A DWARF FORM OF KILLER WHALE IN ANTARCTICA

Authors: Pitman, Robert L., Perryman, Wayne L., LeRoi, Don, and Eilers, Erik

Source: Journal of Mammalogy, 88(1) : 43-48

Published By: American Society of Mammalogists

URL: https://doi.org/10.1644/06-MAMM-A-118R1.1

Journal of Mammalogy, 88(1):43–48, 2007

A DWARF FORM OF KILLER WHALE IN ANTARCTICA

Robert L. Pitman,* Wayne L. Perryman, Don LeRoi, and Erik Eilers

NOAA Fisheries, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA (RLP, WLP, EE) 5 Myrica Way, Old Lyme, CT 06371, USA (DL)

In the early 1980s, 2 groups of Soviet scientists independently described 1, possibly 2 new dwarf species of killer whales (*Orcinus*) from Antarctica. We used aerial photogrammetry to determine total length (TL) of 221 individual Type C killer whales—a fish-eating ecotype that inhabits dense pack ice—in the southern Ross Sea in January 2005. We confirmed it as one of the smallest killer whales known: TL of adult females (with calves) averaged 5.2 m $\pm$ 0.23 *SD* ($n = 33$); adult males averaged 5.6 $\pm$ 0.32 m ($n = 65$), with the largest measuring 6.1 m. Female Type A killer whales—offshore mammal-eaters—from Soviet whaling data in the Southern Ocean were approximately 1–2 m longer, and males were 2–3 m (up to 50%) longer (maximum length 9.2 m). Killer whale communities from the North Atlantic and in waters around Japan also appear to support both a smaller, inshore, fish-eating form and a larger, offshore, mammal-eating form. We suggest that, at least in Antarctica, this degree of size dimorphism could result in reproductive isolation between sympatric ecotypes, which is consistent with hypotheses of multiple species of killer whales in the Southern Ocean.

Key words: aerial photogrammetry, Antarctica, Cetacea, dwarf form, killer whale, morphometrics, *Orcinus orca*

The familiar killer whale (*Orcinus orca*) is a cosmopolitan species, found in all oceans of the world (Ford 2002). Despite being the most widespread mammal in the world, only 1 species is currently recognized (Rice 1998). However, in 1981, Soviet researchers proposed a new species of killer whale, *Orcinus nanus*, based on samples from 321 whales taken by Soviet whalers in the Southern Ocean (mainly Antarctica) during 1961–1978 (Mikhalev et al. 1981). Unfortunately, other than body lengths, no diagnostic details were provided and no holotype specimen was designated; as a result, *O. nanus* is considered a nomen nudem (International Whaling Commission 1982; Rice 1998).

One year later, in 1982, another team of Soviet researchers independently described another new species of killer whale from Antarctica, *Orcinus glacialis* (Berzin and Vladimirov 1982, 1983). This species also was based on Soviet whaling catches, but only from a single season, 1979–1980, when a total of 906 killer whales was taken in Antarctic waters between 60°E and 140°E (Ivashin 1981). Berzin and Vladimirov (1983) provided a fair amount of descriptive detail and deposited a holotype and 5 paratype specimens with the Pacific Institute of Fisheries and Oceanography (TIRO-Center) in Vladivostok, Russia, but these specimens were apparently all discarded after they were damaged in a storm that flooded the museum (R. Brownell, pers. comm.).

Because of this lack of holotype specimens and generally poor descriptions, the possibility of additional species of killer whales in Antarctica has received little mention and no support from the scientific community of cetacean biologists (e.g., Dahlheim and Heyning 1999; Rice 1998).

Recently, Pitman and Ensor (2003) described 3 ecotypes of killer whales from Antarctica based on field observations and photographs, which they designated types A, B, and C. Type A appears to be a ''regular'' killer whale: a large, black and white form with a medium-sized white eye patch. It inhabits open water in Antarctica and apparently feeds mainly on Antarctic minke whales (*Balaenoptera bonaerensis*). Type B is a gray, black, and white form with a dorsal cape and a very large white eye patch; it inhabits loose pack ice and appears to specialize in feeding on pinnipeds. Type C also is a gray, black, and white form with a dorsal cape, but it has a narrow, slanted eye patch; it lives in dense pack ice and apparently eats mainly fish. Based on consistent differences in morphology and ecology, and a lack of evidence for interbreeding among these at least partially sympatric forms, it was suggested that types B, C, or both may represent new species of killer whales (Pitman and Ensor 2003).

Unfortunately, it may never be possible to refer either of the species of killer whale proposed by the Soviet researchers to the forms described by Pitman and Ensor (2003). Part of the problem is that the Soviets worked with specimens on whaling vessels, and their descriptions were based entirely on data on

* *Correspondent: robert.pitman@noaa.gov*

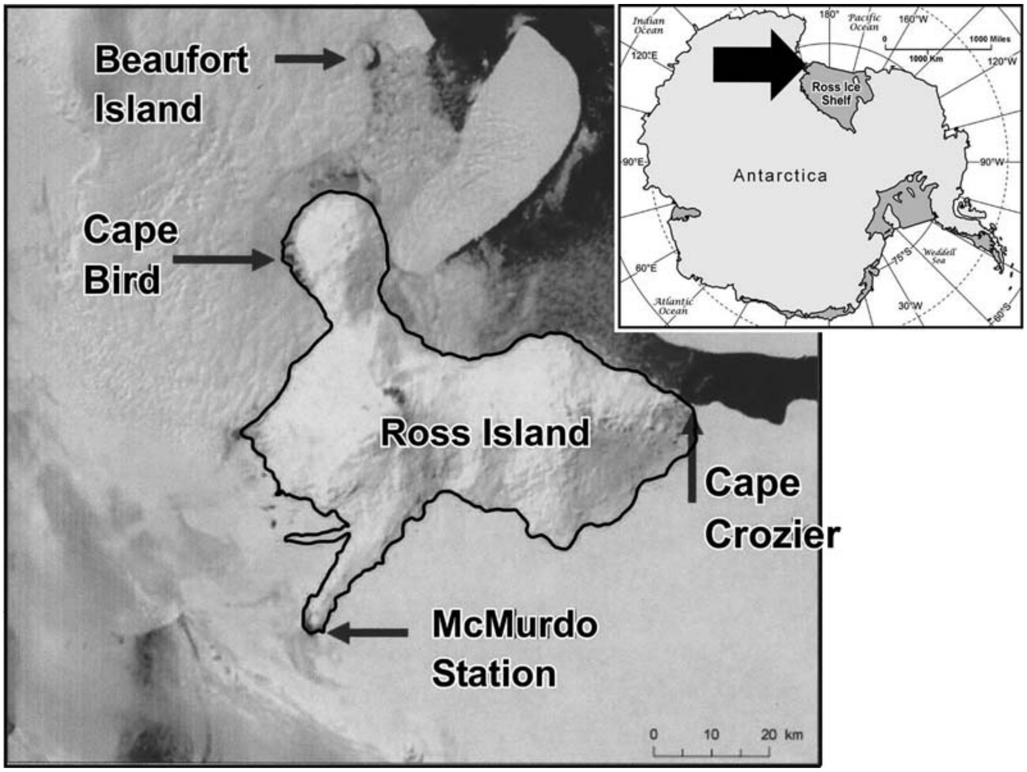

Fig. 1.—The study area: the arrow in the inset indicates the location of Ross Island in the southern Ross Sea, eastern Antarctica. The enlargement shows Ross Island and McMurdo Station, and the areas where we photographed Type C killer whales.

total length (TL) and maturity (Mikhalev et al. 1981), or data on length and maturity combined with osteological measurements and descriptions (Berzin and Vladimirov 1983). Pitman and Ensor (2003), on the other hand, based their distinctions mainly on differences in color patterns of live animals in the field. For *O. nanus*, the lack of descriptive details means that it will never be possible to refer it to either Type B or Type C killer whales, or even to distinguish it from *O. glacialis*.

The possibility of resolving the identity of *O. glacialis* is only slightly better. In the original and subsequent descriptions (Berzin and Vladimirov 1982, 1983) it was characterized as a fish-eater that inhabited pack ice, clearly suggesting a Type C killer whale. But Berzin and Vladimirov (1983) identified only 1 form of killer whale as inhabiting the pack ice; this is significant because the Type B killer whale also inhabits the pack ice and it has a circumpolar distribution in Antarctica (Pitman and Ensor 2003); it was almost certainly taken by the Soviet whalers. Although it is likely that the holotype of *O. glacialis* was a Type C killer whale, it cannot be known with certainty at this time. A final determination will come only after the phylogenetic relationship of types B and C has been resolved, and their physical descriptions (mainly skull characteristics) have been compared with those provided by Berzin and Vladimirov (1983).

What is clear from the Soviet descriptions, however, is that the purported new species was (or were) smaller than regular killer whales: *O. nanus* was reportedly 1–1.5 m shorter (Mikhalev et al. 1981); female *O. glacialis* were on average 0.6 m shorter, and males were 1.1 m shorter than regular killer whales (Berzin and Vladimirov 1983).

Determining whether there are significant differences in body length among the different ecotypes could be important in resolving the systematics of Antarctic killer whales. During January 2005, we obtained in situ body length measurements of Type C killer whales in the southern Ross Sea, Antarctica, using aerial photogrammetry, a method that has previously been used to accurately measure free-swimming cetaceans (Best and Rüther 1992; Perryman and Lynn 1993; Perryman and Westlake 1998). We present here the results of our analyses, and compare our findings with data available on TL of killer whales from the North Pacific, North Atlantic and wider Antarctica.

Materials and Methods

Our study area was the waters adjacent to Ross Island, in the southern Ross Sea, eastern Antarctica (Fig. 1). During the austral summer, Type C killer whales are common around Ross Island, where they occur among the polynyas and pack ice, along leads in the fast ice, and adjacent to the edge of the Ross Ice Shelf (Pitman and Ensor 2003; R. L. Pitman, in litt.). For air support, the National Science Foundation provided use of a United States Coast Guard H65 helicopter based out of McMurdo Station. Flights usually lasted about 2 h; our working altitude was between 150 and 200 m; airspeed was approximately 55 km/h when taking photos. To decrease the possibility of photographing the same animals on different

Table 1.—Date, location at Ross Island, and number of Type C killer whales photographed from the air during January 2005 (see Fig. 1 for locations).

Date (January 2005)	Flight no.	Location	No. whales photographed
14	1	Cape Crozier	0
	2	Cape Crozier	0
	3	Beaufort Island	62
17	1	Cape Crozier	58
	2	Cape Bird	24
19	1	Cape Crozier	10
	2	Cape Crozier	48
20	1	Cape Crozier	5
	2	Beaufort Island	17
	3	Beaufort Island	28
Total	10		252

sorties, we traveled to different areas around Ross Island, including Cape Crozier, Beaufort Island, Cape Bird, and along the Ross Ice Shelf east of Cape Crozier (Fig. 1).

For the photogrammetry, we used a handheld Canon 1D, Mark II, 35 mm digital camera, equipped with a fixed 85 mm, f 1.8 lens (Bob Davis Camera, La Jolla, California). We leaned out the open bay door of the helicopter to take photographs and made repeated passes over individual groups as necessary to obtain useable images of animals at the surface. We used a bubble level on the camera to make sure we were shooting vertically. Our camera and the helicopter's altimeter were wired to a laptop computer, allowing us to record altitude simultaneously with each image acquired. TL (tip of upper jaw to the notch of the flukes) was later measured on a computer screen using the public domain program Image (version 1.32j), available from the National Institutes of Health (Bethesda, Maryland). Lengths measured on the images were converted to true lengths based on the scale of each image (scale = altitude/lens focal length).

Because readings from radar altimeters are typically very precise but can be biased, we calibrated our recorded altimeter readings against altitudes calculated from measurements of known distances between targets we placed on the fast ice. We photographed the targets on a series of helicopter passes at altitudes ranging from 125 to 210 m. Comparisons of recorded altitudes with altitudes calculated from the known target distances on the images indicated that the recorded altitude data were precise and accurate ($r^2 = 0.997$).

We obtained TL measurements for each killer whale that appeared to be swimming parallel to and near the surface. Only images of whales taken in ideal conditions (Beaufort sea state 2 or less) were used in the analyses. Because of the rapid cycle rate of the camera and the replicate passes made on some animals, we often had several measurements of the same whale. We selected the largest TL as the best measurement because the swimming movements of whales tend to make them appear shorter when seen from above. Although we did not have known-sized whales to test the accuracy of our measurements, we could examine the precision of our sampling system by calculating the coefficients of variation (*CV*s) for repeated measurements of the same individual whales. We calculated *CV*s of TL for whales that were measured in at least 3 images and at least 2 separate passes to capture any variance-associated errors in leveling the camera between passes ($n = 14$ individual whales). Average *CV* for TL was 1.9%, which compared favorably with other photogrammetry studies on cetaceans (Angliss et al. 1995; Best and Rüther 1992; Koski et al. 1992; Perryman and Lynn 1993).

Table 2.—Total body length measurements of Type C killer whales from Ross Island, Antarctica, determined by photogrammetry during January 2005.

Age/sex	Sample size (% of total)	Mean length (m) (*SD*)	Minimum length (m)	Maximum length (m)
Calves	26 (12)	2.9 (0.37)	2.1	3.4
Females with calves	33 (15)	5.2 (0.23)	4.6	5.8
Males	64 (29)	5.6 (0.32)	4.9	6.1
Unknown	97 (44)	4.9 (0.57)	3.4	5.9

We identified 4 separate age and sex categories among the whales we measured, based on appearance and proximity to other whales (Ford 2002). Animals with large dorsal fins, conspicuously large pectoral flippers, and convex trailing edge of flukes were identified as adult (or maturing) males. The larger of 2 animals swimming in the typical cow–calf configuration was identified as an adult female and the smaller animal was a calf. All other animals were categorized as unknown sex and age.

Results

We conducted 10 helicopter flights in January 2005, and after working out some technical difficulties during our first 2 flights, we obtained measurable images of killer whales during each of the remaining 8 flights (Table 1). We photographed killer whales at 3 different locations, on 4 separate days, and obtained images of 252 individual animals. The Type C killer whale was easily identified from the air by its distinctive cape and slanted eye patch (Pitman and Ensor 2003), and it was the only form we saw and photographed during our study. Estimated group sizes for the schools we photographed ranged from 20 to 75 animals.

For the 252 individual whales we photographed, images of 220 were of sufficient quality to measure accurately (Table 2). These included 64 males, 33 adult females (with calves), 26 calves, and 97 individuals of unknown age and sex (the latter presumably mainly juveniles and nonbreeding adult females). Females with calves averaged 5.2 m $\pm$ 0.23 *SD* in length and ranged from 4.6 to 5.8 m; males averaged 5.6 $\pm$ 0.32 m and ranged from 4.9 to 6.1 m. Dependent calves averaged 2.9 m and ranged from 2.1 to 3.4 m.

Figure 2 shows a length frequency distribution for all measured animals, broken down by the 4 age and sex categories. Calves became independent of their mothers when their TL was between 3 and 3.5 m, females began calving when they were between 4.5 and 5 m in length, and males began showing secondary sex characteristics (i.e., enlarged flippers and convex flukes) between 4.5 and 5 m. The majority of adult females

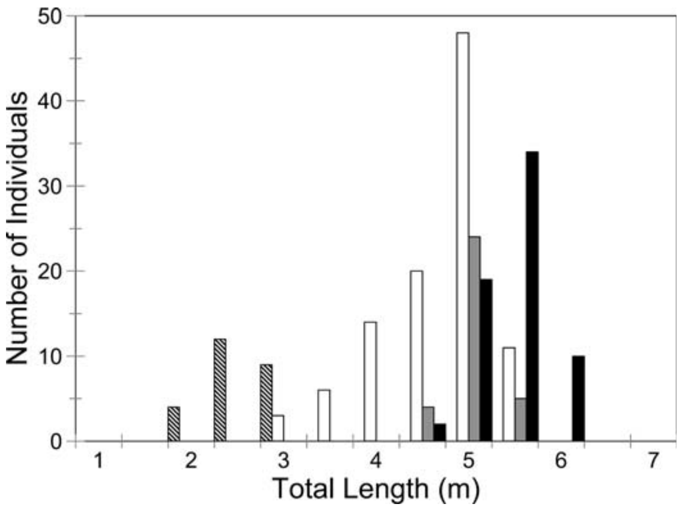

FIG. 2.—Photogrammetric measurements of Type C killer whales from the southern Ross Sea in January 2005; shown are total lengths of calves (hatched, $n = 26$), females with calves (gray, $n = 33$), adult males (black, $n = 64$), and unknowns (white, $n = 97$).

were between 5 and 5.5 m long, and the majority of adult males were between 5.5 and 6 m long.

DISCUSSION

Our results confirm that Type C killer whales represent a population of substantially smaller animals within the community of Antarctic killer whales (Fig. 3a), and that they are even smaller than Soviet researchers indicated. Mikhalev et al. (1981) analyzed a subset of the Soviet whaling data shown in Fig. 3a and reported that among regular (i.e., Type A) killer whales, TL of adult females averaged 6.4 m with a maximum of 7.7 m, and males averaged 7.3 m with a maximum of 9.0 m. This would make Type A females approximately 1–2 m larger, and males 2–3 m (that is, up to 50%) larger than respective Type C killer whales (see "Results"). However, Mikhalev et al. (1981) and Berzin and Vladimirov (1983) reported size differences of only 0.6–1.5 m between their animals and regular killer whales. One explanation for this discrepancy could be that Type B also is smaller than Type A but larger than Type C, and measurements of the 2 smaller forms were pooled in the samples examined by Soviet researchers. Accurate length measurements of Type B killer whales should help clarify this issue.

To put this ecotypic size variation into a broader perspective, we compared our sample from the Ross Sea to samples from the wider Southern Ocean (including mainly Antarctic waters), and the North Pacific and the North Atlantic oceans. The Southern Ocean–Antarctica sample consisted of 1,239 killer whales taken by Soviet whalers between 1961 and 1980 (International Whaling Commission 1982). There were 2 separate samples from the North Atlantic: the 1st included 1,413 killer whales taken by Norwegian whalers throughout much of the eastern and central North Atlantic from 1938 to 1967 (Jonsgård and Lyshoel 1970), and the 2nd included 315 animals taken in Norwegian coastal waters during 1978–1980

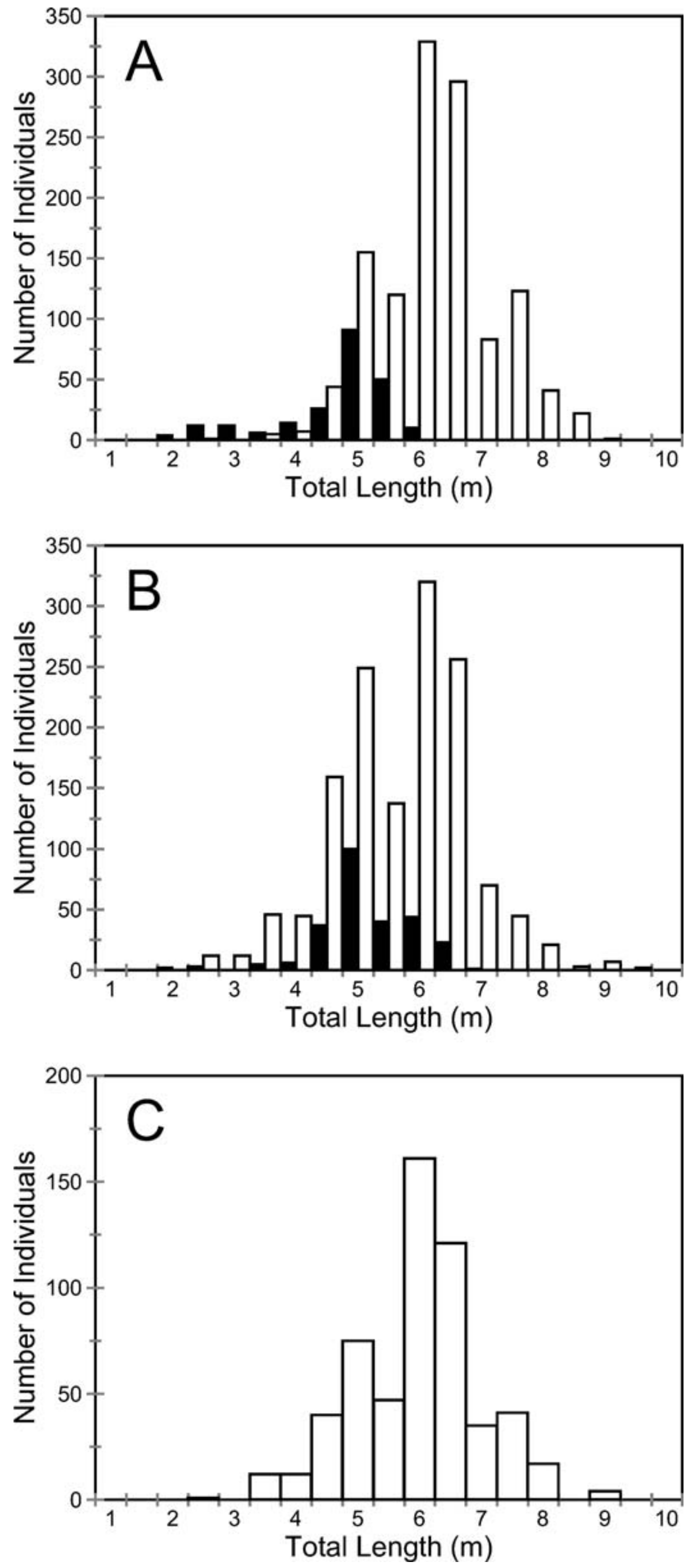

FIG. 3.—Frequency distributions of total lengths of killer whales (all ages and sexes combined) from: A) Soviet Antarctic whaling data (white, $n = 1{,}239$) and Antarctic Type C killer whales (black, $n = 221$); B) North Atlantic/Norway (white, $n = 1{,}413$) and Norway coastal waters (black, $n = 315$); and C) Japan coastal waters ($n = 566$; see "Discussion" for data sources).

(Christensen 1984). The North Pacific sample included 566 whales taken by Japanese whalers in coastal waters of Japan from 1948 to 1957 (Nishiwaki and Handa 1958).

Combined with the TLs from the 221 individuals in our study, this sample represents a total of 3,754 TL measurements of individual killer whales. We have no information on how accurately measurements from the other studies were determined, and in many cases the lengths were known to be only estimates made by whalers (Christensen 1984; Jonsgård and Lyshoel 1970; Nishiwaki and Handa 1958). Also, samples from whaling activities were biased by the fact that whalers inevitably target larger animals, especially adult males (International Whaling Commission 1982; Øien 1988). Nevertheless, a comparison of these data sets can be instructive.

Examination of the data from Soviet researchers in Antarctica (Fig. 3A) shows a strong mode in the 6- to 7-m category and another in the 5- to 5.5-m category, which we suggest represents (at least) 2 different ecotypes. According to Mikhalev et al. (1981) and Berzin and Vladimirov (1983), large numbers of both fish- and mammal-eating killer whales were taken by Soviet whalers, and the larger whales were eating marine mammals (mainly Antarctic minke whales and some pinnipeds). In addition, Berzin and Vladimirov (1983) emphasized that the smaller whales (''*O. glacialis*'') fed almost exclusively on fish, and it is clear in Fig. 3A that the 5- to 5.5-m mode in the Antarctic catch is coincident with Type C killer whales from our study. Based on these considerations, we suggest that the 6- to 7-m mode in the Soviet data represents offshore mammal-eaters (Type A), and the 5- to 5.5-m category corresponds to Type C killer whales. How Type B fits into this scenario is unclear.

Killer whales in the North Atlantic also appear to comprise at least 2 populations of different-sized animals (Fig. 3B). The larger sample came from whales taken throughout much of the North Atlantic, including the nearshore waters of Norway (Jonsgård and Lyshoel 1970). The length frequency distribution of this sample was bimodal with a strong peak in the 6- to 7-m size class and another at 5–5.5 m. Although both fish- and mammal-eaters were included among this sample, Jonsgård and Lyshoel (1970) suggested that larger killer whales were consuming mammals.

During the years 1978–1980, Norwegian whalers specifically targeted fish-eating killer whales in the nearshore waters of Norway (Christensen 1984), and the frequency distribution of TLs from this sample was essentially unimodal in the 5- to 5.5-m size range (Fig. 3B). After noting the size discrepancy between nearshore whales and those from the wider North Atlantic, Christensen (1984:256) stated that the measurements reported by Jonsgård and Lyshoel (1970) appeared to be ''too large for those caught in Norwegian coastal waters.'' It appears that in Norway there also is a smaller, fish-eating ecotype that frequents nearshore waters, and a larger, mammal-eating form that occurs offshore.

The sample from Japan also was bimodal with a strong peak at 6–7 m, and a smaller peak at 5–5.5 m (Fig. 3C). Interestingly, Nishiwaki and Handa (1958:94) reported that although fish were the most common prey among their entire sample, ''larger foods [such] as whales or dolphins can be seen only in the older [i.e., larger] animal.'' Although it is possible that mammals became more important in the diet as the animals grew older and larger, another interpretation is that there is (or was) a smaller, fish-eating ecotype living in close proximity to a larger mammal-eating form in the coastal waters of Japan.

To summarize, based on frequency distributions of total length and (rather limited) information on prey preferences from 3 separate oceans, it appears that killer whale communities may regularly include a smaller, nearshore, fish-eating form with modal length of about 5–5.5 m, and a larger, offshore, mammal-eating form with a modal length of 6–7 m.

The marked size differences reported above have potentially important ecological and phylogenetic implications. As we have seen among Antarctic killer whales, Type A males are up to 3 m larger than Type C males, and perhaps 4 m larger than adult Type C females. These length differences can contribute to an enormous difference in overall size. For example, among regular killer whales, although adult males are on average only 1–2 m longer than females, they can weigh twice as much (Baird 2002; Matkin and Leatherwood 1986).

Although these size differences may represent only morphological variation related to prey specialization and habitat preference, we suggest that the magnitude of this variation by itself could result in reproductive isolation among ecotypes. For example, in Antarctica, the average length of adult Type A females was 6.4 m (Mikhalev et al. 1981), making them 0.8 m longer than the average adult male Type C in our sample. If, as seems likely, sexual selection has driven greatly increased body size in male versus female killer whales (Ralls and Mesnick 2002), then Type A females are not likely to mate with males smaller than they are. Type A males, on the other hand, are 3–4 m longer and presumably several times heavier than adult Type C females, and may be physically incapable of mating with Type C females or might even prey upon them (see Pitman and Ensor 2003).

Systematics of Antarctic killer whales will not be resolved until additional morphological and genetic evidence becomes available. Our findings confirm the presence of at least 1 markedly smaller ecotype, which is consistent with hypotheses that more than 1 species occurs in the Southern Ocean (Berzin and Vladimirov 1983; Mikhalev et al. 1981; Pitman and Ensor 2003).

Acknowledgments

Our research was supported by grants from the National Science Foundation (OPP-0338428) and the United States Marine Mammal Commission. We would also like to thank the United States Coast Guard, especially LCDR G. Matyas, and the Raytheon team at McMurdo Station for the excellent field support. L. Ballance, R. Brownell, W. Perrin, and an anonymous reviewer provided useful comments on an earlier version of the manuscript. J. Walker assisted with Fig. 1.

Literature Cited

Angliss, R. P., D. J. Rugh, D. E. Withrow, and R. C. Hobbs. 1995. Evaluations of aerial photogrammetric length measurements of the Bering–Chukchi–Beaufort Seas stock of bowhead whales (*Balaena* *mysticetus*). Report of the International Whaling Commission 45: 313–324.

BAIRD, R. W. 2002. Killer whales of the world; natural history and conservation. Voyageur Press, Stillwater, Minnesota.

BERZIN, A. A., AND V. L. VLADIMIROV. 1982. Novyi vid kosatok iz Antarktiki. Priroda 6:31–32.

BERZIN, A. A., AND V. L. VLADIMIROV. 1983. Novyi vid kosatku (Cetacea, Delphinidae) iz vod Antarktiki. Zoologicheskiy Zhurnal 62:287–295.

BEST, P. B., AND H. RÜTHER. 1992. Aerial photogrammetry of southern right whales, *Eubalaena australis*. Journal of Zoology (London) 228:595–614.

CHRISTENSEN, I. 1984. Growth and reproduction of killer whales, *Orcinus orca*, in Norwegian coastal waters. Report of the International Whaling Commission, Special Issue 6:253–258.

DAHLHEIM, M. E., AND J. E. HEYNING. 1999. Killer whale *Orcinus orca* (Linnaeus, 1758). Pp. 281–322 in Handbook of marine mammals. Vol. 6 (S. H. Ridgway and R. J. Harrison, eds.). Academic Press, London, United Kingdom.

FORD, J. K. B. 2002. Killer whale *Orcinus orca*. Pp. 669–676 in Encyclopedia of marine mammals (W. F. Perrin, B. Würsig, and J. G. M. Thewissen, eds.). Academic Press, San Diego, California.

INTERNATIONAL WHALING COMMISSION. 1982. Report of the workshop on identity, structure and vital rates of killer whale populations, Cambridge, England, June 23–25, 1981. Report of the International Whaling Commission 32:617–631.

IVASHIN, M. V. 1981. USSR: progress report on cetacean research—June 1979–May 1980. Report of the International Whaling Commission 31:221–228.

JONSGÅRD, Å., AND P. B. LYSHOEL. 1970. A contribution to the knowledge of the biology of the killer whale (*Orcinus orca*) (L.). Nytt Magasin for Zoologi 18:41–48.

KOSKI, W. R., R. A. DAVIS, G. W. MILLER, AND D. E. WITHROW. 1992. Growth rates of bowhead whales as determined from low-level aerial photogrammetry. Report of the International Whaling Commission 42:491–499.

MATKIN, C. O., AND S. LEATHERWOOD. 1986. General biology of the killer whale, *Orcinus orca*: a synopsis of knowledge. Pp. 35–68 in Behavioral biology of killer whales (B. C. Kirkevold and J. S. Lockard, eds.). Alan R. Liss, Inc., New York.

MIKHALEV, Y. A., M. V. IVASHIN, V. P. SAVUSIN, AND F. E. ZELENAYA. 1981. The distribution and biology of killer whales in the Southern Hemisphere. Report of the International Whaling Commission 31: 551–566.

NISHIWAKI, M., AND C. HANDA. 1958. Killer whales caught in the coastal waters off Japan for recent 10 years. Scientific Reports of the Whales Research Institute 13:85–96.

ØIEN, N. 1988. The distribution of killer whales (*Orcinus orca*) in the North Atlantic based on Norwegian catches, 1938–1981, and incidental sightings, 1967–1987. Rit Fiskideildar 11:65–78.

PERRYMAN, W. L., AND M. S. LYNN. 1993. Identification of geographic forms of common dolphin (*Delphinus delphis*) from aerial photogrammetry. Marine Mammal Science 9:119–137.

PERRYMAN, W. L., AND R. L. WESTLAKE. 1998. A new geographic form of the spinner dolphin, *Stenella longirostris*, detected with aerial photogrammetry. Marine Mammal Science 14:38–50.

PITMAN, R. L., AND P. ENSOR. 2003. Three forms of killer whales in Antarctic waters. Journal of Cetacean Research and Management 5:131–139.

RALLS, K., AND S. L. MESNICK. 2002. Sexual dimorphism. Pp. 1071–1078 in Encyclopedia of marine mammals (W. F. Perrin, B. Würsig, and J. G. M. Thewissen, eds.). Academic Press, San Diego, California.

RICE, D. W. 1998. Marine mammals of the world: systematics and distribution. Special Publication 4, Society for Marine Mammalogy, Lawrence, Kansas.

Submitted 11 April 2006. Accepted 3 July 2006.

Associate Editor was Eric A. Rickart.