Scientific Classification

Order: Cetacea

*Cetacea is one of only two scientific orders of large aquatic mammals that live their entire lives in water (Sirenia is the other). Cetaceans include all whales, dolphins and porpoises.

*The word "cetacean" is derived from the Greek word for whale, *kētos*.

*Cetaceans are divided into two suborders: Odontoceti (toothed whales) and Mysticeti (baleen whales).

Suborder: Odontoceti

*The scientific suborder Odontoceti is comprised of toothed whales.

* The structural differences in the skulls and the melons of Odontocetes, such as belugas, enable specialized echolocation (Hooker, 2002).

*Odontoceti whales have one blowhole opening.

*With the exception of the sperm whale, toothed whales are smaller than most baleen whales.

*The word "Odontoceti" comes from the Greek word for tooth, *odontos*.

Family: Monodontidae

*Belugas, along with their closest living relative, the narwhal (*Monodon monoceros*), are the only living members of the family Monodontidae. The word "Monodontidae" comes from the Greek for "one tooth," a reference to the tusk of the male narwhal. This is a misnomer for beluga whales because they possess many teeth (Reeves *et al.*, 2002).

Genus: Delphinapterus

*****Belugas are the only living member of the genus *Delphinapterus*. The name derives from the Greek words *delphinos* ("dolphin"), *a* ("without") and *pteron* ("fin" or "wing"). Belugas lack a dorsal fin, hence the name "dolphin without a fin." However, in spite of what the name suggests, belugas are not dolphins, which is a term reserved for members of the family Delphinidae (Leatherwood *et al.,*1988).

*The genus and species (see below) were identified in 1776 by Pallas.

Species: leucas

*The species name comes from the Greek word for "white," *leukos*, referring to the color of the adult beluga.

*Similarly, the common name *beluga* comes from the Russian word for "white." The name has led to some confusion with the beluga sturgeon (a white sturgeon), a freshwater fish from which beluga caviar is derived.

Fossil Record

Fossil evidence suggests that whales evolved from terrestrial ancestors almost 60 million years ago (Fordyce, 2002). Recent evidence suggests the closest living relative to cetaceans is the hippopotamus (Berta and Sumich, 2003). Around 35 million years ago, both odontocete and mysticete cetaceans evolved and diversified rapidly; most likely due to new food resources resulting from oceanic change (Fordyce, 2002). The earliest fossil monodontid is that of an extinct beluga (*Denebola brachycephala*), which lived along the coast of Baja California, Mexico, about 10 million years ago (O'Corry-Crowe, 2008). Less than 4 million years ago, now-extinct monodontids lived only in temperate and subtropical waters. The earliest fossil of a beluga and narwhal as we know them today were found in Canada. *Delphinapterus leucas* fossils, less than 2 million years old and found in northeastern North America, show that the distribution of the beluga changed as the glacial cover of the oceans altered (Berta and Sumich, 2003; O'Corry-Crowe, 2002).

Distribution

Belugas are found only in the Northern Hemisphere—in Arctic and subarctic waters. Discrete populations are found off the coasts of Alaska, Canada, Russia, Norway and Greenland (Martin, 1996). Occasionally, belugas travel much farther south; lone belugas have been sighted in Long Island Sound and near Cape Cod (Frady, 2004; Katona *et al.*, 1993).

Stocks

Though all living belugas belong to the same species and are generally confined to Arctic regions, they are sometimes further classified by the "stocks" (or subpopulations) to which they belong (COSEWIC, 2004; IWC, 2000; Martin and Richard, 2001), which are genetically isolated from others stocks. Stocks are also identified by distribution and migration patterns, morphological characteristics, and DNA. All stocks are found in the waters of Alaska, Canada, Russia, Norway and Greenland (IWC, 2000). Stocks vary in population size with some as small as a few hundred animals and others perhaps as large as 30,000 animals (Hobbs and Sheldon, 2008; Angliss and Outlaw, 2005; IWC, 2000; DFO, 2005; COSEWIC, 2004).

Habitat

Some beluga populations make seasonal migrations, while others remain in a relatively small area year-round (Nowak, 1991; Leatherwood and Reeves, 1983). They migrate south as the ice pack advances in the autumn, leaving areas of broken pack ice and moving to shallow, brackish estuaries and river mouths in the summer. These patterns indicate that belugas possess an ability to move freely between salt and fresh water, an ability that most other cetaceans do not have (Martin, 1996). In addition, belugas have been sighted in various waters of various depths from extremely shallow waters to deep underwater trenches (Schreer and Kovacs, 1997).

Water temperatures experienced by belugas range from 0° C (32° F) to more than 16° C (61° F), but are closer to freezing for much of the year (Leatherwood *et al.,* 1988; Smith *et al.*, 1994). Some waters are so cold that when a beluga rests at the surface, the water freezes and forms an ice dome molded by the beluga's back. These domes then remain intact when the whale swims away (Leatherwood *et al.,* 1988). Belugas are extremely comfortable among sea ice; satellite-tagged belugas have traveled from the northwest coast of Alaska north through sea ice concentrations of almost 100% (Suydam *et al* 2001).

Estuaries

The summer habitats of belugas generally include an estuary. Belugas show a high degree of philopatry, or site tenacity/fidelity, with stocks returning to the same estuaries year after year (COSEWIC, 2004). Genetic evidence also suggests that the stocks have been visiting separate estuaries for long periods, perhaps since glaciers receded at the end of the last Ice Age, with only limited exchange between the different groups (O'Corry-Crowe, 2008). Rubbing is frequently observed in these areas. This behavior is tied to the seasonal epidermal molt of the beluga (Smith *et al.*, 1992). The completion of the molting process may be the most important reason for the belugas' migration into estuaries. The warmer waters of the estuary may also benefit neonate calves, with their thin blubber layer and dependence on their mother. Females and their calves are especially tied to the estuary and are the first to return after a disturbance, such as boats or hunting (O'Corry-Crowe *et al.,* 1997).

Diet

Belugas have the most varied diet of any small whale (Gurevich, 1980). Diet varies with season and location, and food intake changes with water temperature (Balsiger, 2003). Belugas are opportunistic feeders, preying upon over 100 species of fish and invertebrates throughout their range (Gurevich, 1980). Known prey of belugas include: marine fish (Arctic cod, salmon, herring, haddock, Arctic char, flounder, smelt, sole, sculpin, skates and halibut), freshwater fish (trout, whitefish, northern pike, grayling and tomcod), cephalopods (squids and octopuses), other mollusks (clams, mussels and snails), crustaceans (shrimp and crabs), marine worms and even zooplankton (Balsiger, 2003; Katona *et al.*, 1993; Kleinenberg *et al.*, 1969; Martin, 1996; Reidenberg and Laitman, 2002). Because of their expandable forestomach, belugas can process a large amount of food at once. One whale was found in the Cook Inlet with 12 adult coho salmon in its stomach, weighing a total of 62 lbs (28 kg) (Balsiger, 2003).

Anatomy and Physiology

A beluga's shape is predominantly the result of its thick blubber layer, which causes a rounded midsection that tapers to a relatively small head and tail. Beluga pectoral flippers are also small in proportion to the whales' body size (O'Corry-Crowe, 2002; Reeves *et al.,* 2002). The blubber often results in lumpy sides and undersides, especially in large males (Reeves *et al.,* 2002). Belugas lack a dorsal fin, possessing instead a dorsal ridge (O'Corry-Crowe, 2002). A dorsal fin would be prone to injury from ice, and would be a site for heat loss (Katona *et al.,* 1993). The head of a beluga is dominated by the melon, a fat filled area that obscures the rostrum, or upper jaw (Reeves *et al.,* 2002). The neck of a beluga is very flexible, unlike many other cetaceans whose neck vertebrae are fused. This rare characteristic allows belugas to maneuver as they hunt in very shallow water and to escape from predators (O'Corry-Crowe, 2002).

Average Age to Reach Adult Mass

Female belugas attain their adult size at around 7 years of age. Males continue to grow, achieving their larger mass at about 14 years of age (Kastelein *et al.,* 1994).

Size

An estimated average size for an adult male beluga is 12–15 feet (3.7–4.6 m) long, weighing 1600–2500 pounds (725–1134 kg). Females average 11–13 feet (3.4–4.0 m) in length, weighing 1100-2000 pounds (499–907 kg) (Balsiger, 2003; Katona *et al.,* 1993; Martin, 1996; O'Corry-Crowe, 2002; Reeves *et al.,* 2002; Richard, 2002). Size can vary greatly between different populations of belugas; climate is probably a factor in determining the body size of belugas in different populations (Martin, 1996; Sergeant and Brodie, 1969).

Skin

A beluga's thick skin forms a barrier of protection against abrasion by ice in an arctic environment. The temperature of the beluga's skin is only a degree or two warmer than the surrounding water. Below the skin, blubber insulates the internal organs and tissues (Castellini, 2002). Belugas have particularly thick skin; it is 10 times thicker than dolphin skin and 100 times thicker than the skin of terrestrial mammals (Doige, 1990).

The white color for which belugas are named does not appear until an animal reaches maturity. Calves are born a light brown-grey color, which darkens before turning the characteristic white (Kleinenberg *et al.,* 1969). In adults, dark pigment is often present on the top of the dorsal ridge and along the edges of the flukes and pectoral flippers (Kleinenberg *et al.,* 1969; Martin, 1996). The white coloration may provide camouflage amongst snow and ice; observations of killer whale attacks on belugas show that belugas attempt to hide amongst sea ice to avoid predation. The change in color is not related to sexual maturity, although these events may occur at the same time (Kleinenberg *et al.,* 1969; St. Aubin *et al.,* 1990).

Molt

Belugas are unique among cetaceans; they undergo an annual molt. Typically, growth and replacement of the epidermis (outer layer of skin) of cetaceans is a continuous process. In belugas, it is a cyclical process that may be driven by their seasonal migrations between frigid arctic oceans and relatively warm estuarine waters. Given the dramatic change in habitat a beluga undergoes when entering an estuary, the molting process may be controlled by environmental cues such as temperature and salinity (St. Aubin *et al.*, 1990). By molting, belugas remove the thick surface layer of the skin that may increase the resistance to the smooth flow of water over the whale. After the molt, the flow of water over the beluga's skin would be smoother, which would make them more hydrodynamic (Smith *et al.,* 1990).

Blubber

A thick insulating layer of blubber is one of the beluga's greatest adaptations to life in the Arctic. It allows them to stay warm even when the water is at freezing temperatures. Compared to other odontocetes, belugas have an unusually thick layer of blubber, accounting for 40–50% of their body weight. Among other cetaceans, only the right whales have a similar body composition. Thicknesses of up to 10.6 inches (27 cm) have been reported, but 4 inches (10 cm) is a more typical maximum thickness (Balsiger, 2003; Kleinenberg *et al.,* 1969; Richard, 2002). A beluga's blubber layer is dynamic, varying in thickness seasonally.

Mouth

Belugas can use their lips to form the shape of an "O" with their mouth, a characteristic not shared by any other whale. A beluga's tongue forms a seal around fish, allowing it to swallow prey without having any water go down the throat. This helps to reduce salt intake and prevent dehydration. The tongue also allows the beluga to capture prey by using suction. Belugas can create a very powerful spit by forcing water out of their mouth. This is used to blow away sand, silt, and mud when hunting for benthic prey (Kleinenberg et al.*,* 1969; Martin, 1996).

Similar to other cetaceans, a beluga's tongue is used as a straw for nursing when they are young. It curls, similar to a humans, and goes up against the roof of their mouth. It has a water-tight seal due to scalloped edges around the edge of their tongue. Some whales retain these scalloped edges; in others, the edges fade over time.

Teeth

Belugas use their teeth to grasp their prey, rather than for cutting or chewing. Their teeth are conical in shape and the upper and lower teeth are interposed. This allows the whales to grasp prey efficiently (Kleinenberg *et al.*, 1969). A young beluga's teeth appear when the animal is between 1 to 2 years of age, depending on location, and all teeth have at least partially appeared by the end of a beluga's third year (Brodie, 1971; Kleinenberg *et al.*, 1969). Belugas have only one set of teeth throughout their lives; the teeth are not replaced. The number of teeth varies with sex and age and can range from 30 to 40. The size of the teeth depends on the size of the animal; maximum sizes of 5 cm (2 in) long and 1.8 cm (0.7 in) thick have been recorded. In addition, beluga teeth vary in pattern of wear as a result of their feeding from the sea floor. In some older animals, the teeth may be worn down to the gums (Kleinenberg *et al.,* 1969).

Sensory Systems

Hearing

Belugas have very acute hearing, especially at higher frequencies. Belugas hear a wide range of frequencies with best sensitivity in the ultrasonic range around 30 or 35 kHz and sensitivity extending to at least 130 kHz (Finneran, et al.) . For comparison, the peak range of human hearing is between .02 and 20 kHz (Suydam *et al.,* 2001). Studies have shown that belugas can hear as well in water as deep as 984 feet (300 m), as they can at the surface (Ridgway *et al.,* 2001). Their small external ears may be useful for hearing low frequency sounds (Moore *et al.,* 1995). However, most vocalizations made by odontocetes are above 30 kHz, emphasizing the great importance of the lower jaw pathway for sound reception (see “Echolocation” below). Belugas have good in frequency tuning and are able to detect echolocation signals in high levels of background noise and reverberation (Klishin *et al.,* 2000).

A number of studies have been done to assess the potential impacts of environmental sound on belugas. These have involved determination of when the level of a particular sound impacted hearing by producing a temporary rise in hearing threshold (Schlundt et al., 2000; Finneran et al., 2001).

Echolocation

Echolocation is a biological sonar that provides more information than any human-made sonar (Lammers and Castellote, 2009). During echolocation, a beluga produces sound in the form of clicks. These clicks reflect off of objects in the environment and return to the animal in the form of echoes. The echoes pass through the fat-filled canal in the lower jaw to the ear. The animal can then process these echoes in the ear and brain, allowing it to perceive information about the object, such as size, shape, density, and the material of which it is composed (Harley *et al.,* 1995). Belugas are thought have better abilities than bottlenose dolphins to discriminate targets in clutter (Turl et al. 1991) and in the presence of masking noise (Turl et al. 1987), and have the ability to change the frequency of their clicks in response to background noise (Au *et al.*, 1995; Tyack, 1999).

The Melon
The melon is the fatty region on top of the frontal portion of a beluga's skull. It is critical to focusing and projecting echolocation signals and is the means by which the sounds a beluga makes are ultimately projected to the water. The melon can function as an “acoustic lens,” focusing sound into a beam the way a flashlight's lens and reflector focus light (Cranford *et al.*, 1996; Pabst *et al.* 1999). Belugas have the ability to change the physical shape of their melon, which may allow them to control sound transmission (Frankel, 2002). The fat composing the melon is distinct; it cannot be broken down to produce energy, indicating its importance.

Vision
Belugas have good vision both above and below the water (Balsiger, 2003; Mass and Supin, 2002). Like other odontocetes, they can focus in either air or water, an adaptation made possible by their specially adapted lens and cornea (Mass and Supin, 2002). For belugas, which are sometimes hunted by the polar bear, the ability to see in both air and water is especially important.

Color vision
Belugas' eyes do contain both rod and cone cells. However, like all other cetaceans, they have only one type of cone. Since two or more types of cones are usually necessary to distinguish colors, belugas probably do not see much color if any at all (Griebel and Peichl, 2003.).

Smell, Chemoreception and Taste
Belugas lack a sense of smell, which would be of limited use in water. However, chemoreceptors on the base of a beluga's tongue function in a similar way to taste buds, and allow the animal to detect chemicals suspended in water (Kleinenberg *et al.*, 1969). Chemoreceptors may also perform a social function, enabling one beluga to locate others nearby. In addition, belugas may be able to detect changes in the salinity of water (Dudzinski *et al.,* 2002; Muir *et al.*, 1990).

Touch
Belugas have well-developed skin sensitivity. The most sensitive areas are inside the mouth, the tip of the rostrum, the insertion of the pectoral flipper, and the abdomen (Dudzinski *et al.,* 2002). The sense of touch plays an important role in tactile oriented social behavior.

Swimming and Diving
Swimming Speed
Generally, belugas are slow swimmers, mostly swimming between 2–6 mph /h (3–9 km). They have been recorded swimming at speeds of 9.3–17.1 mph (15–27.5 km/h)

(Richard *et al.*, 1998; Richard *et al.*, 2001; Shaffer *et al.*, 1997). When compared with other toothed whales, belugas are not capable of sustained high-speed swimming at the surface (Shaffer *et al.*, 1997). Belugas tend to swim faster while migrating than during molting or feeding (Suydam *et al.,* 2001).

Diving

Belugas (and all other cetaceans) have several adaptations to conserve oxygen, as well as several adaptations to minimize or eliminate the effects of harmful nitrogen related conditions, such as the bends and nitrogen narcosis, which can be experienced by human scuba divers. Belugas store half the total oxygen in the blood, as opposed to humans, who hold half the total oxygen in the lungs (Berta and Sumich, 2003). Moreover, belugas, like other cetaceans, use approximately 75% of their total lung capacity, while humans use only 10-15%. This allows belugas to load more oxygen and unload more carbon dioxide in each breath (Wartzok, 2002).

Belugas also have more blood per unit weight than terrestrial animals, with blood accounting for 13% of their body weight (127.5 ml/kg), compared to 8% for a human (Ridgway et al., 1984; Elsner, 1999; Shaffer *et al.*, 1997). They also have a higher hemoglobin level than terrestrial mammals, allowing them to carry more oxygen per unit of blood (Ridgway, 1972; Ridgway *et al.*, 1984). Belugas are also able to store oxygen in myoglobin in their muscles. During a dive, belugas exhibit bradycardia, or a slowing of the heart rate, from about 100 beats per minute down to 12–20 (Kanwisher and Ridgway, 1983). This reduces the heart's oxygen requirements and slows the circulation of blood throughout the body.

Average Dive Duration

While dives lasting up to 25 minutes have been recorded, typical feeding dives rarely last longer than 18–20 min; most range between 9 and 18 minutes (Heide-Jørgensen *et al.*, 1998; Reidenberg and Laitman, 2002; Schreer and Kovacs, 1997).

Maximum Dive Depth/Dive Time Reported

Belugas routinely make dives in excess of 15 minutes, with average foraging dives in Arctic Canada exceeding 13 minutes (Martin and Smith, 1999). The deepest recorded dive was to 3300 feet (1000 m), and the longest recorded dive lasted 25 minutes (Schreer and Kovacs, 1997). However, most dives do not last this long or go this deep. Belugas taught to dive in the open ocean (Ridgway et al., 1984) reached depths of up to 2122 feet (647 meters) . Trained animals dived for up to 17 minutes without extended surface times (Shaffer *et al.*, 1997). Dive duration is greatly influenced by descent rates and dive depth. The descent rate is determined by the beluga at the surface and remains constant throughout the descent. This suggests that belugas use echolocation to determine how deep they must dive to reach the bottom before initiating the dive

(Martin and Smith, 1999). To reach a diving test switch in mid-water a whales dive speed became progressively slower as it descended, however it ascended faster at a rate of 2 meters per second (Ridgway et al., 1984).

Behavior

Social Grouping

Belugas normally migrate, hunt and interact in groups and are rarely found alone (Balsiger, 2003; Leatherwood *et al.*, 1988). Belugas typically form groups called pods or schools, most often numbering from 2 to several dozen animals (Gurevich, 1980; Katona *et al.*, 1993; Krasnova *et al.*, 2006). The structure of the pods is fluid, with individuals moving between specific pods. Beluga pods can contain animals of the same sex and age class, but may vary in structure and size seasonally (Gurevich, 1980). Males most often travel in pods of 10-15 individuals that tend to stay away from other groups (Krasnova *et al.*, 2006; Smith *et al.,* 1994). Adult females and their calves and juveniles form pods, while adult females without calves may also form their own groups (Martin, 1996; Richard, 2002). Even older subadult belugas often form their own pods (Richard, 2002). Additionally, the amount of separation by age and sex between pods may be more distinct at certain times of the year, such as during migrations or selection of different feeding habitats (Loseto *et al.*, 2006; Martin, 1996; O'Corry-Crowe, 2002).

Communicative Vocalizations

Belugas, named "sea canaries" by early whalers, are perhaps the most vocal of all cetaceans, producing an extensive repertoire of sounds. They were the first cetacean to have their vocalizations recorded and systematically described (Schevill and Lawrence, 1949). Attempts were made as early as 1821 to categorize the incredible variety of communicative vocalizations produced by the beluga; some were likened to bird calls, the faint mooing of an ox, rubbing a wet finger on glass, deep sighing, a woman's shrill cry, the grunting of pigs and even badly played musical glasses (Fish and Mowbray, 1962). Researchers now understand that the diverse sound repertoire of belugas is composed of the predominant sound types among toothed whales: (1) whistles, or narrow-band, frequency modulated vocalizations, believed to be social signals and (2) pulsed sounds or trains of broad band pulses. Some researchers (e.g. Faucher 1988, Karlsen et al. 2002; Belikov and Belkovitch, 2003; Vergara and Barrett-Lennard 2008, 2010) identified mixed calls in belugas, consisting of either a whistle and a pulsed component or two pulsed sounds, produced synchronously in the same vocalization.

There have been some attempts to interpret the function of beluga calls. A study on wild belugas in the Canada's Cunningham Inlet demonstrated that vocalizations were more numerous during periods of social interaction than during swimming, resting or stressing situations (Sjare and Smith, 1986). It appears that some of the whistles that belugas produce are used for short-range communication and others are used for long-range communication between uncoordinated groups (Belikov and Bel'kovich, 2006). One of the most in-depth studies of acoustic communication in belugas to date documents how beluga calves develop their extensive repertoire of sounds (Vergara and Barrett-Lennard, 2008). Another study classified 28 discrete beluga call types from a social group of belugas at the Vancouver Aquarium and identified broad-band pulsed vocalizations associated with social bonding, termed contact calls, both in the aquarium and in the wild (Vergara et al., 2010). These calls play an important role in establishing or maintaining contact between mothers and calves. The identification of beluga call types that have important survival value: the contact calls described by Vergara and colleagues allows researchers to be better positioned to evaluate the effects of human-related noise on the animals' communication signals.

Belugas are also adept vocal mimics and are able to mimic artificial and other sounds. Belugas in aquariums often imitate sounds in their environments. One learned to mimic the sound of his name and a 15-year-old beluga at the Vancouver Aquarium produced sounds that resembled human speech (Eaton, 1979). Another 9-year old male beluga, held at San Diego Bay, imitated the sound of human conversations (Ridgway et al. 1985; 2012). The ability of adult individuals to imitate sounds that are not part of their repertoire suggests that they may use vocal learning in developing their natural vocalizations (Tyack 1993).

Foraging and Hunting

In general, belugas will hunt in a manner that requires the lowest energy expenditure to gain the greatest nutritional rewards. They are more successful hunters when feeding on large schools of fish or heavy concentrations of prey (Balsiger, 2003). Belugas may also hunt cooperatively to conserve energy. Belugas are known to use man-made structures to increase the success of a hunt: one whale waits along a dock while a second whale chases fish along the dock toward the waiting whale (Balsiger, 2003).

Diving is an important hunting behavior. Belugas can dive deeply to the seabed in search of benthic prey (Martin and Smith, 1999; Richard *et al.*, 1998). Belugas are very successful bottom feeders. Their flexible necks allow them to scan a broader area of the sea bottom, while spit and suction behaviors aid in capture of prey (Martin and Smith, 1999; O'Corry-Crowe, 2002; Ridgway and Carder, 1998).

Sleep State

Studies of brain activity of several odontocete species, including belugas, show unihemispheric brain waves when they sleep. This means that one hemisphere of the cerebrum is always active during sleep, allowing them to control surfacing and breathing patterns (Lyamin *et al.,* 2002; Wagemann *et al.,* 1990). The sleeping hemisphere switches with the non-sleeping hemisphere many times during the sleeping period.

Cetaceans have the ability to swim while sleeping, but a common resting behavior seen is logging, in which the whale lays still at the surface of the water (Goley, 1999).

Reproduction and Maternal Care

Reproductive cycle

The reproductive cycle of the beluga is seasonal, although there is some slight variability between regions (Reidenberg and Laitman, 2002). Most breeding occurs from April to May, although in some areas the breeding season may start as early as February and end as late as early June (Brodie, 1971; Katona *et al.,* 1993; Kleinenberg *et al.*, 1969; Martin, 1996; O'Corry-Crowe, 2002; Reidenberg and Laitman, 2002). Studies with belugas in zoological parks and aquariums have also shown seasonal variation in the production of reproductive hormones. These studies also make it possible to determine conception dates. Most conceptions in zoos and aquariums occur between March and May (Robeck *et* al., 2005). It is thought that ovulating females probably mate with several different males during the breeding season (Martin, 1996).

Gestation

In the wild, gestation ranges from 14-14½ months in most areas (Brodie, 1971; Katona *et al.,* 1993; O'Corry-Crowe, 2002; Reidenberg and Laitman, 2002). Studies on belugas in zoos and aquariums, which allow researchers to follow the development of the fetus from conception until birth, have shown that the gestation period ranges from about 15-16 months (Robeck *et al.,* 2005).

Birthing Season

Most calving takes place from late spring to early summer, mostly in the months of April-July (Balsiger, 2003; COSEWIC, 2004; Kleinenberg *et* al., 1969; O'Corry-Crowe, 2002; Richard, 2002; Sergeant, 1973; Smith *et al.,* 1994). In a given population, calving may be spread out over a period of 2–3 months, with most of the calving occurring during a peak in the middle of the interval (COSEWIC, 2002). Calving season and peak calving may vary between stocks (Cosens and Dueck, 1990).

Birth

Belugas give birth to one calf at a time. There has never been a record of multiple live births in belugas (Kleinenberg *et al.*, 1969). The intense maternal investment in the calf would make it very difficult, if not impossible, for a female beluga to simultaneously nurse two calves.

An average beluga birth lasts eight hours (Robeck *et al.,* 2005). When born, calves weigh between 136.7 and 196.2 lbs (62–89kg) (Robeck *et al.,* 2005; Dr. Greg Bossart). At birth, on average, male calves are 5 feet 1 inch (154 cm) long and females are 5 feet 3 inches (161 cm) long (Robeck *et al.,* 2005).

Newborn beluga calves are immediately capable of swimming and shallow diving, although female belugas have been observed carrying their calves on their backs when they are very young. Despite being born without a thick layer of blubber, beluga calves survive the thermal shock of birth, moving from the warmth of the womb to icy water while maintaining their body temperature (Martin, 1996). A thick outer layer of skin cells insulates calves on birth. This is shed soon after birth as the calf builds up its blubber layer. This shedding also causes a change in skin color (Doidge, 1990).

Nursing Period

Most beluga calves remain partially dependent on milk from their mothers until the age of 2 years (Brodie, 1971; Robeck *et al.*, 2005). Beluga whales in human care are known to nurse for longer. At the Vancouver Aquarium, a juvenile female Qila, was observed nursing until she was six years of age (Leung *et al.*, 2010). Tuvaq, a male calf born in 2002, nursed until he was three years old not only from his mother Aurora, but also from his half sibling Qila, and from an unrelated female Allua, both of whom began lactating despite not having calves of their own (Leung et al. 2010). Calves may not nurse for more than a day after birth. Once they begin, their nursing time increases quickly, reaching a peak 7–10 days after birth and then slowly declining. Beluga calves nurse about every 36 minutes throughout the day and night (Russell *et al.,* 1997).

Average Dependent Period

Observations suggest that the mother/calf bond is the central social relationship for belugas (Krasnova *et al.,* 2006; O'Corry-Crowe, 2002; Smith *et al.*, 1994). Calves may remain with their mothers for 4–5 years or more. A high number of juveniles remain with their mothers even after the mother gives birth to another calf. A mother may leave her calf in the care of the juvenile while diving (Smith *et al.*, 1994). Mothers and their dependent calves produce a vocalization that serves as a “contact call” (described in detail in Vergara et al., 2010).

Average Years between Offspring

Females give birth every 2–4 years, most often once every 3 years (Brodie, 1971; Katona *et al.,* 1993; Martin, 1996; O'Corry-Crowe, 2002; Richard, 2002).

Average Age at Sexual Maturity

The age at which sexual maturity is reached also varies according to reports. Most reports agree that females reach sexual maturity between 5–7 years of age, while males mature later, at the age of 8–9 years (Balsiger, 2003; Burns and Seaman, 1988; Katona *et al.,* 1993; Martin, 1996; O'Corry-Crowe, 2002; Richard, 2002). Sexually mature males may not become socially mature until several years later, when they reach a size that allows for competition with fully grown males (O'Corry-Crowe, 2002). Female belugas in the wild may begin producing calves from the age of 5 or 6, while the youngest female to calf in a zoological park or aquarium was 6.9 years of age at time of conception (McAlpine *et al.,* 1999; Robeck *et al.,* 2005). Males in human care first reproduce at around the age of 9 years, which is consistent with information gathered on wild belugas (Robeck *et al.,* 2005).

Belugas Breeding in Zoological Parks and Aquariums

Belugas in zoological parks and aquariums provide the unique opportunity to track reproduction, growth and development in animals of known age. Breeding and calving have occurred in these facilities since 1981 (O'Brien *et al.*, 2008). As of 2011, there were 34 belugas in seven North American aquariums that manage this group of animals as one breeding population—over half of which (18) were born in a zoological parks or aquarium. The ability to collect regular blood samples and other measurements from these animals has provided substantial and important information on the species (Robeck *et al.*, 2005).

<u>Longevity and Mortality</u>

Tooth Aging of Belugas

The standard method of estimating the age of a wild beluga is counting the number of tooth growth layer groups (GLGs) – the layers of dentine (core of the tooth) and cementum (outer covering of the tooth) that are created as the animals age (Brodie et al., 1990). Although there has been debate about this methodology, the most recently published review of the scientific literature concluded by a preponderance of evidence that two new GLGs are deposited on a beluga's tooth per year; therefore, dividing the number of GLGs by two provides an accurate estimate of the animal's age (Brodie et al, 2013). Based on this standard methodology the oldest recorded wild beluga was approximately 38 years of age (Burns and Seaman, 1986). Belugas in human care have lived into their 40s, and, as of September 2012, over 10% of belugas with a known or estimated birth dates listed in the National Marine Fisheries Service Marine Mammal Inventory Report were over the age of 30.

Life Expectancy

Median Life Expectancy vs. Average Life Expectancy: The life expectancy of beluga whales is typically expressed as both a median and an average number. The median life expectancy is determined by sorting the estimated ages of a group of animals in value order; the mid-point of that set of numbers (ages) is the median life expectancy. The average life expectancy is determined by adding together the estimated ages of a group of animals and dividing that sum by the number of animals. In the case of beluga whales, the number (age) expressed for average life expectancy is higher, since it is more influenced by the animals at the upper end of the age spectrum than is the median.

In the Wild: The reported life expectancies of wild beluga whales vary widely based on the study location and methodology used. A literature search indicates that the age of the oldest documented beluga whale in the wild was estimated to be 38 years old (Burns and Seaman, 1986). Published estimates of adult annual survival rates range from 83% (Heide-Jorgenson and Lockyear, 2000) to 97% (Beland et al., 1992). When applied to animals that have survived one full year, these annual survival rates can be converted into median life expectancies ranging from 3.49 years to 22.76 years, and average life expectancies ranging from 5.4 years to 32.8 years, respectively. The majority of reported values of life expectancy of wild belugas from one year of age range between 10 and 15 years (Braham, 1984; Burns and Seaman, 1986; Beland et al., 1988; Doidge, 1990; Lessage and Kingsley, 1998).

In Human Care: As of January 2013, the oldest beluga whales in zoological parks and aquariums were over 40 years old; based on previous published data on wild belugas, it would be quite rare, though not impossible, for an animal in the wild to reach 40 years of age. Based on an analysis of the data in the National Marine Fisheries Service Marine Mammal Inventory Report, the annual survival rate of beluga whales in human care has been calculated as 97% (Innes, et al., 2005). This is the same as the highest reported value for a wild population. The number can be interpreted as meaning that a one year old beluga in human care would have a median life expectancy of 22.76 years, and an average life expectancy of 32.8 years. Thus, it is clear that from one year of age, the adult life expectancy of beluga whales in human care is at least equal to, if not greater than, beluga whales from one year of age in the wild.

<u>Threats to Beluga Whales</u>

The worldwide population of beluga whales, found in arctic and subarctic waters along the northern coasts of Alaska, Canada, Greenland, Norway and Russia, have been listed by the International Union for the Conservation of Nature (IUCN) as "Near Threatened." IUCN's higher rankings are "Critically Endangered, Endangered, and Vulnerable." IUCN is the world's oldest and largest global environmental organization and is a leading authority on the environment and sustainability.

Although belugas worldwide are not endangered, there are three isolated populations of beluga whales that are critically endangered because of human activities such as noise, pollution, shipping vessel traffic, and industrial activity that cause disease, reduce habitat quality and contaminate the food supply.

The only beluga stock listed as endangered in the United States is the Cook Inlet population in Alaska. www.nmfs.noaa.gov/pr/species/mammals/cetaceans/belugawhale.htm

Canada's Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has analyzed the status of many of the Canadian beluga populations. Its listings, with the dates of evaluations, are as follows:

- St. Lawrence population, endangered (1983 and 1997 evaluations)
- Southeast Baffin Island-Cumberland Sound population, endangered (1990)
- Ungava Bay population, endangered (1988)
- Eastern Hudson Bay population, threatened (1988)
- Eastern High Arctic/Baffin Bay population, special concern (1992)
- Western Hudson's Bay population, not at risk (1993)
- Beaufort Sea-Arctic Ocean population, not at risk (1985)

COSEWIC reports that "several of these populations were reduced by commercial exploitation in the past, some more so than others. At present, subsistence hunting in some parts of the Arctic is a concern because of its potential for continued decline or lack of recovery of the depleted populations. Other potential effects on these populations include habitat loss from shore development, build-up of toxic contaminants and disturbance by commercial shipping, ice breaking and whale watching activities."
www.dfo-mpo.gc.ca/science/publications/uww-msm/articles/beluga-eng.htm

Climate Change

Climate change could prove to be catastrophic for beluga whales, according to Randall Reeves, Chairperson of the IUCN's Cetacean Specialist Group. But, he points out, the "catastrophe could be either dramatic and rapid or very prolonged and subtle." At the same time, he notes, "it is possible that some species of cetaceans, perhaps even one of these Arctic species (narwhals, beluga and bowhead whales), will adapt to some degree and persist and even flourish, at least locally or regionally."
http://cmsdata.iucn.org/downloads/fact_sheet_red_list_beluga.pdf

Further reduction of sea ice cover could increase human activities in previously inaccessible Arctic areas, attracting shipping, oil and gas exploration and production, and commercial fishing. These activities would increase the risks of pollution and environmental and noise disturbance (Hovelsrud et al., 2008). In addition, decreased sea ice would affect the Arctic food web, forcing a change in marine mammals' feeding habits (Bluhm and Gradinger, 2008). Sea ice and extremely cold water serve as barriers to other species of marine mammals not now found in the Arctic. Warmer waters may increase competition for prey, the potential risk of disease (Burek et al., 2008; Moore et al., 1995) and leave beluga populations more vulnerable to predation by killer whales (Shelden et al., 2002). Inuit people in the eastern and northwestern Hudson Bay and the Hudson Strait have already seen effects of climate change on beluga behavior. With less sea ice, belugas are reportedly declining in numbers along the coast and are instead migrating in water currents farther offshore (Ragen et al., 2008).

A U.S. national survey indicates that people who visit zoos and aquariums are more concerned about climate change than other Americans and are willing to take action to help because they feel a connection with animals. The final report, "Global Climate Change as Seen by Zoo and Aquarium Visitors," was analyzed by the Climate Literacy Zoo Education Network. CLiZEN is led by the Chicago Zoological Society, which manages the Brookfield Zoo. CZS officials say the survey's findings suggest that zoo and aquarium visitors are a prime audience for climate change education messages. The survey is part of a $1.2 million planning grant that CZS received from the National Science Foundation Program on Climate Change Education and another grant provided by the Boeing Company. www.czs.org/CZS/clizen

Predators

Killer whale predation on belugas has been observed (Shelden et al., 2002). The other major threat to belugas is the polar bear (Lowry et al., 1987). However, researchers have determined that neither killer whales nor polar bears are currently a significant threat to beluga populations.

Other Threats to Belugas

It is not uncommon for groups of belugas to become trapped in areas that ice over, often restricting them to small holes in the ice for breathing. If the ice does not break up in time for them to escape, the whales face suffocation or starvation. In an unusual incident in 1984-85, 2,500–3,000 belugas were trapped in Russia's Senjavin Strait. Solid ice stretching for 12 miles blocked the path to open water. An estimated 1,000 belugas died during the event from hunting, hunger, lack of air or injuries. The efforts of the Russian icebreaker prevented the deaths of more of the animals (Ivashin and Shevlyagin, 1987).

Despite relative isolation from humans, human activities are negatively affecting beluga whales. These activities include habitat alteration in estuarine environments as a result of hydroelectric development in rivers (Katona et al., 1993; Leatherwood and Reeves, 1983). Other long term threats are competition with fisheries, off-shore oil exploration, vessel traffic, and pollution. (Balsiger, 2003; Caron and Smith, 1990; Finley et al., 1990; Leatherwood et al., 1988; Seaman at al., 1982; Thomas et al., 1990).

Contaminants

Contaminations by toxic chemicals pose one of the most serious long-term threats to some beluga populations. Adult belugas washing ashore in Canada's St. Lawrence River contain such high levels of PCBs and DDTs that they are considered hazardous waste under Canadian law (Beland et al, 1993). Researchers examining St. Lawrence beluga carcasses report an annual cancer rate for the animals higher than any other population of cetacean and similar to that of humans. (Martineau et al, 2002) Because belugas are at the top of the food chain in their environment, they consume more highly contaminated prey (Loseto et al., 2008; Wilson et al., 2005). These toxins may then be passed by mothers to their calves through the milk (Stern et al., 1994).

Noise
Because beluga whales have very acute hearing, especially at higher frequencies, noise can be threat to the animals. Human-caused underwater noise from a number of sources has increased significantly over the past decades (e.g. hydrocarbon and seismic exploration, ocean dredging, military activities, commercial shipping, fishing vessels, passenger ferry traffic and recreational boats) (Richardson et al. 1995; Erbe and Farmer 2000; Tyack 2008). This anthropogenic noise can disrupt echolocation and mask environmental sounds that the animals use for navigation and to identify predators and prey. It can trigger avoidance reactions and stress responses (Erbe and Farmer 2000; Tyack 2008). These sounds can interfere with the animals' acoustic communication (Erbe and Farmer 1998), which is critical to vocalizations used to maintain contact between mothers and calves (McKillop et al. 2010, Vergara, 2011).

Conservation
A majority of the research currently being conducted with beluga whales involves conservation and management of the species, through stock identification and distribution and genetic research (Brown Gladden et al., 1997; Reeves et al., 2002). There are over 150,000 belugas worldwide—a number much lower than historical population sizes. Large scale commercial hunting in the past has contributed to the decline. Belugas have a low rate of reproduction, which limits population recovery (COSEWIC, 2004; Kingsley, 1998).

In some parts of the species' range, particularly in Canada and Greenland, hunting has been a threat to beluga whales. The whales' use of estuaries and return to the same rivers makes them particularly vulnerable to overharvesting (Caron and Smith, 1990; COSEWIC, 2004). There are now moratoriums on hunting whales in the United States and Canada. Both countries make exceptions for limited subsistence hunting of belugas by people of native descent because of the importance of the whales to Inuit survival and culture (MacLean et al., 2002). In both countries, the government and Native groups cooperate to manage beluga populations.

Alliance Facilities' Contributions to Conservation
The study of belugas in zoological parks and aquariums increases understanding of factors threatening the sustainability of the species in the wild, so that steps can be taken to conserve and protect these animals. Much of this research would be difficult or impossible to conduct in the wild. It increases understanding of belugas' biology, physiology and disease pathogenesis, and creates baseline indicators to better understand issues threatening belugas in our oceans and rivers. Hearing and bioacoustics research

helps scientists understand responses, thresholds and the effects of underwater sound levels on these animals. Other research helps explain how beluga whales cope with the increasing pathogens and changing water temperatures in oceans and rivers. Additional studies address nutritional needs and metabolic rates of belugas that face increasing challenges for food sources.

The 2008 health assessments of beluga whales in Bristol Bay, Alaska, benefitted from safe handling methods developed at zoological parks and aquariums.

Georgia Aquarium staffed and sponsored research in Canada's Bristol Bay in 2011. The research focused on what belugas in the bay eat and their exposure to pollution—diet and pollution have long-term effects on beluga populations. This research helped provide comparisons to the challenges facing the endangered beluga population in Alaska's Cook Inlet.

Research on belugas in Russia's Sea of Okhotsk supported by Georgia Aquarium and several other parks and aquariums established the first quantitative information on the daily movements of the belugas in that location.

The belugas cared for at the Mystic Aquarium have cooperated in a number of studies, and new studies are initiated each year. Studies conducted since 2005 include artificial insemination, effects of the exposure of blood to organochlorine contaminants, testing of EKG and ultrasound tags for use on wild cetaceans, beluga cognition, metabolic rate determination, immune system function, body condition and others.

The SeaWorld & Busch Gardens Reproductive Research Center is a collaborative resource that pioneers technology and research to help with the management and conservation of wildlife and ensure genetic diversity in marine mammal populations in parks and aquariums throughout the world. Much of SeaWorld's recent research with beluga whales is aimed at gaining an understanding of the animals' reproductive endocrinology, anatomy, behavior and physiology. Tools developed through this reproductive monitoring and assisted breeding research can be integrated into in situ population management and conservation strategies (Steinman, K.J., O'Brien, J. K., Monfort, S. L. and Robeck, T. R., 2012; Osborn, S., Dalton, L., Dold, C. and Robeck, T., 2011; O'Brien, J. K. and Robeck, T. R., 2010; Robeck, T. R., Steinman, K. J., Montano, G. A., Katsumata, E., Osborn, S., Dalton, L., Dunn, J. L., Schmitt, T., Reidarson, T. and O'Brien, J. K., 2010; O'Brien J. K. and Robeck, T. R., 2010; Hill, Heather, 2009; O'Brien, J.K., K.J. Steinman, T. Schmitt, and T.R. Robeck, 2008).

Similarly, the belugas at the Vancouver Aquarium have been involved in studies of social behaviour (Recchia, 1994); masking of beluga whale vocalizations by icebreaker noise (Erbe, 1997, 1998), vocal development of beluga calves (Vergara and Barrett-Lennard, 2008), allonursing or the provision of milk to non-offspring by females (Leung et al, 2010), and contact calls in wild belugas and in human care (Vergara et al, 2010).

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