1973; Kellogg 1929; Pilleri 1986).

### FORM AND FUNCTION

**Form.**—Dental osteology of *Kogia* is unique. Teeth are present only in the rostral half of the mandible and consist of long, fanglike dentine elements that recurve caudomedially (Handley 1966; Schulte 1917; Wall 1851). Enamel has been found in very young individuals but likely wears away quickly (Plön 2004). Age is established by dentine layer

count, with 1 growth layer group likely corresponding to 1 year (Plön 2004; Ross 1979).

Postcranial osteology of *K. breviceps* is similar to that of other odontocetes, but highly derived from terrestrial mammals. Vertebral formulas are 7 C, 12–14 T, 9–11 L, 0 S, 20–26 Ca, total 50–55 (Benham 1902; Carvalho 1966; Haast 1873; Hale 1962, 1963; Kreffft 1866; Omura et al. 1984; Secchi et al. 1994; Wall 1851). Cervical vertebrae are fused in all age groups. Epiphyses were free in a 1.93-m specimen, closing at 2.73–2.9 m, and fused at 2.98 m (Hale 1962), suggesting physical maturity at this size (Ross 1979). Chevrons are located ventral of the caudal vertebrae and number 10–16 (Carvalho 1966; Haast 1873; Hale 1962, 1963; Wall 1851). Rib counts are not necessarily symmetric and can be 12–14 on either side; the caudalmost ribs may not have a vertebral articulation (Benham 1902; Carvalho 1966; Haast 1873; Hale 1962, 1963; Kreffft 1865; Omura et al. 1984; Secchi et al. 1994; Wall 1851). Sternebrae are composed of 3 or 4 elements (Benham 1902; Hale 1962, 1963; Schulte and Smith 1918; Secchi et al. 1994). Four cartilaginous sternal ribs articulate to the cranialmost true ribs (Benham 1902). Inominant bones have been replaced by a dense lamella of fibrotic tissue (Benham 1902; Schulte and Smith 1918), although Wall (1851), likely erroneously, reported finding 2 pelvic bones per side. Basihyals and thyrohyals are broad and likely function in suction feeding (Benham 1902; Bloodworth and Marshall 2005, 2007; Hale 1962). The scapular spine is poorly developed, but a prominent acromion is present (Benham 1902). Humerus, radius, and ulna are reduced and the olecranon is cartilaginous (Benham 1902). Five to 7 carpal bones are present and phalangeal counts are variable: I 2, II 6–10, III 6–8, IV 4–6, and V 2–4, and can be unequal between sides, even in the same specimen (Benham 1902; Carvalho 1966; Schulte and Smith 1918; Wall 1851).

Myology is generally characterized by enlarged propulsory and reduced pectoral musculature. Epaxial and hypaxial muscle groups are massive, with several muscles joining and breaking apart (Schulte and Smith 1918). Coloration is dark red to nearly black and is possibly due to a high myoglobin content (N. Barros, pers. comm.) that aids in deep diving. Abdominal musculature, including intercostals, rectus abdominus, and transversalis muscles, are well developed (Schulte and Smith 1918). Trapezius and all pectoral extensors are absent, except for the common digital extensor, whereas latissimus dorsi, supraspinatus, and flexor carpi ulnaris are reduced. Deltoideus and flexor digitorum ulnaris muscles are enlarged and the rhomboideus is differentiated into 3 heads. Facial musculature is highly undifferentiated and diffuse within fibrous tissue. Narial musculature dilates and retracts the blowhole, and is highly asymmetrical because of underlying cranial osteology.

The brain of *K. breviceps* has thus far received little attention. However, the rostroventral dura of the brain of *K. breviceps* shows a significant concentration of magnetite

crystals, a magnetically reactive material potentially involved with magnetoreception and stranding incidence (Credle 1988). Although information on the central nervous system of *K. breviceps* is sparse, the brain of *K. sima* appears similar to that of other odontocetes, although separation between dorsal aspects of the orbital lobes is wider than in any other cetacean thus far studied (Marino et al. 2003). Only 1 comprehensive description of the peripheral nervous system of *K. breviceps* has been published (Schulte and Smith 1918). Although the eye of *K. breviceps* has not been described, *K. sima* lacks ciliary muscles, has a frail sclera-ciliary body attachment, and a relatively low number of retinacular receptor nuclei (Dawson 1980). However, ample light-gathering ability is available from a significant tapetum layer and optic nerves containing 1.2 million axons, an order of magnitude more than bottlenose dolphins (*Tursiops truncatus*), suggesting good vision in low light conditions, such as while foraging during deep dives.

Digestive tract morphology is the best-studied aspect of the visceral anatomy of *K. breviceps*. The stomach consists of 3 segments and 1 connecting channel (Kernan and Schulte 1918; Rice and Wolman 1990). Data from a single frozen stomach describes the forestomach as nonglandular and lacking a sphincter to the fundic chamber. The fundic is glandular, with the potential to reflux digestive fluid into the forestomach. A small connecting channel passes from the fundic to a glandular pyloric chamber, which then opens into the duodenal ampulla and duodenum (Rice and Wolman 1990). A cecum is absent, but biliary bile acid composition indicates that anaerobic fermentation occurs (Hagey et al. 1993). The pancreas resembles that of other mammals, with the exception of A- and B-cells associated with pancreatic acinar cells (Brown et al. 1988). The colon is enlarged into an “ink sac” containing notably liquid brownish red feces (Benham 1901; Caldwell and Caldwell 1989). Absolute and relative percentage values for various tissues from a single young animal have been recorded (Omura et al. 1984); muscle and blubber each composed 38% and 40% of total body weight, respectively, the skeleton was 8.5%, and organs constituted 10%. However, these values are likely positively biased by blood loss.

A complex echolocation system is present within the snout of *K. breviceps*. The spermaceti organ, located posterior to the melon, is composed of wax esters and triglycerides (Carvan 1988; Karol et al. 1978). The melon itself is composed of a denser inner melon of primarily wax esters and an outer melon of predominantly triglycerides, although both lipids are common throughout the melon. A fibrous coat (junk case) surrounds the melon and spermaceti organ, which has been proposed as a homolog to the right posterior dorsal bursa of other odontocetes (Carvan 1988; Cranford et al. 1996).

**Function.**—Sound production is thought to occur as air moves into a vocal chamber of the right nare and passed through a vocal valve (the “monkey lips” or museau de

singe—Clarke 2003; Cranford et al. 1996). Presumably, sound is produced by the vibration of the vocal reed, a thickened portion on the valve’s dorsal lip. A cushion composed of ligamentlike fibers encompasses the vocal valve, and may assist in sound production. Sound may be received at the tip of the spermaceti organ, which might focus sound waves into a beam that passes through the melon and skin. The differential densities of the inner and outer melons also focus sound. A gas-recycling system may be present to prevent air escape through the blowhole. Imaging of anatomical structures suggests adaptation for function under high hydrostatic pressure, such as during deep dives (Carvan 1988). However, alternative or additional functions may be served by these structures (Schenkkan and Purves 1973).

## ONTOGENY AND REPRODUCTION

**Ontogeny.**—Several characters change ontogenetically in *Kogia breviceps*, at least for individuals in the Southern Hemisphere. The rostrum is known to lengthen and widen relative to total body length with age (Ross 1979). Mandibular, supraoccipital, and occipital condyle widths also increase relative to total body length as individuals age (Ross 1979). The dental pulp cavity closes and becomes occluded at about 20 growth layer groups (Plön 2004). Corpora albicantia regress in size with age (Ross 1979). Snout shape changes from a sloping dorsal surface in smaller animals to an elongated, bulbous appearance in longer (presumably older) individuals (Hale 1962; Ross 1979).

Male sexual maturity can be classified in 3 stages that correlate total body length to seminiferous tubule diameter: immature, maturing, and mature (Ruiz 1993). Sexual maturity is reached at total body lengths of 1.9–2.5 m and 2.5–6 growth layer groups (Plön 2004; Ruiz 1993). Testis mass in adult males can be large; in excess of 5 kg each from a 3.23-m specimen (Ruiz 1993). Adult testicular mass is roughly 1% of body mass (Plön 2004). From a sample size of 44 stranded males in the western Atlantic, 58% were sexually mature (Ruiz 1993). Female reproductive anatomy is generally similar to that of other cetaceans, although pseudocervices and complex rugae of the vaginal epithelium are relatively unique to *Kogia* (Beckman 1986).

For individuals from the Southern Hemisphere, physical maturity is reached at 15 growth layer groups for both sexes, whereas female sexual maturity is reached at 5 growth layer groups, or about 262 cm in total body length (Plön 2004). Maximum recorded female age is 23 growth layer groups, and females likely grow to a larger size than do males (Plön 2004).

**Reproduction.**—Conception in South African waters is proposed to occur from April through September and parturition from December through March (Plön 2004). Conception and parturition have been proposed to occur

from autumn to spring as well for *K. breviceps* in the western Atlantic (Caldwell and Caldwell 1989; Caldwell et al. 1971a; Leatherwood et al. 1983, 1988; Nagorsen 1985). Enlargement of seminiferous tubules from June through August and strandings of most calves from May to July along the Atlantic United States suggest a breeding season during this time (Caldwell and Caldwell 1989; Ruiz 1993). Ovulation rate is 0.9 ovum per year and estrus appears to occur annually (Plön 2004). Up to 8 corpora have been identified on a single ovary (Ross 1979).

An approximate 11-month gestation period has been suggested (Plön 2004; Ross 1979), during which a single calf develops in utero. Unlike other cetaceans for which parturition has been observed (with the exception of killer whales [*Orcinus orca*]), the only observation of parturition indicates a headfirst birth (Huckstadt and Antezana 2001). *K. breviceps* averages 1.2 m in length at birth and may nurse for roughly 1 year (Caldwell and Golley 1965; Caldwell et al. 1971b; Plön 2004; Ross 1979; Ruiz 1993). Strandings of simultaneously lactating and pregnant females suggest that females may bear young in successive years (Plön 2004; Ross 1979). Milk composition appears to contain less fat (particularly long-chained fatty acids) and more lactose than that of other studied cetaceans (Jenness and Odell 1978).

## ECOLOGY

**Population characteristics.**—Ecological parameters of *Kogia breviceps* other than diet are generally poorly known. Because of cryptic behavior, difficulty in identifying kogiids to species, and a generally deepwater distribution, little information is available regarding stock structure, abundance, movement, or human impact on *K. breviceps* (Baird et al. 1996; National Marine Fisheries Service 2006; Würsig et al. 1998). The best estimate of abundance for *Kogia* species in the northern Gulf of Mexico is 742 (coefficient of variation [ $CV$ ] = 0.29) and in the western North Atlantic is 395 ( $CV$  = 0.40) individuals (National Marine Fisheries Service 2006), but is likely negatively biased, because problems with detectability, avoidance, and deep-diving behavior are not accounted for. The Hawaiian stock is estimated to number 7,251 ( $CV$  = 0.77) and incorporates a correction factor for individuals missed while diving. Census and tracking are generally accomplished by aerial or shipboard surveys or satellite tagging of rehabilitated strandlings.

**Space use.**—*Kogia breviceps* is considered the more temperate *Kogia* species (Plön 2004; Ross 1979, 1984; Wade and Gerrodette 1993; Willis and Baird 1998). In the eastern tropical Pacific, *K. breviceps* is not seen in truly tropical waters south of the southern tip of Baja California, where *K. sima* is common. This occurrence is supported by stranding distribution in South American waters (Muñoz-Hincapié et

al. 1998). *K. breviceps* also is much less common than *K. sima* in the western tropical Indian Ocean (Ballance and Pitman 1998).

Both *Kogia* species occur in waters along the continental shelf break and over the continental slope (Baumgartner et al. 2001; McAlpine 2002). However, several studies have suggested that *K. breviceps* generally occurs beyond the continental shelf edge (MacLeod et al. 2004; Rice 1998; Wang et al. 2002). In the Gulf of Mexico, where *Kogia* species sightings are abundant, *Kogia* species have been sighted year-round in waters 400–3,500 m in depth, but are most frequently observed in 400–1,000 m of water (Baumgartner et al. 2001; Davis et al. 1998; Mullin et al. 1994). This is particularly true in areas of upwelling that concentrate zooplankton biomass and cephalopod prey along the continental shelf (Davis et al. 1998). For example, a satellite-tagged, rehabilitated juvenile female *K. breviceps* released off eastern Florida remained over the continental slope and western edge of the Gulf Stream until the tag failed (Scott et al. 2001). Seasonal movements are generally unknown. *K. breviceps* is not known to associate with other cetacean species (Baird et al. 1996).

**Diets.**—Stomach contents (Plön 2004), hemoglobin oxygen-binding capacity (Lenfant 1969), and long dive durations (Scott and Cordaro 1987) support a deep-diving ability in *Kogia* species. It has been suggested that *Kogia* species dive into prey patches and feed by sucking prey (Baird et al. 2004, Supporting Information S1, <http://dx.doi.org/10.1644/819.S1>) into the mouth while moving slowly through or remaining stationary in prey patches (Bloodworth and Marshall 2005, 2007).

Dietary information from numerous stranded and a few live-captured specimens supports cephalopods as the staple diet of *K. breviceps*. Cephalopods of 4 orders (Octopoda, Sepiida, Sepiolida, and Teuthida), 23 families, and at least 50 species from 39 genera have been documented in the diet of *K. breviceps* (N. Klages, in litt.; Plön 2004; Ross 1979; Santos et al. 2006; Secchi et al. 1994; Wang et al. 2002). The most common prey are members of the families Cranchiidae, Enoploteuthidae, Histioteuthidae, Lycoteuthidae, and Ommastrephidae. Members of these groups are generally bioluminescent and reside in midwater oceanic environments. Many prey genera also use ammonium ion displacement for buoyancy and are not as evasive as muscular squids (Clarke 1996). Deep-sea (*Notostomus*) and penaeid (*Farfantepenaeus californiensis*) shrimps also have been identified from stranded individuals (Ross 1979; Vidal et al. 1987). Unlike *K. sima*, *K. breviceps* appears to only rarely ingest mesopelagic fishes, including silver gemfish (*Rexea solandri*), lanternfish (*Scopelopsis multipunctatus*), and cod (*Gadus*—McAlpine et al. 1997; Plön 2004; Ross 1979).

**Diseases and parasites.**—*Kogia breviceps* has been noted for having high levels of parasitic infections (McAlpine et al. 1997). Parasites include the cestodes *Monorygma grimaldii*, *Phyllobothrium delphini*, and *Scolex pleuronectis*; the nema-

todes *Anisakis physeteris*, *A. simplex*, *A. typical*, *Crassicauda magna*, *C. duguyi*, *Phocanema*, *Pseudoterranova kogiae*, *Terranova ceticola*, and *Stenurus auditivus*; the acanthocephalan *Bolbosoma vasculosum*; the copepod *Penella balaenopterae*; and lampreys (Caldwell et al. 1971a; Daily and Brownell 1972; McAlpine et al. 1997). Morbillivirus also has been diagnosed in *K. breviceps* from Pacific waters (Yang et al. 2006). Protozoans also have been identified from *K. breviceps*, including a trypanoplasmid-like flagellate that was isolated from blowhole cultures of a stranded individual (Poynton et al. 2001). This is the 1st flagellate identified from any marine mammal.

Low-level incidental takes of *K. breviceps* have been reported in gillnet, seine nets, and longline fisheries from Colombia (Vidal et al. 1990), eastern Florida (Yeung 2001), Sri Lanka (Leatherwood and Reeves 1989), the Philippines (Dolar et al. 1994), and in open waters of the North Pacific (Baird et al. 1996; Omura et al. 1984). Widespread, directed fisheries for *K. breviceps* are not known to exist presently. However, a “traditional” whaling fishery has been documented for *Kogia* species off Taiji and Shioyama, Japan, from at least the early 1950s, in which *Kogia* species were caught most frequently during summer months, and from at least 1887 in Awa Province (Yamada 1954). Directed fisheries of *Kogia* species also occurred historically in the Timor Sea off Indonesia (Baird et al. 1996). *K. breviceps* has been known to ingest plastic debris (Stamper et al. 2006), which has been lethal in at least 1 case (Baird et al. 1996; National Marine Fisheries Service 2006; Tarpley and Marwitz 1993).

**Interspecific interactions.**—Little is known about predation on *Kogia* species. An attack by a great white shark (*Carcharodon carcharias*) on a *K. breviceps* was reported (Long 1991), and a *K. sima* was killed and eaten by killer whales (*Orcinus orca*) in The Bahamas (Dunphy-Daly et al. 2008).

**Miscellaneous.**—Study of organochlorines in *K. breviceps* showed that levels of polychlorinated biphenyls and chlorinated pesticides were higher in males than in females, suggesting that females pass toxins to calves (King 1987). Dichlorodiphenyltrichloroethane (DDT) also was found, but in relatively low concentrations.

## HUSBANDRY

*Kogia* species are difficult to maintain in captivity; of 33 rehabilitation attempts in the United States between 1948 and 1981, all died within 1 month (Sylvestre 1983). Since then, numerous rehabilitation attempts of stranded specimens have yet to produce success in long-term captivity. The longest captive duration for *K. breviceps* was 21 months in duration for a calf. Captive individuals are susceptible to dehydration and severe dietary or pharmacological reactions (Manire et al. 2004). Continu-

ous movement of material through the gut is critical to survival in captivity (Manire et al. 2004). Necropsies have identified gastrointestinal ruptures, blockages, torsions, or impactions, and stress-induced cardiomyopathy as the most frequent causes of death in captivity (Manire et al. 2004). Cardiomyopathy is more common in adults than in younger animals (Bossart et al. 1985). Detailed observations on *Kogia* species veterinary and husbandry care are provided by Manire et al. (2004).

## BEHAVIOR

Because of the paucity of studies on free-ranging individuals, the behavior of *Kogia breviceps* is poorly known. However, animals may be approachable under some conditions (Caldwell and Caldwell 1989). A reddish brown feces can be excreted in large amounts when animals are startled or excited (Yamada 1954), possibly serving as a cryptic screen in *K. sima* (Scott and Cordaro 1987). Solitary *K. breviceps* are frequently seen, but small groups may occur. Mean group size has been reported as roughly 2 individuals (Willis and Baird 1998).

Dives of up to 45 min have been reported for a *K. sima* (Willis and Baird 1998), and an average dive duration of about 11 min has been calculated (Barlow 1999). A juvenile female *K. breviceps* released off Florida was found to make long (>8 min mean duration) nighttime dives (Scott et al. 2001). Most *Kogia* species sightings are brief, because animals are difficult to approach and frequently avoid survey aircraft and vessels (Würsig et al. 1998).

Sound recordings of *K. breviceps* originate from strandings and these reveal echolocation clicks ranging from 60 to 200 kHz, with a dominant frequency of 120–130 kHz (D. K. Caldwell and M. C. Caldwell, in litt.; Marten 2000), although lower frequencies also have been recorded (Caldwell and Caldwell 1991). “Cries” in the 1- to 2-kHz range have been recorded by Thomas et al. (1990). Low-frequency vocalizations have been noted for having almost all energy below 2 kHz (Caldwell et al. 1966). Staff at SeaWorld of Florida recorded echolocation pulse trains (🔊), Supporting Information S2, <http://dx.doi.org/10.1644/819.S2> with variable pulse rates from a 1.32-m male *K. breviceps* calf that stranded 14 June 1988. An auditory brainstem response study supports a hearing range of 90–150 kHz (Ridgway and Carder 2001).

## GENETICS

The genetics of Physeteroidea have received significant attention to identify phylogenetic relationships within Cetacea. Physeteroidea have a  $2n = 42$  chromosome number, whereas other studied cetaceans (excluding beaked whales) are  $2n = 44$  (Árnason and Benirschke 1973).

Chromosomes of *Kogia breviceps* are not telocentric, and nucleolus formation is believed to occur in the sm8 region (Árnason and Benirschke 1973). Genetic analyses of transversions support the division of Kogiidae from Physeteridae (Milinkovitch et al. 1994). Several genome and protein structures of *K. breviceps* have been sequenced, including mitochondrial DNA and the control region (Árnason et al. 1993, 2004; Chivers et al. 2005; Plön 2004), common cetacean satellite (Grétarsdóttir and Árnason 1993), interphotoreceptor retinoid-binding protein (Smith et al. 1996), ZFX and ZXY (Morin et al. 2005), cytochrome-*b* (Chivers et al. 2005; Milinkovitch et al. 1994; Plön 2004), and 12S genes (Milinkovitch et al. 1994). Nucleotide diversity was calculated to be 0.0165, with an average pairwise difference of 13.154 in Northern Hemisphere individuals (Chivers et al. 2005). However, overall cytochrome-*c* nucleotide diversity was found to be 0.84 in South African samples, and as high as 2.07 within the control region (Plön 2004). The 74 haplotypes identified for *K. breviceps* form a single clade, supporting gene flow throughout the worldwide distribution of *K. breviceps* (Chivers et al. 2005; Plön 2004).

## CONSERVATION

Protection is afforded under the Convention on International Trade in Endangered Species of Wild Fauna and Flora, Marine Mammal Protection Act (United States and The Bahamas), the Cetacean Protection Regulations of the Fisheries Act (Canada), and regulations of several other nations.

## REMARKS

Owen (1865) and Kreffft (1865) identify *Euphysetes grayii* as being 1st described by William Sharpe MacLeay. However, Wall (1851) is credited with the naming of *E. grayi*, because he was the designated author on the manuscript originally describing the species. Haast (1873) claims MacLeay wrote the manuscript, but it is apparent that MacLeay was not credited with authorship. Before the publication of Handley (1966), distinguishing *Kogia breviceps* from *K. sima*, most observers combined these species into a single species. Therefore, publications prior to this year should be scrutinized carefully for species-specific traits to avoid misidentification. Recent genetic evidence supports the possibility that 2 parapatric species of *K. sima* may exist; 1 occupying the Atlantic Ocean and 1 in Indian and Pacific oceans (Chivers et al. 2005).

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Ferrar for composition of Fig. 3. Data from Fig. 3 originate from several unpublished sources including the National Marine Fisheries Service—Northeast, Southeast, Southwest, Northwest, and Pacific Islands Marine Mammal Stranding Networks; Smithsonian Stranding Database; GulfCet; New Zealand Department of Conservation (Anton van Helden); Australian National Whale and Dolphin Stranding and Sighting Database; The Bahamas Marine Mammal Survey; and the United Kingdom Whale and Dolphin Stranding Scheme. Fig. 3 also incorporates published data from Baird (2005), Baird et al. (1996), Ballance and Pitman (1998), Benham (1902), Brownell (1969), Caldwell et al. (1966), Cardona-Maldonado and Mignucci-Giannoni (1999), Carvalho (1966, 1967), Castello et al. (1986), Chantrapornsyl et al. (1991), de Blainville (1838), Dolar et al. (1994), Eldredge (1991), Everitt et al. (1979), Fritts et al. (1983), Geise and Borobia (1987), Gunther et al. (1955), Hale (1962), Harrison and Jamuth (1958), Hubbs (1951), Huckstadt and Antezana (2001), Hysmith et al. (1976), Jefferson and Shiro (1997), Kreffft (1865), Long (1991), Martins et al. (1985), McAlpine et al. (1997), Measures et al. (2004), Munoz-Hincapié et al. (1998), Nelson et al. (1991), Omura and Takahashi (1981), Omura et al. (1984), Osbourne and Ransom (1988), Plön (2004), Roest (1970), Ross (1979), Sanino and Yanez (1997), Santos et al. (2006), Schulte and Smith (1918), Secchi et al. (1994), Sylvestre (1983, 1988), Van Canneyt (1998), Van Waerebeek et al. (1987), Vidal (1987), Wade and Gerrodette (1993), and Yeung (2001). We thank C. Marshall for video editing of Supporting Information S2. We thank W. Noke Durden, G. Mitchell, S. Plön, M. Stolen, and 1 anonymous reviewer for improving previous drafts of this manuscript.

## SUPPORTING INFORMATION

**Supporting Information S1.**—Recording was made during rehabilitation of stranding at SeaWorld of Florida while housed in an isolated tank of 12.2 m diameter and 3.66 m depth. A calibrated Gould CH-17U hydrophone (Gould Instruments, Dayton, Ohio) and Uher 4400IC recorder (Uher of America, Inc., Inglewood, California) at a tape speed of 4.7 cm/s was placed at a depth of 1 m. More information and analysis will be available in “Analysis of the acoustic signals from three pygmy sperm whales (*Kogia breviceps*)” by Jennifer Scharnitz (Master’s thesis, Nova Southeastern University, Fort Lauderdale, Florida).

Found at DOI: 10.1644/819.S1 (2687KB AIF)

**Supporting Information S2.**—Video recording by B. Bloodworth of juvenile dwarf sperm whale (*K. sima*) at Mote Marine Laboratory (Sarasota, Florida). Clip illustrates the ability of kogiids to feed by suction-based methods. Additional information is available in Bloodworth and Marshall (2005).

Found at DOI: 10.1644/819.S2 (9613KB AVI)



## LITERATURE CITED

- ÁRNASON, U. A., AND K. BENIRSCHKE. 1973. Karyotypes and ideograms of sperm and pygmy sperm whales. *Hereditas* 75:67–74.
- ÁRNASON, U. A., A. GULLBERG, AND A. JANKE. 2004. Mitogenomic analyses provide new insights into cetacean origin and evolution. *Gene* 333:27–34.
- ÁRNASON, U. A., A. GULLBERG, AND B. WIDEGREN. 1993. Cetacean mitochondrial DNA control region: sequences of all extant baleen whales and two sperm whale species. *Molecular Biology and Evolution* 10:960–970.
- BAIRD, R. W. 2005. Sightings of dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whales from the main Hawaiian Islands. *Pacific Science* 59:461–466.
- BAIRD, R. W., D. NELSON, J. LEIN, AND D. W. NAGORSEN. 1996. Status of the pygmy sperm whale, *Kogia breviceps* in Canada. *Canadian Field-Naturalist* 110:525–532.
- BALLANCE, L. T., AND R. L. PITMAN. 1998. Cetaceans of the western tropical Indian Ocean: distribution, relative abundance, and comparisons with cetacean communities of two other tropical ecosystems. *Marine Mammal Science* 14:429–459.
- BARLOW, J. 1999. Trackline detection probability for long-diving whales. Pp. 209–221 in *Marine mammal survey and assessment methods* (G. W. Garner, S. C. Amstrup, J. L. Laake, B. F. J. Manly, L. L. McDonald, and D. G. Robertson, eds.). A. A. Balkema, Brookfield, Vermont.
- BARNES, L. G. 1973. *Praekogia cedrosensis*, a new genus and species of pygmy sperm whale from Isla Cedros, Baja California, Mexico. *Contributions to Science* 247:1–20.
- BAUMGARTNER, M. F., K. D. MULLIN, L. M. MAY, AND T. D. LEMING. 2001. Cetacean habitats in the northern Gulf of Mexico. *Fisheries Bulletin* 99:219–239.
- BECKMAN, K. B. 1986. Gross and microscopic anatomy of the female reproductive tracts of the dwarf and pygmy sperm whales (genus *Kogia*). M.S. thesis, University of Miami, Coral Gables, Florida.
- BENHAM, W. B. 1901. On the anatomy of *Cogia breviceps*. *Proceedings of the Zoological Society of London* 1:107–134.
- BENHAM, W. B. 1902. Notes on the osteology of the short nosed sperm whale. *Proceedings of the Zoological Society of London* 1:54–62.
- BIANUCCI, G. 1997. The Odontoceti (Mammalia, Cetacea) from Italian Pliocene. *The Ziphidae*. *Palaeontographica Italica* 84:163–192.
- BLOODWORTH, B., AND C. D. MARSHALL. 2005. Feeding kinematics of *Kogia* and *Tursiops* (Odontoceti: Cetacea): characterization of suction and ram feeding. *Journal of Experimental Biology* 208: 3721–3730.
- BLOODWORTH, B., AND C. D. MARSHALL. 2007. A functional comparison of the hyolingual complex in pygmy and dwarf sperm whales (*Kogia breviceps* and *K. sima*), and bottlenose dolphins (*Tursiops truncatus*). *Journal of Anatomy* 211:78–91.
- BOSSART, G. D., D. K. ODELL, AND N. H. ALTMAN. 1985. Cardiomyopathy in stranded pygmy and dwarf sperm whales. *Journal of the American Veterinary Medical Association* 187:1137–1140.
- BROWN, E., G. BOSSART, AND J. REYNOLDS, III. 1988. The microscopic and immunohistologic anatomy of the endocrine pancreas of pygmy and dwarf sperm whales (Kogiidae). *Marine Mammal Science* 4:291–296.
- BROWN, S. G. 1975. Relation between stranding mortality and population abundance of smaller Cetacea in the northeast Atlantic Ocean. *Journal of the Fisheries Research Board of Canada* 32: 1095–1099.
- BROWNELL, R. L., JR. 1969. Pygmy sperm whale in the Gulf of California. *Journal of Mammalogy* 50:356–357.
- CALDWELL, D. K., AND M. C. CALDWELL. 1989. Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838): dwarf sperm whale *Kogia simus* Owen, 1866. Pp. 235–260 in *Handbook of marine mammals* (S. H. Ridgway and R. Harrison, eds.). Vol. 4. Academic Press, London, United Kingdom.
- CALDWELL, D. K., AND M. C. CALDWELL. 1991. A note describing sounds recorded from two cetacean species, *Kogia breviceps* and *Mesoplodon europaeus*, stranded in northeastern Florida. Pp. 151–154 in *Marine mammal strandings in the United States* (J. E. Reynolds, III. and D. K. Odell, eds.). NOAA Technical Report NMFS 98. The National Marine Fisheries Service, Seattle, Washington.
- CALDWELL, D. K., M. C. CALDWELL, AND S. ZAM. 1971a. A preliminary report on some ectoparasites and nasal sac-parasites from small odontocete cetaceans from Florida and Georgia. *Marineland of Florida Research Laboratory Technical Report* 5:1–7.
- CALDWELL, D. K., AND F. B. GOLLEY. 1965. Marine mammals from the coast of Georgia to Cape Hatteras. *Journal of the Elisha Mitchell Scientific Society* 81:24–32.
- CALDWELL, D. K., H. NEUHAUSER, M. C. CALDWELL, AND H. W. COOLRIDGE. 1971b. Recent records of marine mammals from the coasts of Georgia and South Carolina. *Cetology* 5:1–12.
- CALDWELL, D. K., J. H. PRESCOTT, AND M. C. CALDWELL. 1966. Production of pulsed sounds by the pygmy sperm whale, *Kogia breviceps*. *Bulletin of the Southern California Academy of Science* 65:245–248.
- CARDONA-MALDONADO, M. A., AND A. A. MIGNUCCI-GIANNONI. 1998. Estatus de los cachalotes pigmeo y enano (*Kogia* spp.) en el Caribe. *Congreso da Sociedade Latinoamericana em Mamiferos Aquaticos (SOLAMAC)*, Olinda, Brasil.
- CARDONA-MALDONADO, M. A., AND A. A. MIGNUCCI-GIANNONI. 1999. Pigmy and dwarf sperm whales in Puerto Rico and the Virgin Islands with a review of *Kogia* in the Caribbean. *Caribbean Journal of Science* 35:29–37.
- CARVALHO, C. T. 1966. Notas sobre *Kogia breviceps* (Cetacea, Physteridae). *Revista de Biologia Tropical* 114:169–181.
- CARVALHO, C. T. 1967. Pigmy sperm whale (*Kogia breviceps*) in the Brazil. *Mammalia* 31:168–169.
- CARVAN, M. J., III. 1988. The descriptive anatomy of sound production and propagation tissues in *Kogia* spp. using magnetic resonance and computed topographic imaging. M.S. thesis, University of Miami, Miami, Florida.
- CASTELLO, H. P., F. ERIZE, AND A. A. LICHTER. 1986. Primer registro del cachalote pigmeo, *Kogia breviceps* (Blainville, 1838) para las costas de la republica Argentina. Pp. 69–77 in *Primera Reunion de Trabajo de Expertos en Mamiferos Acuaticos de America del Sur*. South American Society of Experts in Aquatic Mammals. Buenos Aires, Argentina.
- CHANTRAPORNYSYL, S., C. C. KINZE, S. LEATHERWOOD, AND W. P. PREMATUNGA. 1991. Notes on the genus *Kogia* in the northern Indian Ocean. *United Nations Environmental Programme Marine Mammal Technical Report* 3:79–88.
- CHIVERS, S. J., R. G. LEDUC, K. M. ROBERTSON, N. B. BARROS, AND A. E. DIZON. 2005. Genetic variation of *Kogia* spp. with preliminary evidence for two species of *Kogia sima*. *Marine Mammal Science* 21:619–634.
- CLARKE, M. R. 1996. Cephalopods as prey: cetaceans: the role of cephalopods in the world's oceans. *Philosophical Transactions of the Royal Society of London, B. Biological Sciences* 351: 1053–1065.
- CLARKE, M. R. 2003. Production and control of sound by the small sperm whale, *Kogia breviceps* and *K. sima* and their implications for other Cetacea. *Journal of the Marine Biological Association of the United Kingdom* 83:241–263.
- CRANFORD, T. W., M. AMUNDIN, AND K. S. NORRIS. 1996. Functional morphology and homology in the odontocete nasal complex: implications for sound generation. *Journal of Morphology* 228: 223–285.
- CREDLER, V. 1988. Magnetite and magnetoreception in stranded dwarf and pygmy sperm whales, *Kogia simus* and *Kogia breviceps*. University of Miami at Coral Gables, Coral Gables, Florida.
- DAILY, M. D., AND R. L. BROWNELL. 1972. A checklist of marine mammal parasites. Pp. 528–589 in *Mammals of the sea: biology and medicine* (R. Ridgway, ed.). Charles C. Thomas, Springfield, Illinois.
- DAVIS, R. W., ET AL. 1998. Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. *Marine Mammal Science* 14:490–507.
- DAWSON, W. W. 1980. The cetacean eye. Pp. 53–100 in *Cetacean behavior: mechanisms and functions* (L. Herman, ed.). John Wiley & Sons, Inc., New York.
- DE BLAINVILLE, H. M. D. 1838. Sue les cachalots. *Annales Francaises et Étrangères. d'Anatomie et de Physiologie* 2:335–337, pl. 10.

- DOLAR, M. L. L., S. LEATHERWOOD, C. WOOD, M. N. R. ALAVA, C. HILL, AND L. V. ARAGONES. 1994. Directed fisheries for cetaceans in the Philippines. Reports of the International Whaling Commission 44:439–449.
- DUNPHY-DALY, M. M., M. R. HEITHAUS, AND D. E. CLARIDGE. 2008. Temporal variation in dwarf sperm whale (*Kogia sima*) habitat use and group size off Great Abaco Island, Bahamas. Marine Mammal Science 24:171–182.
- ELDRIDGE, L. G. 1991. Annotated checklist of the marine mammals of Micronesia. Micronesica 24:217–230.
- ELDRIDGE, L. G. 2003. The marine reptiles and mammals of Guam. Micronesica 35–36:653–660.
- EVERITT, R. D., C. H. FISCUS, AND R. L. DELONG. 1979. Marine mammals of northern Puget Sound and the Straits of Juan de Fuca: a report on investigations November 1, 1977–October 31, 1978. Final report to the Marine Mammal Division, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Seattle, Washington. ERL MESA-41. U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, Seattle, Washington.
- FRITTS, T. H., A. B. IRVINE, R. D. JENNINGS, L. A. COLLUM, W. HOFFMAN, AND M. A. MCGEHEE. 1983. Turtles, birds, and mammals in the northern Gulf of Mexico and nearby Atlantic waters. FWS/OBS-82/65. U.S. Fish and Wildlife Service, Division of Biological Services, Washington, D.C.
- GEISE, L., AND M. BOROBIA. 1987. New Brazilian records for *Kogia*, *Pontoporia*, *Grampus* and *Sotalia* (Cetacea, Physeteridae, Platanistidae and Delphinidae). Journal of Mammalogy 68:873–875.
- GILL, T. 1871. The sperm whales, giant and pygmy. American Naturalist 4:723–743, figs. 164–176.
- GRAY, J. E. 1846. On the cetaceous animals. Pp. 13–53 in The zoology of the voyage of *H. M. S. Erebus* and *Terror* under the command of Captain Sir James Clark Ross, R. N., F. R. S., during the years 1839 to 1843 (J. Richardson and J. E. Gray, eds.). Vol. 1, pt. 3 (Mammals). Longman, Brown, Green, and Longmans, London, United Kingdom.
- GRAY, J. E. 1866. Catalogue of seals and whales in the British Museum. British Museum (Natural History), London, Great Britain.
- GRÉTARSDÓTTIR, S., AND U. ÁRNASON. 1993. Molecular studies on two variant repeat types of the common cetacean DNA satellite of the sperm whale and the relationship between Physeteridae (sperm whales) and Ziphiidae (beaked whales). Molecular Biology and Evolution 10:306–318.
- GUNTHER, G., C. L. HUBBS, AND M. A. BEAL. 1955. Records of *Kogia breviceps* from Texas, with remarks on movements and distribution. Journal of Mammalogy 36:263–270.
- HAAST, J. 1873. On the occurrence of a new species of *Euphysetes* (*E. pottsii*), a remarkably small catodont whale, on the coast of New Zealand. Transactions and Proceedings of the New Zealand Institute 6:97–102, pl. 15.
- HAGEY, L. R., D. K. ODELL, S. S. ROSSI, D. L. CROMBIE, AND A. F. HOFMANN. 1993. Biliary bile acid composition of the Physeteridae (sperm whales). Marine Mammal Science 9:23–33.
- HALE, H. M. 1962. The pigmy sperm whale (*Kogia breviceps*) on South Australian coasts, part III. Records of the South Australian Museum 14:197–230.
- HALE, H. M. 1963. Young female pigmy sperm whale (*Kogia breviceps*) from Western and South Australia. Records of the South Australia Museum 14:561–577.
- HANDLEY, C. O., JR. 1966. A synopsis of the genus *Kogia* (pygmy sperm whale). Pp. 62–69 in Whales, dolphins and porpoises (K. S. Norris, ed.). University of California Press, Berkeley.
- HARRISON, T., AND G. JAMUTH. 1958. Pigmy sperm whale (*Kogia breviceps*) in Borneo. Nature 182:543.
- HEINTZELMAN, D. S. 1981. Pygmy sperm whale *Kogia breviceps*. Pp. 20–21 in A world guide to whales, dolphins, and porpoises. Winchester Press, Tulsa, Oklahoma.
- HUBBS, C. 1951. Eastern Pacific records and general distribution of the pygmy sperm whale. Journal of Mammalogy 32:403–410.
- HUCKSTADT, L. A. 2005. New records of cetaceans for the VIII region, Chile (1997 to 1999). Gayana 69:291–299.
- HUCKSTADT, L. A., AND T. ANTEZANA. 2001. An observation of parturition in a stranded *Kogia breviceps*. Marine Mammal Science 17:362–365.
- HYSMITH, B. T., R. L. COLURA, AND J. C. KANA. 1976. Beaching of a live pygmy sperm whale (*Kogia breviceps*) at Port O'Connor, Texas. Southwestern Naturalist 21:409.
- JEFFERSON, T. A., AND A. J. SHIRO. 1997. Distribution of cetaceans in the offshore Gulf of Mexico. Mammal Review 27:27–50.
- JENNESS, R., AND D. K. ODELL. 1978. Composition of milk of pygmy sperm whale (*Kogia breviceps*). Comparative Biochemistry and Physiology A. Comparative Physiology 61:383–386.
- KAROL, R., C. LITCHFIELD, D. K. CALDWELL, AND M. C. CALDWELL. 1978. Compositional topography of melon and spermaceti organ lipids in the pygmy sperm whale *Kogia breviceps*: implications for echolocation. Marine Biology 47:115–123.
- KAZAR, E. 2002. Revised phylogeny of the Physeteridae (Mammalia: Cetacea) in light of Placoziphius Van Beneden, 1869 and Aulophyseter Kellogg, 1927. Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Sciences de la Terre 72:151–170.
- KELLOGG, R. 1929. A new fossil toothed whale from Florida. American Museum Novitates 389:1–10.
- KERNAN, J. D., JR., AND H. VON W. SCHULTE. 1918. Memorandum upon the anatomy of the upper respiratory tract, foregut, and thoracic viscera of *Kogia breviceps*. Bulletin of the American Museum of Natural History 38:231–268.
- KING, C. A. 1987. Organochlorides in bottlenose dolphins (*Tursiops truncatus*) and pygmy sperm whales (*Kogia breviceps*) from southeastern Florida. M.S. thesis, University of Miami, Miami, Florida.
- KREFFT, G. 1865. Notice of a new species of sperm whale belonging to the genus *Euphysetes* of MacLeay. Proceedings of the Zoological Society of London 1865:708–713.
- LEATHERWOOD, S., AND R. R. REEVES. 1989. Marine mammal research and conservation in Sri Lanka, 1985–1986. Marine Mammal Technical Report 1. United Nations Environment Programme, Nairobi, Kenya.
- LEATHERWOOD, S., R. REEVES, AND L. FOSTER. 1983. Pp. 90–93 in The Sierra Club handbook of whales and dolphins. Part III, section 4. Sierra Club Books, San Francisco, California.
- LEATHERWOOD, S. H., R. R. REEVES, W. PERRIN, AND W. EVANS. 1988. Bottlenose dolphin, pygmy sperm whale, dwarf sperm whale. Pp. 193–200 in Whales, dolphins and porpoises of the eastern North Pacific and adjacent arctic waters (S. H. Leatherwood, R. R. Reeves, W. Perrin, and W. Evans, eds.). Dover Publications, New York.
- LENFANT, C. 1969. Physiological properties of blood of marine mammals. Pp. 95–116 in The biology of marine mammals (H. T. Anderson, ed.). Academic Press, San Diego, California.
- LONG, D. J. 1991. Apparent predation by a white shark *Carcharodon carcharias* on a pygmy sperm whale *Kogia breviceps*. Fishery Bulletin 89:538–540.
- MACLEOD, C. D., N. HAUSER, AND H. PECKHAM. 2004. Diversity, relative density and structure of the cetacean community in summer months east of Great Abaco, Bahamas. Journal of the Marine Biological Association of the United Kingdom 84:469–474.
- MANIRE, C. A., H. L. RHEINHARDT, N. B. BARROS, L. BYRD, AND P. CUNNINGHAM-SMITH. 2004. An approach to the rehabilitation of *Kogia* sp. Aquatic Mammals 30:209–219.
- MARINO, L., K. SUDHEIMER, D. A. PABST, W. McLELLAN, AND J. JOHNSON. 2003. Magnetic resonance images of the brain of a dwarf sperm whale (*Kogia sima*). Journal of Anatomy 203:57–76.
- MARTEN, K. 2000. Ultrasonic analysis of pygmy sperm whale (*Kogia breviceps*) and Hubbs' beaked whale (*Mesoplodon carlhubbsi*) clicks. Aquatic Mammals 26:45–48.
- MARTINS, H. R., M. R. CLARKE, F. REINER, AND R. S. SANTOS. 1985. A pygmy sperm whale, *Kogia breviceps* (Blainville, 1838) (Cetacea: Odontoceti) stranded on Fail Island, Azores, with notes on cephalopod beaks in stomach. Arquipelago, Serie Ciencia da Natureza 6:63–70.
- MCALPINE, D. F. 2002. Pygmy and dwarf sperm whales: *Kogia breviceps* and *K. sima*. Pp. 1007–1009 in Encyclopedia of marine

- mammals (W. F. Perrin, B. Würsig, and J. G. M. Thewissen, eds.). Academic Press, San Diego, California.
- MCALPINE, D. F., L. MURISON, AND E. HOBERG. 1997. New records for the pygmy sperm whale *Kogia breviceps* (Physeteridae) from Atlantic Canada with notes on diet and parasites. *Marine Mammal Science* 13:701–704.
- MEASURES, L. N., B. ROBERGE, AND R. SEARS. 2004. Stranding of a pygmy sperm whale, *Kogia breviceps*, in the northern Gulf of St. Lawrence, Canada. *Canadian Field-Naturalist* 118:495–498.
- MILINKOVITCH, M. C., A. MEYER, AND J. R. POWELL. 1994. Phylogeny of all major groups of cetaceans based on DNA sequences from three mitochondrial genes. *Molecular Biology and Evolution* 11: 939–948.
- MORIN, P. A., A. NESTLER, N. T. RUBIO-CISNEROS, K. M. ROBERTSON, AND S. L. MESNICK. 2005. Interfamilial characterization of a region of the ZFX and ZFY gene facilitates sex determination in cetaceans and other mammals. *Molecular Ecology* 14:3275–3286.
- MULLIN, K., W. HOGGARD, C. RODEN, R. LOHOEFER, C. ROGERS, AND B. TAGGERT. 1994. Cetaceans of the upper continental slope in the north-central Gulf of Mexico. *Fisheries Bulletin* 92:773–786.
- MUÑOZ-HINCAPIÉ, M. F., D. M. MORA-PINTO, D. M. PALACIOS, E. R. SECCHI, AND A. A. MIGNUCCI-GIANNONI. 1998. First osteological record of the dwarf sperm whale in Columbia, with notes on the zoogeography of *Kogia* in South America. *Revista de la Academia Colombiana de Ciencias* 22:433–444.
- NAGORSEN, D. W. 1985. *Kogia simus*. *Mammalian Species* 239:1–6.
- NELSON, D., A. DESBROSSE, J. LIEN, P. OSTRUM, AND R. SETON. 1991. A new stranding record of the pygmy sperm whale, *Kogia breviceps*, in waters off eastern Canada. *Canadian Field-Naturalist* 105: 407–408.
- NESS, A. R. 1967. A measure of asymmetry of the skulls of odontocetes whales. *Journal of Zoology* (London) 153:209–221.
- [NMFS] NATIONAL MARINE FISHERIES SERVICE. 2006. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments—2005. NOAA Technical Memorandum NMFS-NE-194:1–358.
- OMURA, H., M. SHIRAKIHARA, AND H. ITO. 1984. A pygmy sperm whale accidentally taken by drift net in the North Pacific. *Scientific Reports of the Whales Research Institute, Tokyo* 35:183–193.
- OMURA, H., AND Y. TAKAHASHI. 1981. A pygmy sperm whale stranded at Tokaimura, Ibaragi, Japan. *Scientific Reports of the Whales Research Institute, Tokyo* 33:119–124.
- OSBOURNE, R. W., AND T. W. RANSOM. 1988. Two rare strandings in Washington state. *Cetus* 8:24–25.
- OWEN, R. 1865. On some Indian Cetacea collected by Walter Elliott, Esquire. *Transactions of the Zoological Society of London* 6: 17–47.
- PILLERI, G. 1986. Pygmy sperm whales (*Kogia*) in the Italian Pliocene. *Investigations on Cetacea* 18:133–153.
- PILLERI, G., AND F. CIGALA-FULGOSI. 1989. Additional observations on the Lower Serravallian marine mammal fauna of Visiano and the Stirone River (northern Apennines). *Contributions to the Paleontology of Some Tethyan Cetacea and Sirenia* (Mammalia) II:63–83.
- PLÓN, S. 2004. The status and natural history of pygmy (*Kogia breviceps*) and dwarf (*Kogia sima*) sperm whales off southern Africa. Ph.D. dissertation, Rhodes University, Grahamstown, South Africa.
- POYNTON, S. L., B. R. WHITAKER, AND A. B. HEINRICH. 2001. A novel trypanoplasm-like flagellate *Jarrellia atramenti* n.g., n.sp. (Kinetoplastida: Bodonidae) and ciliates from the blowhole of a stranded pygmy sperm whale *Kogia breviceps* (Physeteridae): morphology, life cycle and potential pathogenicity. *Diseases of Aquatic Organisms* 44:191–201.
- RAUN, G. G., H. D. HOESE, AND F. MOSELEY. 1970. Pygmy sperm whales, genus *Kogia*, on the Texas coast. *Texas Journal of Science* 21:269–274.
- RICE, D. W. 1998. Marine mammals of the world: systematics and distribution. Society for Marine Mammalogy Special Publication 4:84.
- RICE, D. W., AND A. A. WOLMAN. 1990. The stomach of *Kogia breviceps*. *Journal of Mammalogy* 71:237–242.
- RIDGWAY, S. H., AND D. A. CARDER. 2001. Assessing hearing and sound production in cetaceans not available for behavioral audiograms: experiences with sperm, pygmy sperm, and gray whales. *Aquatic Mammals* 27:267–276.
- ROEST, A. I. 1970. *Kogia simus* and other cetaceans from San Luis Obispo County, California. *Journal of Mammalogy* 51:410–417.
- ROSS, G. J. B. 1979. Records of pygmy and dwarf sperm whales, genus *Kogia*, from southern Africa, with biological notes and some comparisons. *Annals of the Cape Provincial Museums (Natural History)* 11:259–327.
- ROSS, G. J. B. 1984. The smaller cetacea of the south east coast of southern Africa. *Annals of the Cape Provincial Museums (Natural History)* 15:173–411.
- RUIZ, G. M. 1993. Male reproductive anatomy of the pygmy sperm whale, *Kogia breviceps*, and the dwarf sperm whale, *Kogia simus*, based on gross and histological observations. M.S. thesis, University of South Florida, Tampa.
- SANINO, G. P., AND J. YANEZ. 1997. Estudios sobre un cachalote pigmeo, *Kogia breviceps* (de Blainville, 1838), varado en la costa de Chile. *Boletín del Museo Nacional de Historia Natural Chile* 46: 81–93.
- SANTOS, M. B., G. J. PIERCE, A. LÓPEZ, R. J. REID, V. RIDOUX, AND E. MENTE. 2006. Pygmy sperm whales *Kogia breviceps* in the northeast Atlantic: new information on stomach contents and strandings. *Marine Mammal Science* 23:600–616.
- SCHENKKAN, E. J., AND P. E. PURVES. 1973. The comparative anatomy of the nasal tract and the function of the spermaceti organ in the Physeteridae (Mammalia, Odontoceti). *Bijdragen tot de Dierkunde* 43:93–112.
- SCHULTE, H. VON W. 1917. The skull of *Kogia breviceps* Blainville. *Bulletin of the American Museum of Natural History* 37:361–404.
- SCHULTE, H. VON W., AND M. F. SMITH. 1918. The external characters, skeletal muscles, and peripheral nerves of *Kogia breviceps* (Blainville). *Bulletin of the American Museum of Natural History* 38:7–72.
- SCOTT, M. D., AND J. G. CORDARO. 1987. Behavioral observations of the dwarf sperm whale, *Kogia simus*. *Marine Mammal Science* 3: 353–354.
- SCOTT, M. D., A. A. HOHN, A. J. WESTGATE, J. R. NICOLAS, B. R. WHITAKER, AND W. B. CAMPBELL. 2001. A note on the release and tracking of a rehabilitated pygmy sperm whale (*Kogia breviceps*). *Journal of Cetacean Research and Management* 31:87–94.
- SECCHI, E. R., M. B. CAMPOLIM, AND L. MOLLER. 1994. Notas sobre o encalhe de dois cachalotes pigmeus *Kogia breviceps* NA costa sul do Rio Grande do Sul—Brasil. Pp. 244–262 in *Anais, IV Reunión de Especialistas en Mamíferos Acuáticos de América del Sur*. Valdivia, Chile.
- SMITH, M. R., M. S. SHIVJI, V. G. WADDELL, AND M. J. STANHOPE. 1996. Phylogenetic evidence from the IRBP gene for the paraphyly of toothed whales, with mixed support for Cetacea as a suborder of Artiodactyla. *Molecular Biology and Evolution* 13:918–922.
- STAMPER, M. A., B. R. WHITAKER, AND T. D. SCHOFIELD. 2006. Case study: morbidity in a pygmy sperm whale *Kogia breviceps* due to ocean-borne plastic. *Marine Mammal Science* 22: 719–722.
- SYLVESTRE, J. P. 1983. Review of *Kogia* specimens (Physeteridae, Kogiinae) kept alive in captivity. *Investigations on Cetacea* 15: 201–219.
- SYLVESTRE, J. P. 1988. On a specimen of pygmy sperm whale *Kogia breviceps* (Blainville, 1838) from New Caledonia. *Aquatic Mammals* 14:76–77.
- TARPLEY, R. J., AND S. MARWITZ. 1993. Plastic debris ingestion by cetaceans along the Texas coast: two case reports. *Aquatic Mammals* 19:93–98.
- THOMAS, J. A., P. W. B. MOORE, P. E. NACHTIGALL, AND W. G. GILMARTIN. 1990. A new sound from a stranded pygmy sperm whale. *Aquatic Mammals* 16:28–30.
- TOMILIN, A. G. 1957. *Cetacea* (V. G. Heptner, ed.), Translation from Russian original by Israel Program for Scientific Translations, Jerusalem, Israel, 1967.
- TRUE, F. W. 1884. Great international fisheries expedition, London, 1883: United States of America: H. Catalogue of the aquatic animals exhibited by the United States National Museum. *Bulletin of the United States National Museum* 27:623–644.

- VAN CANNEYT, O., W. DABIN, AND A. COLLET. 1998. Synthèse sur les mammifères marins échoués sur le littoral Français de 1992 à 1996. Direction de la Nature et des Paysages, Paris, France.
- VAN WAEREBEEK, K., J. C. REYES, AND B. A. LUSCOMBE. 1987. A second record of the pygmy sperm whale *Kogia breviceps* (de Blainville, 1838) (Cetacea, Physeteridae) from the Peruvian coast. *Zeitschrift für Säugetierkunde* 52:192–194.
- VIDAL, O., L. FINDLEY, P. TURK, AND R. BOYER. 1987. Recent records of pygmy sperm whales in the Gulf of California, Mexico. *Marine Mammal Science* 3:354–356.
- VIDAL, O., K. VAN WEAREBEEK, AND L. T. FINDLEY. 1990. Cetaceans and gillnet fisheries in Mexico, Central America and the Caribbean: a preliminary review. Report of the International Whaling Commission 15:221–233.
- WADE, P. R., AND T. GERRODETTE. 1993. Estimates of cetacean abundance and distribution in the eastern tropical Pacific. Reports of the International Whaling Commission 43:477–493.
- WALL, W. 1851. History and description of the skeleton of a new sperm-whale lately set up in the Australian Museum, together with some account of a new genus of sperm whale called *Euphysetes*. W. R. Piddington, Sydney, Australia.
- WANG, M. C., W. A. WALKER, K. T. SHAO, AND L. S. CHOU. 2002. Comparative analysis of the diets of pygmy sperm whales and dwarf sperm whales in Taiwanese waters. *Acta Zoologica Taiwanica* 13:53–62.
- WILLIS, P. M., AND R. W. BAIRD. 1998. Status of the dwarf sperm whale, *Kogia simus*, with consideration of special reference to Canada. *Canadian Field-Naturalist* 112:114–125.
- WÜRSIG, B., S. K. LYNN, T. A. JEFFERSON, AND K. D. MULLIN. 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. *Aquatic Mammals* 24:41–50.
- WYNNE, K., AND M. SCHWARTZ. 1999. Pygmy sperm whale, dwarf sperm whale. Pp. 28–31 in *Guide to marine mammals and turtles of the U.S. Atlantic and Gulf of Mexico* (K. Wynne and M. Schwartz, eds.). Rhode Island Sea Grant, Narragansett, Rhode Island.
- YAMADA, M. 1954. Some remarks on the pygmy sperm whale, *Kogia*. *Scientific Reports of the Whales Research Institute, Tokyo* 9: 37–61.
- YANG, W., P. PANG, C. JENG, L. CHOU, AND L. CHUEH. 2006. Morbilliviral infection in a pygmy sperm whale (*Kogia breviceps*) from Taiwanese waters. *Veterinary Microbiology* 116:69–76.
- YEUNG, C. 2001. Estimates of marine mammal and marine turtle bycatch by the U.S. Atlantic pelagic longline fishing fleet in 1999–2000. National Oceanic and Atmospheric Administration Technical Memorandum NMFS-SEFSC 467: 1–43.

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