

- Issue 6: Reproduction of Whales, Dolphins and Porpoises, pp. 311–335. International Whaling Commission, Cambridge.
- McCann, T.S., Fedak, M.A., and Harwood, J. (1989). Parental investment in southern elephant seals. *Mirounga leonina*. *Behav. Ecol. Sociobiol.* **25**, 81–87.
- Overstrom, N.A. (1983). Association between burst-pulse sounds and aggressive behavior in captive Atlantic bottlenosed dolphins (*Tursiops truncatus*). *Zoo. Biol.* **2**, 93–103.
- Rendell, L.E., and Whitehead, H. (2003). Vocal clans in sperm whales (*Physeter macrocephalus*). *Proc. R. Soc. London B* **270**, 225–231.
- Simon, M., Johnson, M., Tyack, P., and Madsen, P.T. (2009). Behaviour and kinematics of continuous ram filtration in bowhead whales (*Balaena mysticetus*). *Proc. R. Soc. B* **276**, 3819–3828.
- Smith, J.N., Goldizen, A.W., Dunlop, R.A., and Noad, M.J. (2008). Songs of male humpback whales, *Megaptera novaeangliae*, are involved in intersexual interactions. *Anim. Behav.* **76**, 467–477.
- Tyack, P.L. (1986). Population biology, social behavior and communication in whales and dolphins. *Trends Ecol. Evol.* **1**, 144–150.
- Whitehead, H. (1990). Rules for roving males. *J. Theor. Biol.* **145**, 355–368.
- Whitehead, H. (2003). *Sperm Whales: Social Evolution in the Ocean*. University of Chicago Press, Chicago.

## BELUGA WHALE

### *Delphinapterus leucas*

GREGORY M. O’CORRY-CROWE

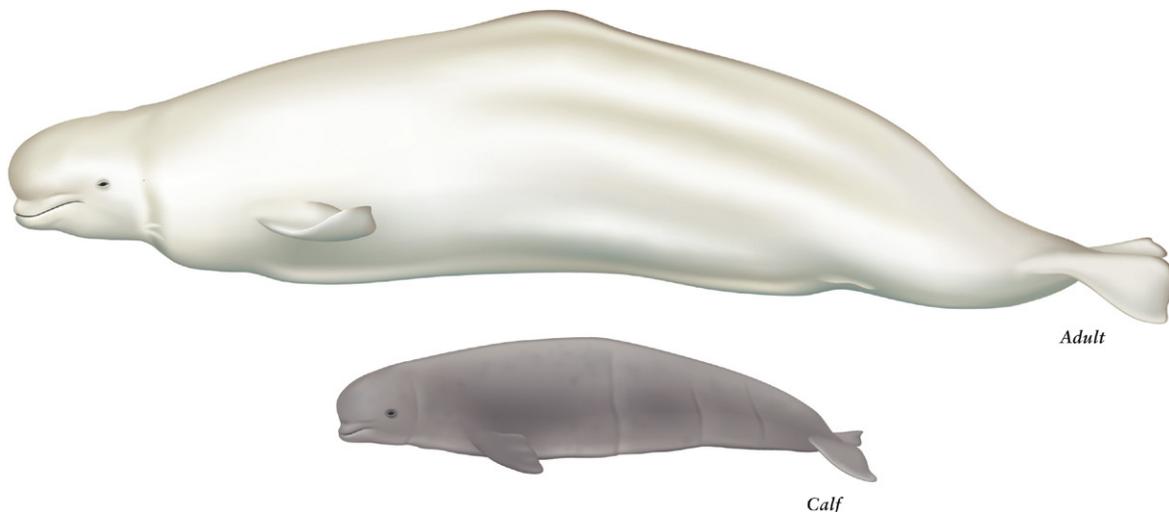
The beluga whale is a member of the Monodontidae, an odontocete cetacean family in the order Cetartiodactyla. Its name, a derivation of the Russian “beloye,” meaning “white,” captures the species most distinctive feature, the pure white color of adults (Fig. 1). This whale is often simply referred to as the white whale in many countries, as well as several other aboriginal names across the north including Sisuaq by the Inupiat and Kooyedee by the Tlingit. The scientific name *Delphinapterus leucas* means “the white dolphin without a wing,” which refers to its lack of a dorsal fin.

### I. Characteristics and Taxonomy

The beluga whale is one of two extant monodontid whales; the other is the narwhal, *Monodon monoceros*. The earliest fossil record of the monodontids is of an extinct beluga *Denebola brachycephala* from late Miocene deposits in Baja California, Mexico, indicating that this family once occupied temperate ecozones. Recent phylogenetic studies contend that the Monodontidae emerged some 10.4–14.5 million years ago (Hassanin et al., 2012).

The beluga whale is a medium-sized toothed whale, 3.5–5.5 m in length and weighing up to 1500 kg. Males are up to 25% longer than females and have a more robust build. This species lacks a dorsal fin and is unusual among cetaceans in having unfused cervical vertebrae allowing lateral flexibility of the head and neck. They possess a maximum of 40 homodont peg-like teeth, which become worn with age. Recent studies have found that beluga whales live much longer than previously thought. Levels of the radioisotope  $^{14}\text{C}$  rose sharply in the marine environment in the late 1950s because of nuclear bomb testing, and researchers were able to detect this increase in growth layers in beluga teeth. Using this increase as a reference point they determined that beluga whales lay down only one growth layer group a year, rather than two (Stewart et al., 2006). As well as doubling the maximum-recorded age from around 40 to 80 years, this discovery has increased the age of first reproduction and necessitated a revision of other life history parameters. Neonates are about 1.6 m in length and are born a creamy-gray color that quickly turns to a dark brown or blue-gray. They become progressively lighter as they grow, changing to gray, light gray, and finally becoming the distinctive pure white by about age 14 in females and 18 in males (Fig. 2) though some females retain shades of gray long into adulthood.

Belugas are adapted to life in cold waters. They possess a thick insulating layer of blubber up to 15-cm thick beneath their skin, and their head, tail, and flippers are relatively small. The absence of a dorsal fin is believed by some to be an adaptation to life in the ice or perhaps this feature was lost as a means to reduce heat loss. In its place, belugas possess a prominent dorsal ridge that is used to break through thin sea ice.



**Figure 1** *Beluga whale*, *Delphinapterus leucas* (Illustrations by Uko Gorter).



**Figure 2** Tail waving behavior by a juvenile beluga whale in a summering group of whales congregating in shallow waters near the Arctic coast. Note the gray coloration of younger animals (Photo by Flip Nicklin/Minden Pictures).

## II. Distribution and Abundance

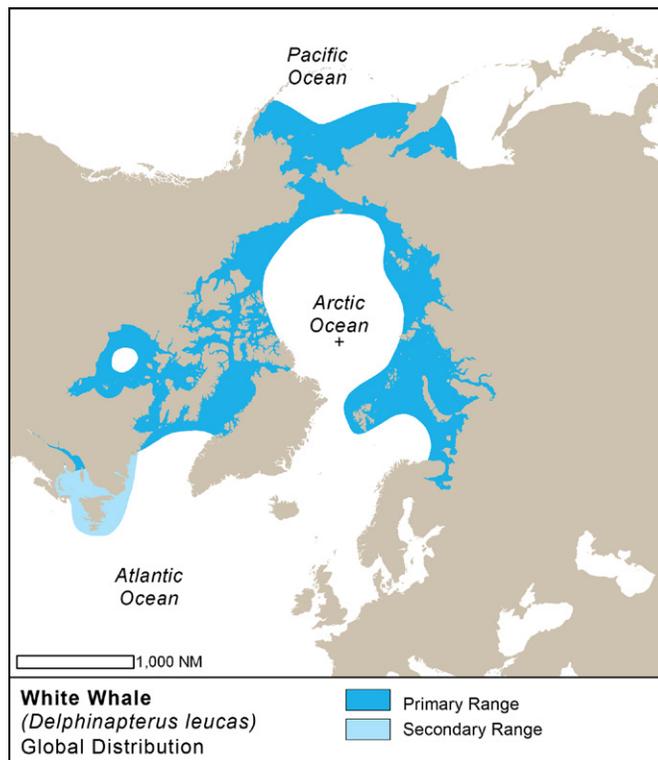
The beluga, or white whale, inhabits the cold waters of the Arctic and subarctic (Fig. 3). Variation in body size across the species range has been taken as evidence of separate populations. Their nonuniform pattern of distribution, and their predictable return to specific coastal areas, further suggests population structure, which has led to summering groups being managed as separate stocks. Resightings of marked or tagged individuals as well as differences in contaminant signatures and geographic variation in vocalizations add support to the independent identification of a number of these stocks.

A number of molecular genetic studies have confirmed that beluga whales tend to return to their natal areas year after year and that dispersal among different summering concentrations is limited, even in cases where there are few geographic barriers (e.g., O’Corry-Crowe et al., 1997) and where interbreeding takes place in their wintering range (Turgeon et al., 2012). These molecular findings reveal that knowledge of migration routes and destinations appears to be passed from mother to offspring, generation after generation.

## III. Ecology

The evolutionary history and ecology of belugas are inextricably linked to the extreme seasonal contrasts of the north and the dynamic nature of sea ice. As well as adaptation to the cold, life in this region has necessitated the evolution of discrete calving and possibly mating seasons, annual migrations in some populations, and a unique feature distinguishing it from most other cetaceans, an annual molt. During the molt belugas rub on the bottom to facilitate the shedding and regeneration of the cork and upper layers of skin (Fig. 2).

When sea ice recedes in spring, most populations shift to their summering grounds, often forming dense concentrations at discrete coastal locations, including river estuaries, shallow inlets, and bays (Fig. 2). Several explanations have been proposed as to why belugas return to these traditional summering areas. In some regions, sheltered coastal waters are warmer, which may aid thermoregulation in neonates. The relatively warm, low-salinity coastal waters may also facilitate molting of dead skin and epidermal regrowth.



**Figure 3** Beluga whale distribution. Map drawn by Anders Skoglund, Norwegian Polar Institute.

Belugas feed on a wide variety of invertebrate and vertebrate prey in benthic and pelagic environments, including crangonid shrimps and Arctic cod, *Boreogadus saida*. In some parts of their range belugas feed in nearshore waters on seasonally abundant anadromous and coastal fish such as salmon, *Oncorhynchus* spp.; herring, *Clupea harengus*; capelin, *Mallotus villosus*; smelt, *Osmerus mordax*; and saffron cod, *Eleginus gracilis* (Quakenbush et al., 2015). The relative importance of the above factors in determining coastal distribution patterns may vary among regions depending on environmental and biological characteristics. It is clear, however, that belugas exhibit some degree of dependence on specific coastal areas.

Resident populations in the subarctic display temporal shifts in the use of discrete habitats that have been linked to foraging, calving, and other behaviors including avoidance of anthropogenic disturbance (Lefebvre et al., 2012). In some Arctic populations, such as that in Svalbard, Norway, white whales are not migratory. They live in coastal waters year-round in this archipelago, concentrating a lot of their foraging time in front of tidal glacier fronts (Lydersen et al., 2001). In many areas of the Arctic, however, belugas leave coastal areas in summer to range widely offshore. Satellite tracking has recorded belugas moving up to 1100km from shore and penetrating 700km into dense polar ice where ice coverage exceeds 90% (Suydam et al., 2001; Fig. 4). How these animals find breathing holes in this environment is still a mystery. Analysis of dive profiles suggests that beluga whales may use sound at depth to find cracks in the ice ceiling overhead. Diving data also indicate that belugas are probably feeding on deep water benthic prey as well as ice-associated species closer to the surface, and may focus foraging efforts along prey-rich hydrographic fronts between different water masses (Martin et al., 1998; Hauser et al., 2015).



**Figure 4** *Beluga whales migrating through fractured sea-ice in the Beaufort Sea (Photo by Vicki Beaver/NOAA-NMFS).*

Little is known about the distribution, ecology, or behavior of beluga whales in winter. In most regions, belugas are believed to migrate in the direction of the advancing polar ice front, and recent telemetry studies suggest that different populations may have discrete wintering as well as summering ranges (Citta et al., 2016). However, in some areas belugas may remain behind this front and overwinter in polynyas and ice leads. In the eastern Canadian Arctic, some belugas overwinter in the North Water, a large polynya that remains open throughout the year in northern Baffin Bay, while in the White, Barents, Kara, and Laptev Seas in Russia belugas may occur year-round, remaining in polynyas in deep water during winter.

Killer whales (*Orcinus orca*), polar bears (*Ursus maritimus*), and humans prey on beluga whales. Belugas sometimes become entrapped in the ice, where large numbers may perish or be hunted intensively by humans.

#### IV. Behavior and Physiology

Belugas can alter the shape of their mouth and melon, enabling them to make an impressive array of facial expressions. The lateral flexibility of the head and neck further enhances visual signaling and enables beluga whales to maneuver in very shallow waters (1–3 m deep) in pursuit of prey, to evade predators, and to generally exploit a habitat rarely used by other cetaceans.

Belugas typically swim in a slow rolling pattern and are rarely given to aerial displays. In nearshore areas, such as Cunningham Inlet on Somerset Island in the Canadian High Arctic, concentrations of belugas sometimes engage in demonstrative behaviors, including spy hopping, tail waving, and tail slapping (Figs 2, 5). When annoyed they can perform quite dramatic jaw-clapping and bubble-blowing displays.

Satellite telemetry studies have confirmed that belugas are capable of covering thousands of kilometers in just a few months, in open water and heavy pack ice alike, while swimming at rates of 2.5–6 km/hr (Lydersen et al., 2001; Suydam et al., 2001). Sensors on satellite transmitters have also recorded belugas regularly diving to depths of 300–600 m, often to the sea floor, and utilizing different oceanographic regimes. In the deep waters beyond the continental shelf, dives can exceed 1000 m, and have durations up to 25 min (Martin et al., 1998).

Belugas are sometimes seen singly, but they usually occur in groups of 2–10 that may aggregate at times to form herds of several hundred to more than a thousand animals. Adult males often form

separate pods of 6–20 individuals. Adult females form tight associations with newborns and sometimes a larger juvenile, presumably an older calf. These “triads” may join similar groupings to form large nursery groups. At certain times of the year, age and sex segregation may be more dramatic than at others with males migrating ahead of, or feeding apart from females, young, and immature. In general, group structure appears to be fluid, with individuals readily forming and breaking brief associations with other whales. Apart from cow-calf pairs there appear to be few stable associations, although a recent study found groups of related whales migrating together (Colbeck et al., 2013). However, considering the diverse vocal repertoire of beluga whales including individual signature calls, their wide array of facial expressions, and the variety of interactive behaviors they perform, as well as the numerous accounts of cooperative behavior, this species appears capable of forming complex societies where group members may not always be in close physical proximity to each other.

In areas of open water, beluga whales sometimes divide their days into regular feeding and resting bouts. Belugas appear to hunt individually, even when within a group, but cooperative hunting has also been observed. A typical hunting sequence begins with slow directed movement combined with passive acoustic localization (search mode) followed by short bursts of speed and rapid changes of direction using echolocation for orientation and capture of prey (hunt mode) (Bel’kovitch and Sh’ekotov, 1990).

The beluga possesses one of the most diverse vocal repertoires among marine mammals and has long been called the “sea canary” by mariners awed by the myriad of sounds they make, which can reverberate through the hulls of ships. Communicative and emotive calls are broadly divided into whistles and pulsed calls and are typically made at frequencies from 0.1 to 12 kHz. As many as 50 call types have been recognized; *groans*, *whistles*, *buzzes*, *trills*, and *roars* to name but a few. Belugas are capable of producing individually distinctive calls and can conduct individual exchanges of acoustic signals, or dialogues, over some distance (Bel’kovitch and Sh’ekotov, 1990).

The echolocation system of the beluga whale is well adapted to the icy waters of the Arctic. Its ability to project and receive signals off the surface and to detect targets in high levels of ambient noise and backscatter enables it to navigate through heavy pack ice, locate areas of ice-free water, and possibly even find air pockets under the ice. Geographic variation in aspects of the beluga’s vocal repertoire and in echolocation activity have been documented and attributed to evolutionary divergence and habitat differences (i.e., water turbidity, predator presence/absence), respectively.

#### VI. Life History

Females become sexually mature at age 8–13; males are somewhat older. Gestation lasts 14–14.5 months with a single calf born in late spring–early summer. Mothers produce milk of high caloric content and nurse their young for up to 2 years. The entire reproductive interval averages 3 years. Little is known about the mating behavior or mating season of beluga whales. Mating is believed to occur primarily in late winter–early spring, a period when most belugas are still on their wintering grounds or on spring migration. Mating behavior, however, has also been observed at other times of the year and the question of whether this species has delayed implantation is unresolved.

#### VII. Interactions With Humans

Beluga whales have long been an important and reliable resource for many coastal peoples throughout the Arctic and subarctic because of their predictable migration routes and return to coastal areas in summer. However, because past commercial harvesting drove a

number of populations to the point of economic extinction, current levels of subsistence take from these populations may not be sustainable and comanagement efforts have curtailed subsistence harvest in some populations to maximize recovery (e.g., Cook Inlet, Alaska). Increasing human activity in the beluga's environment brings with it the threat of habitat destruction, disturbance, and pollution. In areas where there are large commercial fishing operations, belugas, particularly neonates, may be incidentally caught in gill nets. In a number of regions of the Arctic, beluga whales exhibit strong avoidance reactions to ship traffic, whereas in some coastal locations they appear to have developed a high tolerance to boat traffic. The potential impacts of emerging whale watching activities (e.g., Churchill, Manitoba; St Lawrence, Quebec; White Sea, Russia) are not yet assessed. In some areas, belugas may also be victims of industrial pollution. A high incidence of various pathologies and immune system dysfunction found in beluga whales in the St Lawrence River, Canada were linked to high levels of heavy metals and organohalogenes found in these whales. Recent decades have seen an improvement in water quality in the St Lawrence, though legacy effects of persistent lipophilic contaminants in the long-lived beluga whale will likely continue for some time (Martineau, 2012). Finally, there is concern over the possible downstream effects of hydroelectric dams on estuarine habitats and the environmental and health risks associated with oil and gas development and mining in the Arctic.

Beluga whales were one of the first cetaceans to be held in captivity when in 1861 a whale caught in the St Lawrence River went on display at Barnum's Museum in New York. Today, beluga whales are one of the more common and popular marine mammals in oceanaria across North America, Europe, and Asia including Japan. The majority of these animals were wild-caught, but successful breeding programs at a number of facilities are increasing the number of belugas born in captivity. Russia has become the sole regular supplier of wild-caught beluga whales to zoos and aquaria (Reeves et al., 2011).

The large sizes of some Arctic populations and flexible habitat requirements of beluga whales indicate that this species may not be as sensitive to the environmental consequences of current and future climate change as other arctic marine mammals. Nevertheless, a number of small, isolated populations at the southern margins of the species range are vulnerable to continued climate warming, where habitat loss in concert with the genetic and demographic effects of small population sizes may compromise individual fitness and population viability. Furthermore, it is difficult at present to predict the consequences for beluga whales of increased human activities across the Arctic associated with climate change.



**Figure 5** Aggregations of beluga whales interacting and rubbing on the substrate of a shallow Arctic estuary during the summer molt (Photo by Flip Nicklin/Minden Pictures).

### See Also the Following Articles

Arctic Marine Mammals ■ Climate Change

### References

- Bel'kovitch, V.M., and Sh'ekotov, M.N. (1990). "The Belukha Whale: Natural Behaviour and Bioacoustics." USSR Academy of Science, Moscow, Translated by Woods Hole Oceanographic Institution, 1993.
- Citta, J.J., Richard, P., Lowry, L.F., O'Corry-Crowe, G., Marcoux, M., Suydam, R., Quakenbush, L.T., Hobbs, R.C., Litovka, D.I., Frost, K.J., Gray, T., Orr, J., Tinker, B., Aderman, H., and Drukenmiller, M.L. (2016). Satellite telemetry reveals population specific winter ranges of beluga whales in the Bering Sea. *Mar. Mamm. Sci.* doi:10.1111/mms.12357.
- Colbeck, G.J., Duchesne, P., Postma, L.D., Lesage, V., Hammill, M.O., and Turgeon, J. (2013). Groups of related belugas (*Delphinapterus leucas*) travel together during their seasonal migrations in and around Hudson Bay. *Proc. R. Soc. B* **280**, 20122552.
- Hassanin, A., Delsuc, F., Ropiquet, A., Hammer, C., Jansen van Vuuren, B., Matthee, C., Ruiz-Garcia, M., Catzeflis, F., Areskou, V., and Nguyen, T.T. (2012). Pattern and timing of diversification of Cetartiodactyla (Mammalia, Laurasiatheria), as revealed by a comprehensive analysis of mitochondrial genomes. *C. R. Biol.* **335**, 32–50.
- Hauser, D.D.W., Laidre, K.L., Parker-Stetter, S.L., Horne, J.K., Suydam, R.S., and Richard, P.R. (2015). Regional diving behavior of Pacific Arctic beluga whales *Delphinapterus leucas* and possible associations with prey. *Mar. Ecol. Prog. Ser.* **541**, 245–264.
- Lefebvre, S.L., Michaud, R., Lesage, V., and Berteaux, D. (2012). Identifying high residency areas of the threatened St. Lawrence beluga whale from fine-scale movements of individuals and coarse-scale movements of herds. *Mar. Ecol. Prog. Ser.* **450**, 243–257.
- Lydersen, C., Martin, A.R., Kovacs, K.M., and Gjertz, I. (2001). Summer and autumn movements of white whales *Delphinapterus leucas* in Svalbard, Norway. *Mar. Ecol. Prog. Ser.* **219**, 265–274.
- Martin, A.R., Smith, T.G., and Cox, O.P. (1998). Dive form and function in belugas *Delphinapterus leucas* of the eastern Canadian High Arctic. *Polar Biol.* **20**, 218–228.
- Martineau, D. (2012). Contaminants and health of beluga whales of the Saint Lawrence Estuary. In "Ecosystem Health and Sustainable Agriculture 2", (L. Norrgren, and J. Levengood, Eds), pp. 139–148. The Baltic University Programme, 2295, Uppsala University.
- O'Corry-Crowe, G.M., Suydam, R.S., Rosenberg, A., Frost, K.J., and Dizon, A.E. (1997). Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western Nearctic revealed by mitochondrial DNA. *Mol. Ecol.* **6**, 955–970.
- Quakenbush, L.T., Suydam, R.S., Bryan, A.L., Lowry, L.L., Frost, K.J., and Mahoney, B.A. (2015). Diet of beluga whales, *Delphinapterus leucas*, in Alaska from stomach contents, March–November. *Mar. Fish. Rev.* **77**, 70–84.
- Reeves, R.R., Brownell Jr., R.L., Burkanov, V., Kingsley, M.C.S., Lowry, L.F., and Taylor, B.L. (2011). Sustainability assessment of beluga (*Delphinapterus leucas*) live-capture removals in the Sakhalin–Amur region, Okhotsk Sea, Russia. Report of an independent scientific review panel *Occasional Paper of the Species Survival Commission*, No. 44. IUCN, Gland, Switzerland.
- Stewart, R.E.A., Campana, S.E., Jones, C.M., and Stewart, B.E. (2006). Bomb radiocarbon dating calibrates beluga (*Delphinapterus leucas*) age estimates. *Can. J. Zool.* **84**, 1840–1852.
- Suydam, R.S., Lowry, L.F., Frost, K.J., O'Corry-Crowe, G.M., and Pikok Jr., D. (2001). Satellite tracking of eastern Chukchi Sea beluga whales in the Arctic Ocean. *Arctic* **54**, 237–243.
- Turgeon, J., Duchesne, P., Colbeck, G.J., Postma, L.D., and Hammill, M.O. (2012). Spatiotemporal segregation among summer stocks of beluga (*Delphinapterus leucas*) despite nuclear gene flow: implication for the endangered belugas in eastern Hudson Bay (Canada). *Conserv. Genet.* **13**, 419–433.