All About
Seabirds and Cetaceans

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Seabird

The Sooty Tern is highly aerial and marine and will spend months flying at sea, returning to land only for breeding.

Seabirds (also known as **marine birds**) are birds that have adapted to life within the marine environment. While seabirds vary greatly in lifestyle, behaviour and physiology, they often exhibit striking convergent evolution, as the same environmental problems and feeding niches have resulted in similar adaptations. The first seabirds evolved in the Cretaceous period, and modern seabird families emerged in the Paleogene.

In general, seabirds live longer, breed later and have fewer young than other birds do, but they invest a great deal of time in their young. Most species nest in colonies, which can vary in size from a few dozen birds to millions. Many species are famous for undertaking long annual migrations, crossing the equator or circumnavigating the Earth in some cases. They feed both at the ocean's surface and below it, and even feed on each other. Seabirds can be highly pelagic, coastal, or in some cases spend a part of the year away from the sea entirely.

Seabirds and humans have a long history together: they have provided food to hunters, guided fishermen to fishing stocks and led sailors to land. Many species are currently threatened by human activities, and conservation efforts are under way.

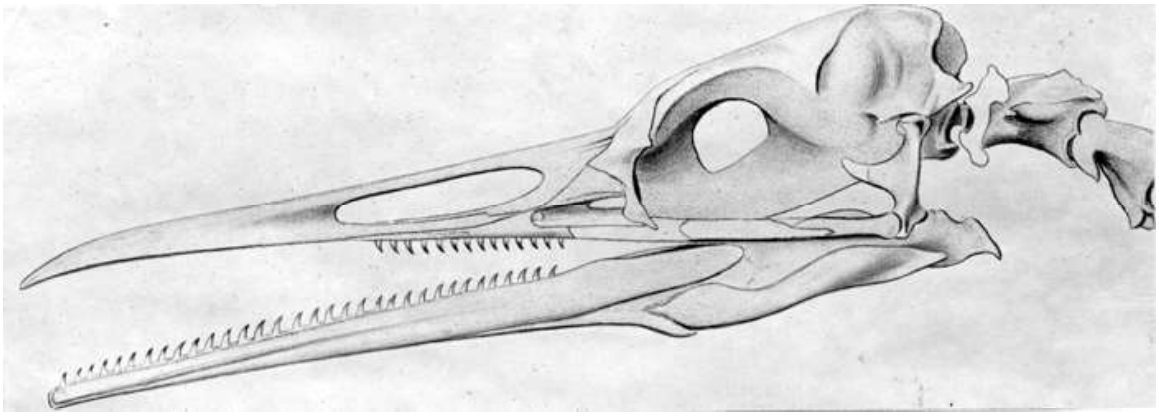
Classification of seabirds

There exists no single definition of which groups, families, and species are seabirds, and most definitions are in some way arbitrary. In the words of two seabird scientists, "The one common characteristic that all seabirds share is that they feed in saltwater; but, as seems to be true with any statement in biology, some do not." However, by convention all of the Sphenisciformes and Procellariiformes, all of the Pelecaniformes except the darters, and some of the Charadriiformes (the skuas, gulls, terns, auks and skimmers) are classified as seabirds. The phalaropes are usually included as well, since although they are waders ("shorebirds" in North America), two of the three species are oceanic for nine months of the year, crossing the equator to feed pelagically.

Loons and grebes, which nest on lakes but winter at sea, are usually categorized as water birds, not seabirds. Although there are a number of sea ducks in the family Anatidae which are truly marine in the winter, by convention they are usually excluded from the seabird grouping. Many waders (or shorebirds) and herons are also highly marine, living on the sea's edge (coast), but are also not treated as seabirds.

Evolution and fossil record

Seabirds, by virtue of living in a geologically depositional environment (that is, in the sea where sediments are readily laid down), are well represented in the fossil record. They are first known to occur in the Cretaceous Period, the earliest being the Hesperornithiformes, like *Hesperornis regalis*, a flightless loon-like seabird that dove in a fashion similar to grebes and loons (using its feet to move underwater) but had a beak filled with sharp teeth.



The Cretaceous seabird *Hesperornis*

While *Hesperornis* is not thought to have left descendants, the earliest modern seabirds also occurred in the Cretaceous, with a species called *Tytthostonyx glauconiticus*, which seems allied to the Procellariiformes and/or Pelecaniformes. In the Paleogene the seas were dominated by early Procellariidae, giant penguins and two extinct families, the Pelagornithidae and the Plotopteridae (a group of large seabirds that looked like the penguins). Modern genera began their wide radiation in the Miocene, although the genus *Puffinus* (which includes today's Manx Shearwater and Sooty Shearwater) might date back to the Oligocene. The highest diversity of seabirds apparently existed during the Late Miocene and the Pliocene. At the end of the latter, the oceanic food web had undergone a period of upheaval due to extinction of considerable numbers of marine species; subsequently, the spread of marine mammals seems to have prevented seabirds from reaching their erstwhile diversity.

Characteristics

Adaptations to life at sea

Seabirds have made numerous adaptations to living on and feeding in the sea. Wing morphology has been shaped by the niche an individual species or family has evolved, so that looking at a wing's shape and loading can tell a scientist about its life feeding behaviour. Longer wings and low wing loading are typical of more pelagic species, whilst diving species have shorter wings. Species such as the Wandering Albatross, which forage over huge areas of sea, have a reduced capacity for powered flight and are dependent on a type of gliding called dynamic soaring (where the wind deflected by waves provides lift) as well as slope soaring. Seabirds also almost always have webbed feet, to aid movement on the surface as well as assisting diving in some species. The Procellariiformes are unusual amongst birds in having a strong sense of smell, which is used to find widely distributed food in a vast ocean, and possibly to locate their colonies.

Salt glands are used by seabirds to deal with the salt they ingest by drinking and feeding (particularly on crustaceans), and to help them osmoregulate. The excretions from these

glands (which are positioned in the head of the birds, emerging from the nasal cavity) are almost pure sodium chloride.

Cormorants, like this Double-Crested Cormorant, have plumage that is partly wettable, allowing them to dive without fighting buoyancy.

With the exception of the cormorants and some terns, and in common with most other birds, all seabirds have waterproof plumage. However, compared to land birds, they have far more feathers protecting their bodies. This dense plumage is better able to protect the bird from getting wet, and cold is kept out by a dense layer of down feathers. The cormorants possess a layer of unique feathers that retain a smaller layer of air (compared to other diving birds) but otherwise soak up water. This allows them to swim without fighting the buoyancy that retaining air in the feathers causes, yet retain enough air to prevent the bird losing excessive heat through contact with water.

The plumage of most seabirds is less colourful than that of land birds, restricted in the main to variations of black, white or grey. A few species sport colourful plumes (such as the tropicbirds or some penguins), but most of the colour in seabirds appears in the bills and legs. The plumage of seabirds is thought in many cases to be for camouflage, both defensive (the colour of US Navy battleships is the same as that of Antarctic Prions, and in both cases it reduces visibility at sea) and aggressive (the white underside possessed by many seabirds helps hide them from prey below).

Diet and feeding

Seabirds evolved to exploit different food resources in the world's seas and oceans, and to a great extent, their physiology and behaviour have been shaped by their diet. These evolutionary forces have often caused species in different families and even orders to evolve similar strategies and adaptations to the same problems, leading to remarkable convergent evolution, such as that between auks and penguins. There are four basic feeding strategies, or ecological guilds, for feeding at sea: surface feeding, pursuit diving, plunge diving, and predation of higher vertebrates; within these guilds there are multiple variations on the theme.

Surface feeding

Many seabirds feed on the ocean's surface, as the action of marine currents often concentrates food such as krill, forage fish, squid or other prey items within reach of a dipped head.

Wilson's Storm Petrels pattering on the water's surface

Surface feeding itself can be broken up into two different approaches, surface feeding while flying (for example as practiced by gadfly petrels, frigatebirds and storm-petrels), and surface feeding whilst swimming (examples of which are practiced by fulmars, gulls, many of the shearwaters and gadfly petrels). Surface feeders in flight include some of the

most acrobatic of seabirds, which either snatch morsels from the water (as do frigate-birds and some terns), or "walk", pattering and hovering on the water's surface, as some of the storm-petrels do. Many of these do not ever land in the water, and some, such as the frigatebirds, have difficulty getting airborne again should they do so. Another seabird family that does not land while feeding is the skimmer, which has a unique fishing method: flying along the surface with the lower mandible in the water—this shuts automatically when the bill touches something in the water. The skimmer's bill reflects its unusual lifestyle, with the lower mandible uniquely being longer than the upper one.

Surface feeders that swim often have unique bills as well, adapted for their specific prey. Prions have special bills with filters called lamellae to filter out plankton from mouthfuls of water, and many albatrosses and petrels have hooked bills to snatch fast-moving prey. Gulls have more generalised bills that reflect their more opportunistic lifestyle.

Pursuit diving

The Chinstrap Penguin is a highly streamlined pursuit diver.

Pursuit diving exerts greater pressures (both evolutionary and physiological) on seabirds, but the reward is a greater area in which to feed than is available to surface feeders. Propulsion underwater can be provided by wings (as used by penguins, auks, diving petrels, and some other species of petrel) or feet (as used by cormorants, grebes, loons and several types of fish-eating ducks). Wing-propelled divers are generally faster than foot-propelled divers. In both cases, the use of wings or feet for diving has limited their utility in other situations: loons and grebes walk with extreme difficulty (if at all), penguins cannot fly, and auks have sacrificed flight efficiency in favour of underwater diving. For example, the razorbill (an Atlantic auk) requires 64% more energy to fly than a petrel of equivalent size. Many shearwaters are intermediate between the two, having longer wings than typical wing-propelled divers but heavier wing loadings than the other surface-feeding procellariids, leaving them capable of diving to considerable depths

while still being efficient long-distance travellers. The most impressive diving exhibited by shearwaters is found in the Short-tailed Shearwater, which has been recorded diving below 70 m. Some albatross species are also capable of some limited diving, with Light-mantled Sooty Albatrosses holding the record at 12 m. Of all the wing-propelled pursuit divers, the most efficient in the air are the albatrosses, and it is no coincidence that they are the poorest divers. This is the dominant guild in polar and subpolar environments, as it is energetically inefficient in warmer waters. With their poor flying ability, many wing-propelled pursuit divers are more limited in their foraging range than other guilds, especially during the breeding season when hungry chicks need regular feeding.

Plunge diving

Gannets, boobies, tropicbirds, some terns and Brown Pelicans all engage in plunge diving, taking fast moving prey by diving into the water from flight. Plunge diving allows birds to use the energy from the momentum of the dive to combat natural buoyancy (caused by air trapped in plumage), and thus uses less energy than the dedicated pursuit divers, allowing them to utilise more widely distributed food resources, for example, in impoverished tropical seas. In general, this is the most specialised method of hunting employed by seabirds; other non-specialists (such as gulls and skuas) may employ it but do so with less skill and from lower heights. In Brown Pelicans the skills of plunge diving take several years to fully develop—once mature, they can dive from 20 m (70 ft) above the water's surface, shifting the body before impact to avoid injury. It has been suggested that plunge divers are restricted in their hunting grounds to clear waters that afford a view of their prey from the air, and while they are the dominant guild in the tropics, the link between plunge diving and water clarity is inconclusive. Some plunge divers (as well as some surface feeders) are dependent on dolphins and tuna to push shoaling fish up towards the surface.

Kleptoparasitism, scavenging and predation

Some seabirds, like this South Polar Skua (left), will take the eggs of other birds. This skua is attempting to push an Adelie Penguin (right) off its nest.

This catch-all category refers to other seabird strategies that involve the next trophic level up. Kleptoparasites are seabirds that make a part of their living stealing food of other seabirds. Most famously, frigatebirds and skuas engage in this behaviour, although gulls, terns and other species will steal food opportunistically. The nocturnal nesting behaviour of some seabirds has been interpreted as arising due to pressure from this aerial piracy. Kleptoparasitism is not thought to play a significant part of the diet of any species, and is instead a supplement to food obtained by hunting. A study of Great Frigatebirds stealing from Masked Boobies estimated that the frigatebirds could at most obtain 40% of the food they needed, and on average obtained only 5%. Many species of gull will feed on seabird and sea mammal carrion when the opportunity arises, as will giant petrels. Some species of albatross also engage in scavenging: an analysis of regurgitated squid beaks has shown that many of the squid eaten are too large to have been caught alive, and include mid-water species likely to be beyond the reach of albatrosses. Some species will also feed on other seabirds; for example, gulls, skuas and giant petrels will often take eggs, chicks and even small adult seabirds from nesting colonies.

Life history

Seabirds' life histories are dramatically different from those of land birds. In general, they are K-selected, live much longer (anywhere between twenty and sixty years), delay

breeding for longer (for up to ten years), and invest more effort into fewer young. Most species will only have one clutch a year, unless they lose the first (with a few exceptions, like the Cassin's Auklet), and many species (like the tubenoses and sulids), only one egg a year.

Northern Gannet pair "billing" during courtship; like all seabirds except the phalaropes they maintain a pair bond throughout the breeding season.

Care of young is protracted, extending for as long as six months, among the longest for birds. For example, once Common Guillemot chicks fledge, they remain with the male parent for several months at sea. The frigatebirds have the longest period of parental care of any bird, with the chicks fledging after four to six months and with continued assistance after that for up to fourteen months. Due to the extended period of care, breeding occurs every two years rather than annually for some species. This life-history strategy has probably evolved both in response to the challenges of living at sea (collecting widely scattered prey items), the frequency of breeding failures due to unfavourable marine conditions, and the relative lack of predation compared to that of land-living birds.

Because of the greater investment in raising the young and because foraging for food may occur far from the nest site, in all seabird species except the phalaropes, both parents participate in caring for the young, and pairs are typically at least seasonally monogamous. Many species, such as gulls, auks and penguins, retain the same mate for several seasons, and many petrel species mate for life. The albatrosses and procellariids

which mate for life can take many years to form a pair bond before they breed, and the albatrosses have an elaborate breeding dance that is part of pair-bond formation.

Breeding and colonies

Common Murres breed on densely packed colonies on offshore rocks, islands and cliffs.

Ninety-five per cent of seabirds are colonial, and seabird colonies are amongst the largest bird colonies in the world, providing one of Earth's great wildlife spectacles. Colonies of over a million birds have been recorded, both in the tropics (such as Kiritimati in the Pacific) and in the polar latitudes (as in Antarctica). Seabird colonies occur exclusively for the purpose of breeding; non-breeding birds will only collect together outside the breeding season in areas where prey species are densely aggregated.

Seabird colonies are highly variable. Individual nesting sites can be widely spaced, as in an albatross colony, or densely packed as with a murre colony. In most seabird colonies, several different species will nest on the same colony, often exhibiting some niche separation. Seabirds can nest in trees (if any are available), on the ground (with or without nests), on cliffs, in burrows under the ground and in rocky crevices. Competition can be strong both within species and between species, with aggressive species such as Sooty Terns pushing less dominant species out of the most desirable nesting spaces. The tropical Bonin Petrel nests during the winter to avoid competition with the more

aggressive Wedge-tailed Shearwater. When the seasons overlap, the Wedge-tailed Shearwaters will kill young Bonin Petrels in order to use their burrows.

Many seabirds show remarkable site fidelity, returning to the same burrow, nest or site for many years, and they will defend that site from rivals with great vigour. This increases breeding success, provides a place for returning mates to reunite, and reduces the costs of prospecting for a new site. Young adults breeding for the first time usually return to their natal colony, and often nest close to where they hatched. This tendency, known as philopatry, is so strong that a study of Laysan Albatrosses found that the average distance between hatching site and the site where a bird established its own territory was 22 m; another study, this time on Cory's Shearwaters nesting near Corsica, found that of nine out of 61 male chicks that returned to breed at their natal colony bred in the burrow they were raised in, and two actually bred with their own mother.

Colonies are usually situated on islands, cliffs or headlands which land mammals have difficulty accessing. This is thought to provide protection to seabirds, which are often very clumsy on land. Coloniality often arises in types of bird which do not defend feeding territories (such as swifts, which have a very variable prey source); this may be a reason why it arises more frequently in seabirds. There are other possible advantages: colonies may act as information centres, where seabirds returning to the sea to forage can find out where prey is by studying returning individuals of the same species. There are disadvantages to colonial life, particularly the spread of disease. Colonies also attract the attention of predators, principally other birds, and many species attend their colonies nocturnally to avoid predation.

Migration

Pelicans flock flying over Havana Bay area. These birds come to Cuba every year from North America in the north hemisphere winter season.

Arctic Terns breed in the arctic and subarctic and winter in Antarctica.

Like many birds, seabirds often migrate after the breeding season. Of these, the trip taken by the Arctic Tern is the farthest of any bird, crossing the equator in order to spend the Austral summer in Antarctica. Other species also undertake trans-equatorial trips, both from the north to the south, and from south to north. The population of Elegant Terns, which nest off Baja California, splits after the breeding season with some birds travelling north to the Central Coast of California and some travelling as far south as Peru and Chile to feed in the Humboldt Current. The Sooty Shearwater undertakes an annual migration cycle that rivals that of the Arctic Tern; birds that nest in New Zealand and Chile and spend the northern summer feeding in the North Pacific off Japan, Alaska and California, an annual round trip of 40,000 statute miles (64,000 km).

Other species also migrate shorter distances away from the breeding sites, their distribution at sea determined by the availability of food. If oceanic conditions are unsuitable, seabirds will emigrate to more productive areas, sometimes permanently if the bird is young. After fledging, juvenile birds often disperse further than adults, and to different areas, so are commonly sighted far from a species' normal range. Some species, such as the auks, do not have a concerted migration effort, but drift southwards as the winter approaches. Other species, such as some of the storm-petrels, diving petrels and cormorants, never disperse at all, staying near their breeding colonies year round.

Away from the sea

While the definition of seabirds suggests that the birds in question spend their lives on the ocean, many seabird families have many species that spend some or even most of their lives inland away from the sea. Most strikingly, many species breed many tens, hundreds or even thousands of miles inland. Some of these species still return to the ocean to feed; for example, the Snow Petrel, the nests of which have been found 480 kilometres (300 mi) inland on the Antarctic mainland, are unlikely to find anything to eat around their breeding sites. The Marbled Murrelet nests inland in old growth forest, seeking huge conifers with large branches to nest on. Other species, such as the California Gull, nest and feed inland on lakes, and then move to the coasts in the winter. Some cormorant, pelican, gull and tern species have individuals that never visit the sea at all, spending their lives on lakes, rivers, swamps and, in the case of some of the gulls, cities and agricultural land. In these cases it is thought that these terrestrial or freshwater birds evolved from marine ancestors. Some seabirds, principally those that nest in tundra-like skuas and phalaropes, will migrate over land as well.

The more marine species, such as petrels, auks, and gannets, are more restricted in their habits, but are occasionally seen inland as vagrants. This most commonly happens to young inexperienced birds, but can happen in great numbers to exhausted adults after large storms, an event known as a *wreck*, where they provide prized sightings for birders.

Relationship with humans

Seabirds and fisheries

Seabirds have had a long association with both fisheries and sailors, and both have drawn benefits and disadvantages from the relationship.

Fishermen have traditionally used seabirds as indicators of both fish shoals, underwater banks that might indicate fish stocks, and of potential landfall. In fact, the known association of seabirds with land was instrumental in allowing the Polynesians to locate tiny landmasses in the Pacific. Seabirds have provided food for fishermen away from home, as well as bait. Famously, tethered cormorants have been used to catch fish directly. Indirectly, fisheries have also benefited from guano from colonies of seabirds acting as fertilizer for the surrounding seas.

Negative effects on fisheries are mostly restricted to raiding by birds on aquaculture, although long-lining fisheries also have to deal with bait stealing. There have been claims of prey depletion by seabirds of fishery stocks, and while there is some evidence of this, the effects of seabirds are considered smaller than that of marine mammals and predatory fish (like tuna).

Seabirds (mostly Northern Fulmars) flocking at a long-lining vessel

Some seabird species have benefited from fisheries, particularly from discarded fish and offal. These discards compose 30% of the food of seabirds in the North Sea, for example, and compose up to 70% of the total food of some seabird populations. This can have other impacts; for example, the spread of the Northern Fulmar through the United Kingdom is attributed in part to the availability of discards. Discards generally benefit surface feeders, such as gannets and petrels, to the detriment of pursuit divers like penguins.

Fisheries also have negative effects on seabirds, and these effects, particularly on the long-lived and slow-breeding albatrosses, are a source of increasing concern to conservationists. The bycatch of seabirds entangled in nets or hooked on fishing lines has had a big impact on seabird numbers; for example, an estimated 100,000 albatrosses are hooked and drown each year on tuna lines set out by long-line fisheries. Overall, many hundreds of thousands of birds are trapped and killed each year, a source of concern for some of the rarest species (for example, only about 2,000 Short-tailed Albatrosses are known to still exist). Seabirds are also thought to suffer when overfishing occurs.

Exploitation

The hunting of seabirds and the collecting of seabird eggs have contributed to the declines of many species, and the extinction of several, including the Great Auk and the Spectacled Cormorant. Seabirds have been hunted for food by coastal peoples throughout history—one of the earliest instances known is in southern Chile, where archaeological excavations in middens has shown hunting of albatrosses, cormorants and shearwaters from 5000 BP. This pressure has led to some species becoming extinct in many places; in particular, at least 20 species of an original 29 no longer breed on Easter Island. In the 19th century, the hunting of seabirds for fat deposits and feathers for the millinery trade

reached industrial levels. Muttonbirding (harvesting shearwater chicks) developed as important industries in both New Zealand and Tasmania, and the name of one species, the Providence Petrel, is derived from its seemingly miraculous arrival on Norfolk Island where it provided a windfall for starving European settlers. In the Falkland Islands, hundreds of thousands of penguins were harvested for their oil each year. Seabird eggs have also long been an important source of food for sailors undertaking long sea voyages, as well as being taken when settlements grow in areas near a colony. Eggers from San Francisco took almost half a million eggs a year from the Farallon Islands in the mid-19th century, a period in the islands' history from which the seabird species are still recovering.

Both hunting and egging continue today, although not at the levels that occurred in the past, and generally in a more controlled manner. For example, the Māori of Stewart Island/Rakiura continue to harvest the chicks of the Sooty Shearwater as they have done for centuries, using traditional methods (called *kaitiakitanga*) to manage the harvest, but now work with the University of Otago in studying the populations. In Greenland, however, uncontrolled hunting is pushing many species into steep decline.

Other threats

Other human factors have led to declines and even extinctions in seabird populations, colonies and species. Of these, perhaps the most serious are introduced species. Seabirds, breeding predominantly on small isolated islands, have lost many predator defence behaviours. Feral cats are capable of taking seabirds as large as albatrosses, and many introduced rodents, such as the Pacific Rat, can take eggs hidden in burrows. Introduced goats, cattle, rabbits and other herbivores can lead to problems, particularly when species need vegetation to protect or shade their young. Disturbance of breeding colonies by humans is often a problem as well—visitors, even well-meaning tourists, can flush brooding adults off a colony leaving chicks and eggs vulnerable to predators.

This Crested Auklet was oiled in Alaska during the M/V Selendang Ayu spill of 2004.

The build-up of toxins and pollutants in seabirds is also a concern. Seabirds, being apex predators, suffered from the ravages of DDT until it was banned; among other effects, DDT was implicated in embryo development problems and the skewed sex ratio of Western Gulls in southern California. Oil spills are also a threat to seabird species, as both a toxin and because the feathers of the birds become saturated by the oil, causing them to lose their waterproofing. Oil pollution threatens species with restricted ranges or already depressed populations.

Conservation

The threats faced by seabirds have not gone unnoticed by scientists or the conservation movement. As early as 1903, U.S. President Theodore Roosevelt was convinced of the need to declare Pelican Island in Florida a National Wildlife Refuge to protect the bird colonies (including the nesting Brown Pelicans), and in 1909 he protected the Farallon Islands. Today many important seabird colonies are given some measure of protection, from Heron Island in Australia to Triangle Island in British Columbia.

Island restoration techniques, pioneered by New Zealand, enable the removal of exotic invaders from increasingly large islands. Feral cats have been removed from Ascension Island, Arctic Foxes from many islands in the Aleutian Islands, and rats from Campbell

Island. The removal of these introduced species has led to increases in numbers of species under pressure and even the return of extirpated ones. After the removal of cats from Ascension Island, seabirds began to nest there again for the first time in over a hundred years.

Seabird mortality caused by long-line fisheries can be greatly reduced by techniques such as setting long-line bait at night, dying the bait blue, setting the bait underwater, increasing the amount of weight on lines and by using bird scarers, and their deployment is increasingly required by many national fishing fleets. The international ban on the use of drift nets has also helped reduce the mortality of seabirds and other marine wildlife.

One of the Millennium Projects in the UK was the Scottish Seabird Centre, near the important bird sanctuaries on Bass Rock, Fidra and the surrounding islands. The area is home to huge colonies of gannets, puffins, skuas and other seabirds. The centre allows visitors to watch live video from the islands as well as learn about the threats the birds face and how we can protect them, and has helped to significantly raise the profile of seabird conservation in the UK. Seabird tourism can provide income for coastal communities as well as raise the profile of seabird conservation. For example, the Northern Royal Albatross colony at Taiaroa Head in New Zealand attracts 40,000 visitors a year.

The plight of albatross and large seabirds, as well as other marine creatures, being taken as bycatch by long-line fisheries, has been addressed by a large number of non-governmental organizations (including BirdLife International, the American Bird Conservancy, and the Royal Society for the Protection of Birds). This led to the Agreement on the Conservation of Albatrosses and Petrels, a legally binding treaty designed to protect these threatened species, which has been ratified by eleven countries as of 2008 (namely Argentina, Australia, Chile, Ecuador, France, New Zealand, Norway, Peru, South Africa, Spain, and the United Kingdom).

Role in culture

Depiction of a pelican with chicks on a stained glass window, Saint Mark's Church, Gillingham, Kent.

Many seabirds are little studied and poorly known, due to living far out to sea and breeding in isolated colonies. However, some seabirds, particularly, the albatrosses and gulls, have broken into popular consciousness. The albatrosses have been described as "the most legendary of birds", and have a variety of myths and legends associated with them, and today it is widely considered unlucky to harm them, although the notion that sailors believed that is a myth which derives from Samuel Taylor Coleridge's famous poem, "The Rime of the Ancient Mariner", in which a sailor is punished for killing an albatross by having to wear its corpse around his neck.

Instead of the Cross the Albatross
About my neck was hung

Sailors did, however, consider it unlucky to touch a storm-petrel, especially one that has landed on the ship.

Gulls are one of the most commonly seen seabirds, given their use of human-made habitats (such as cities and dumps) and their often fearless nature. They therefore also have made it into the popular consciousness - they have been used metaphorically, as in *Jonathan Livingston Seagull* by Richard Bach, or to denote a closeness to the sea, such as their use in *The Lord of the Rings* – both in the insignia of Gondor and therefore Númenor (used in the design of the films), and to call Legolas to (and across) the sea. Other species have also made an impact; pelicans have long been associated with mercy and altruism because of an early Western Christian myth that they split open their breast to feed their starving chicks.

Seabird families

The following are the groups of birds normally classed as seabirds.

Sphenisciformes (Antarctic and southern waters; 16 species)

- Spheniscidae penguins

Procellariiformes (Tubenoses: pan-oceanic and pelagic; 93 species)

- Diomedeidae albatrosses
- Procellariidae fulmars, prions, shearwaters, gadfly and other petrels
- Pelacanoididae diving-petrels
- Hydrobatidae storm-petrels

Pelecaniformes (Worldwide; 57 species)

- Pelecanidae pelicans
- Sulidae gannets and boobies
- Phalacrocoracidae cormorants
- Fregatidae frigatebirds

- Phaethontidae tropicbirds

Charadriiformes (Worldwide; 305 species, but only the families listed are classed as seabirds.)

- Stercorariidae skuas
- Laridae gulls
- Sternidae terns
- Rhynchopidae skimmers
- Alcidae auks

Chapter- 2

Penguin

Penguins
Temporal range: Paleocene-Recent, 62–0 Ma

Gentoo Penguin, *Pygoscelis papua*

Scientific classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Aves
Infraclass:	Neognathae
Order:	**Sphenisciformes** Sharpe, 1891
Family:	**Spheniscidae** Bonaparte, 1831

Modern genera

Aptenodytes
Eudyptes
Eudyptula
Megadyptes
Pygoscelis
Spheniscus

Penguins (order **Sphenisciformes**, family **Spheniscidae**) are a group of aquatic, flightless birds living almost exclusively in the southern hemisphere, especially in Antarctica. Highly adapted for life in the water, penguins have countershaded dark and white plumage, and their wings have become flippers. Most penguins feed on krill, fish, squid, and other forms of sealife caught while swimming underwater. They spend about half of their lives on land and half in the oceans.

Although all penguin species are native to the southern hemisphere, they are not found only in cold climates, such as Antarctica. In fact, only a few species of penguin live so far south. Several species are found in the temperate zone, and one species, the Galápagos Penguin, lives near the equator.

The largest living species is the Emperor Penguin (*Aptenodytes forsteri*): adults average about 1.1 m (3 ft 7 in) tall and weigh 35 kg (75 lb) or more. The smallest penguin species is the Little Blue Penguin (*Eudyptula minor*), also known as the Fairy Penguin, which stands around 40 cm tall (16 in) and weighs 1 kg (2.2 lb). Among extant penguins, larger penguins inhabit colder regions, while smaller penguins are generally found in temperate or even tropical climates. Some prehistoric species attained enormous sizes, becoming as tall or as heavy as an adult human. These were not restricted to Antarctic regions; on the contrary, subantarctic regions harboured high diversity, and at least one giant penguin occurred in a region not quite 2,000 km south of the equator 35 mya, in a climate decidedly warmer than today.

Etymology

The etymology of the word "penguin" is highly disputed. The English word is not apparently of French, nor of Breton or Spanish origin (both attributed to the French word *pingouin* "auk"), but first appears in English or Dutch.

Some dictionaries suggest a derivation from Welsh *pen* "head" and *gwyn* "white", including the Oxford English Dictionary, the American Heritage Dictionary, the Century Dictionary and Merriam-Webster, on the basis that the name was originally applied to the great auk, which had white spots in front of its eyes (although its head was black).

An alternative etymology, found in a few English dictionaries, links the word to Latin *pinguis* "fat", from its perceived appearance. This etymology would be improbable if "penguin" were found to have been originally applied to the great auk, as some sources suggest.

A third theory states that the word is an alteration of "pen-wing", with reference to the rudimentary wings of great auks. This has been criticised for the unexplained nature of the alteration of the word.

Systematics and evolution

Living species and recent extinctions

Emperor Penguins (*Aptenodytes forsteri*), the largest living species.

Magellanic Penguins (*Spheniscus magellanicus*). The closed neck collar denotes this species.

Closeup of Southern Rockhopper Penguin (*Eudyptes chrysocome*).

The number of extant penguin species is debated. Depending on which authority is followed, penguin biodiversity varies between 17 and 20 living species, all in the subfamily **Spheniscinae**. Some sources consider the White-flippered Penguin a separate *Eudyptula* species, while others treat it as a subspecies of the Little Penguin; the actual situation seems to be more complicated. Similarly, it is still unclear whether the Royal Penguin is merely a color morph of the Macaroni penguin. The status of the Rockhopper penguins is also unclear.

Updated after Marples (1962), Acosta Hospitaleche (2004), and Ksepka *et al.* (2006).

Subfamily Spheniscinae – Modern penguins

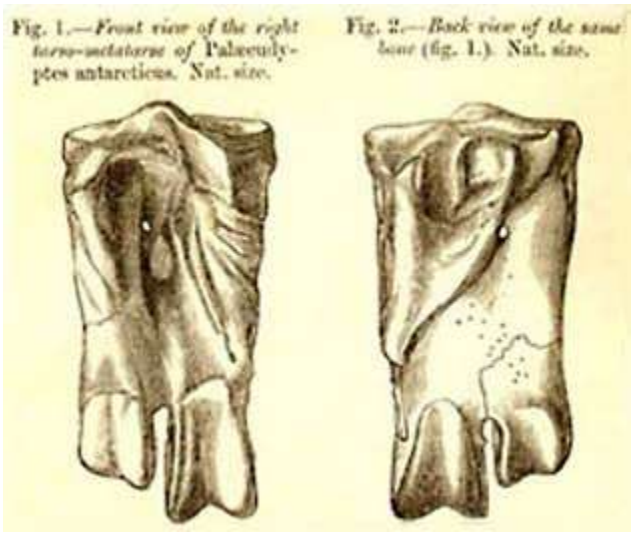
- *Aptenodytes* – Great penguins
  - King Penguin, *Aptenodytes patagonicus*
  - Emperor Penguin, *Aptenodytes forsteri*
- *Pygoscelis* – Brush-tailed penguins
  - Adélie Penguin, *Pygoscelis adeliae*
  - Chinstrap Penguin, *Pygoscelis antarctica*
  - Gentoo Penguin, *Pygoscelis papua*
- *Eudyptula* – Little penguins
  - Little Blue Penguin, *Eudyptula minor*
  - White-flippered Penguin, *Eudyptula albosignata* (provisional)
- *Spheniscus* – Banded penguins
  - Magellanic Penguin, *Spheniscus magellanicus*
  - Humboldt Penguin, *Spheniscus humboldti*
  - Galapagos Penguin, *Spheniscus mendiculus*
  - African Penguin, *Spheniscus demersus*
- *Megadyptes*
  - Yellow-eyed Penguin, *Megadyptes antipodes*
  - Waitaha Penguin, *Megadyptes waitaha* (extinct)
- *Eudyptes* – Crested penguins
  - Fiordland Penguin, *Eudyptes pachyrynchus*
  - Snares Penguin, *Eudyptes robustus*
  - Erect-crested Penguin, *Eudyptes sclateri*
  - Western Rockhopper Penguin, *Eudyptes chrysocome*
  - Eastern Rockhopper Penguin, *Eudyptes filholi*
  - Northern Rockhopper Penguin, *Eudyptes moseleyi*
  - Royal Penguin, *Eudyptes schlegeli* (disputed)
  - Macaroni Penguin, *Eudyptes chrysolophus*
  - Chatham Islands Penguin, *Eudyptes* sp. (extinct)

Fossil genera

Order Sphenisciformes

- **Basal and unresolved taxa** (all fossil)

- *Waimanu* – basal (Middle-Late Paleocene)
- *Perudyptes* (Middle Eocene of Atacama Desert, Peru) – basal?
- Spheniscidae gen. et sp. indet. CADIC P 21 (Leticia Middle Eocene of Punta Torcida, Argentina)
- *Delphinornis* (Middle/Late Eocene? – Early Oligocene of Seymour Island, Antarctica) – Palaeeudyptinae, basal, new subfamily 1?
- *Archaeospheniscus* (Middle/Late Eocene – Late Oligocene) – Palaeeudyptinae? New subfamily 2?
- *Marambiornis* (Late Eocene –? Early Oligocene of Seymour Island, Antarctica) – Palaeeudyptinae, basal, new subfamily 1?
- *Mesetaornis* (Late Eocene –? Early Oligocene of Seymour Island, Antarctica) – Palaeeudyptinae, basal, new subfamily 1?
- *Tonniornis* (Late Eocene –? Early Oligocene of Seymour Island, Antarctica)
- *Wimanornis* (Late Eocene –? Early Oligocene of Seymour Island, Antarctica)
- *Duntroonornis* (Late Oligocene of Otago, New Zealand) – possibly Spheniscinae
- *Korora* (Late Oligocene of S Canterbury, New Zealand)
- *Platydyptes* (Late Oligocene of New Zealand) – possibly not monophyletic; Palaeeudyptinae, Paraptenodytinae or new subfamily?
- Spheniscidae gen. et sp. indet. (Late Oligocene/Early Miocene of Hakataramea, New Zealand)
- *Madrynornis* (Puerto Madryn Late Miocene of Argentina) – possibly Spheniscinae
- *Pseudaptenodytes* (Late Miocene/Early Pliocene)
- *Dege* (Early Pliocene of South Africa) – possibly Spheniscinae
- *Marplesornis* (Early Pliocene) – possibly Spheniscinae
- *Nucleornis* (Early Pliocene of Duinfontain, South Africa) – possibly Spheniscinae
- *Inguza* (Late Pliocene) – probably Spheniscinae; formerly *Spheniscus predemersus*



A damaged tarsometatarsus of the prehistoric Narrow-flippered Penguin (*Palaeeudyptes antarcticus*).

- **Family Spheniscidae**
  - **Subfamily Palaeeudyptinae** – Giant penguins (fossil)
    - *Crossvallia* (Cross Valley Late Paleocene of Seymour Island, Antarctica) – tentatively assigned to this subfamily
    - *Anthropornis* (Middle Eocene? – Early Oligocene of Seymour Island, Antarctica) – tentatively assigned to this subfamily
      - Nordenskjoeld's Giant Penguin, *Anthropornis nordenskjoeldi*
    - *Icadyptes* (Late Eocene of Atacama Desert, Peru)
    - *Palaeeudyptes* (Middle/Late Eocene – Late Oligocene) – polyphyletic; some belong in other subfamilies
    - *Pachydyptes* (Late Eocene)
    - *Anthropodyptes* (Middle Miocene) – tentatively assigned to this subfamily
  - **Subfamily Paraptenodytinae** – Stout-footed penguins (fossil)
    - *Arthrodytes* (San Julian Late Eocene/Early Oligocene – Patagonia Early Miocene of Patagonia, Argentina)
    - *Paraptenodytes* (Early – Late Miocene/Early Pliocene)
  - **Subfamily Palaeospheniscinae** – Slender-footed penguins (fossil)
    - *Eretiscus* (Patagonia Early Miocene of Patagonia, Argentina)
    - *Palaeospheniscus* (Early? – Late Miocene/Early Pliocene) – includes *Chubutodyptes*

The Early Oligocene genus *Cruschedula* was formerly thought to belong to Spheniscidae, however reexamination of the holotype in 1943 resulted in the genus being placed in Accipitridae. Further examination in 1980 resulted in placement as Aves *incertae sedis*.

Taxonomy

Some recent sources apply the phylogenetic taxon SPHENISCIDAE to what here is referred to as Spheniscinae. Furthermore, they restrict the phylogenetic taxon *Sphenisciformes* to flightless taxa, and establish the phylogenetic taxon PANSPHENISCIFORMES as equivalent to the Linnean taxon Sphenisciformes, i.e., including any flying basal "proto-penguins" to be discovered eventually. Given that neither the relationships of the penguin subfamilies to each other nor the placement of the penguins in the avian phylogeny is presently resolved, this is confusing, so the established Linnean system is thus followed here.

Evolution

The evolutionary history of penguins is well-researched and represents a showcase of evolutionary biogeography; though as penguin bones of any one species vary much in size and few good specimens are known, the alpha taxonomy of many prehistoric forms still leaves much to be desired. Some seminal articles about penguin prehistory have been published since 2005, the evolution of the living genera can be considered resolved by now.

The basal penguins lived around the time of the Cretaceous–Tertiary extinction event somewhere in the general area of (southern) New Zealand and Byrd Land, Antarctica. Due to plate tectonics, these areas were at that time less than 1,500 kilometers (932 mi) apart rather than the 4,000 kilometers (2,485 mi) of today. The most recent common ancestor of penguins and their sister clade can be roughly dated to the Campanian–Maastrichtian boundary, around 70–68 mya. What can be said as certainly as possible in the absence of direct (i.e., fossil) evidence is that by the end of the Cretaceous, the penguin lineage must have been evolutionarily well distinct, though much less so morphologically; it is fairly likely that they were not yet entirely flightless at that time, as flightless birds have generally low resilience to the breakdown of trophic webs that follows the initial phase of mass extinctions because of their below-average dispersal capabilities.

The basal fossils

The oldest known fossil penguin species is *Waimanu manneringi*, which lived in the early Paleocene epoch of New Zealand, or about 62 mya. While they were not as well-adapted to aquatic life as modern penguins, *Waimanu* were generally loon-like birds but already flightless, with short wings adapted for deep diving. They swam on the surface using mainly their feet, but the wings were – as opposed to most other diving birds, living and extinct – already adapting to underwater locomotion.

Perudyptes from northern Peru was dated to 42 mya. An unnamed fossil from Argentina proves that by the Bartonian (Middle Eocene), some 39–38 mya, primitive penguins had spread to South America and were in the process of expanding into Atlantic waters.

Palaeeudyptines

During the Late Eocene and the Early Oligocene (40–30 mya), some lineages of gigantic penguins existed. Nordenskjoeld's Giant Penguin was the tallest, growing nearly 1.80 meters (6 ft) tall. The New Zealand Giant Penguin was probably the heaviest, weighing 80 kg or more. Both were found on New Zealand, the former also in the Antarctic farther eastwards.

Traditionally, most extinct species of penguins, giant or small, had been placed in the paraphyletic subfamily called Palaeeudyptinae. More recently, with new taxa being discovered and placed in the phylogeny if possible, it is becoming accepted that there were at least two major extinct lineages. One or two closely related ones occurred in Patagonia, and at least one other—which is or includes the paleeudyptines as recognized today – occurred on most Antarctic and subantarctic coasts.

But size plasticity seems to have been great at this initial stage of penguin radiation: on Seymour Island, Antarctica, for example, around 10 known species of penguins ranging in size from medium to huge apparently coexisted some 35 mya during the Priabonian (Late Eocene). It is not even known whether the gigantic palaeeudyptines constitute a monophyletic lineage, or whether gigantism was evolved independently in a much restricted Palaeeudyptinae and the Anthropornithinae – whether they were considered valid, or whether there was a wide size range present in the Palaeeudyptinae as delimited as usually done these days (i.e., including *Anthropornis nordenskjoeldi*). The oldest well-described giant penguin, the 5-foot-tall *Icadyptes salasi*, actually occurred as far north as northern Peru about 36 mya.

In any case, the gigantic penguins had disappeared by the end of the Paleogene, around 25 mya. Their decline and disappearance coincided with the spread of the Squalodontoidea and other primitive, fish-eating toothed whales, which certainly competed with them for food, and were ultimately more successful. A new lineage, the Paraptenodytes, which includes smaller but decidedly stout-legged forms, had already arisen in southernmost South America by that time. The early Neogene saw the emergence of yet another morphotype in the same area, the similarly sized but more gracile Palaeospheniscinae, as well as the radiation that gave rise to the penguin biodiversity of our time.

Origin and systematics of modern penguins

Modern penguins consititute two undisputed clades and another two more basal genera with more ambiguous relationships. The origin of the Spheniscinae lies probably in the latest Paleogene, and geographically it must have been much the same as the general area in which the order evolved: the oceans between the Australia-New Zealand region and the Antarctic. Presumedly diverging from other penguins around 40 mya, it seems that the Spheniscinae were for quite some time limited to their ancestral area, as the well-researched deposits of the Antarctic Peninsula and Patagonia have not yielded Paleogene

fossils of the subfamily. Also, the earliest spheniscine lineages are those with the most southern distribution.

The genus *Aptenodytes* appears to be the basalmost divergence among living penguins they have bright yellow-orange neck, breast, and bill patches; incubate by placing their eggs on their feet, and when they hatch the chicks are almost naked. This genus has a distribution centered on the Antarctic coasts and barely extends to some subantarctic islands today.

Pygoscelis contains species with a fairly simple black-and-white head pattern; their distribution is intermediate, centered on Antarctic coasts but extending somewhat northwards from there. In external morphology, these apparently still resemble the common ancestor of the Spheniscinae, as *Aptenodytes'* autapomorphies are in most cases fairly pronounced adaptations related to that genus' extreme habitat conditions. As the former genus, *Pygoscelis* seems to have diverged during the Bartonian, but the range expansion and radiation that led to the present-day diversity probably did not occur until much later; around the Burdigalian stage of the Early Miocene, roughly 20–15 mya.

The genera *Spheniscus* and *Eudyptula* contain species with a mostly subantarctic distribution centered on South America; some, however, range quite far northwards. They all lack carotenoid coloration, and the former genus has a conspicuous banded head pattern; they are unique among living penguins by nesting in burrows. This group probably radiated eastwards with the Antarctic Circumpolar Current out of the ancestral range of modern penguins throughout the Chattian (Late Oligocene), starting approximately 28 mya. While the two genera separated during this time, the present-day diversity is the result of a Pliocene radiation, taking place some 4–2 mya.

The *Megadyptes–Eudyptes* clade occurs at similar latitudes (though not as far north as the Galapagos Penguin), has its highest diversity in the New Zealand region, and represent a westward dispersal. They are characterized by hairy yellow ornamental head feathers; their bills are at least partly red. These two genera diverged apparently in the Middle Miocene (Langhian, roughly 15–14 mya), but again, the living species of *Eudyptes* are the product of a later radiation, stretching from about the late Tortonian (Late Miocene, 8 mya) to the end of the Pliocene.

The geographical and temporal pattern or spheniscine evolution corresponds closely to two episodes of global cooling documented in the paleoclimatic record. The emergence of the subantarctic lineage at the end of the Bartonian corresponds with the onset of the slow period of cooling that eventually led to the ice ages some 35 million years later. With habitat on the Antarctic coasts declining, by the Priabonian more hospitable conditions for most penguins existed in the subantarctic regions rather than in Antarctica itself. Notably, the cold Antarctic Circumpolar Current also started as a continuous circumpolar flow only around 30 mya, on the one hand forcing the Antarctic cooling, and on the other facilitating the eastward expansion of *Spheniscus* to South America and eventually beyond. Despite this, there is no fossil evidence to support the idea a crown radiation from the antarctic continent in the Paleogene.

Later, an interspersed period of slight warming was ended by the Middle Miocene Climate Transition, a sharp drop in global average temperature from 14–12 mya, and similar abrupt cooling events followed at 8 mya and 4 mya; by the end of the Tortonian, the Antarctic ice sheet was already much like today in volume and extent. The emergence of most of today's subantarctic penguin species almost certainly was caused by this sequence of Neogene climate shifts.

Relationship to other bird orders

Penguin ancestry beyond *Waimanu* remains unknown and not well-resolved by molecular or morphological analyses. The latter tend to be confounded by the strong adaptive autapomorphies of the Sphenisciformes; a sometimes perceived fairly close relationship between penguins and grebes is almost certainly an error based on both groups' strong diving adaptations, which are homoplasies. On the other hand, different DNA sequence datasets do not agree in detail with each other either.

Humboldt Penguins in an aquarium. The penguin is an accomplished swimmer, having flippers instead of wings.

What seems clear is that penguins belong to a clade of Neoaves (living birds except paleognaths and fowl) that comprises what is sometimes called "higher waterbirds" to distinguish them from the more ancient waterfowl. This group contains such birds as storks, rails, and the seabirds, with the possible exception of the Charadriiformes.

Inside this group, penguin relationships are far less clear. Depending on the analysis and dataset, a close relationship to Ciconiiformes or to Procellariiformes has been suggested. Some think the penguin-like plotopterids (usually considered relatives of anhingas and cormorants) may actually be a sister group of the penguins, and that penguins may have ultimately shared a common ancestor with the Pelecaniformes and consequently would have to be included in that order, or that the plotopterids were not as close to other pelecaniforms as generally assumed, which would necessitate splitting the traditional Pelecaniformes in three.

Anatomy and physiology

Orcas swim by an iceberg with Adelie Penguins in the Ross Sea, Antarctica. The Drygalski ice tongue is visible in the background.

Penguins are superbly adapted to aquatic life. Their vestigial wings have become flippers, useless for flight in the air. In the water, however, penguins are astonishingly agile. Penguins' swimming looks very similar to bird's flight in the air. Within the smooth plumage a layer of air is preserved, ensuring buoyancy. The air layer also helps insulate the birds in cold waters. On land, penguins use their tails and wings to maintain balance for their upright stance.

All penguins are countershaded for camouflage – that is, they have black backs and wings with white fronts. A predator looking up from below (such as an orca or a leopard seal) has difficulty distinguishing between a white penguin belly and the reflective water surface. The dark plumage on their backs camouflages them from above.

Diving penguins reach 6 to 12 km/h (3.7 to 7.5 mph), though there are reports of velocities of 27 km/h (17 mph) (which are more realistic in the case of startled flight). The small penguins do not usually dive deep; they catch their prey near the surface in dives that normally last only one or two minutes. Larger penguins can dive deep in case of need. Dives of the large Emperor Penguin have been recorded reaching a depth of 565 m (1,870 ft) for up to 22 minutes.

Penguins either waddle on their feet or slide on their bellies across the snow, a movement called "tobogganing", which conserves energy while moving quickly. They also jump with both feet together if they want to move more quickly or cross steep or rocky terrain.

Penguins have an average sense of hearing for birds; this is used by parents and chicks to locate one another in crowded colonies. Their eyes are adapted for underwater vision, and are their primary means of locating prey and avoiding predators; in air it has been suggested that they are nearsighted, although research has not supported this hypothesis.

Gentoo Penguin swimming underwater at Nagasaki Penguin Aquarium.

Penguins have a thick layer of insulating feathers that keeps them warm in water (heat loss in water is much greater than in air). The Emperor Penguin (the largest penguin) has the largest body mass of all penguins, which further reduces relative surface area and heat loss. They also are able to control blood flow to their extremities, reducing the amount of blood that gets cold, but still keeping the extremities from freezing. In the extreme cold of the Antarctic winter, the females are at sea fishing for food leaving the males to brave

the weather by themselves. They often huddle together to keep warm and rotate positions to make sure that each penguin gets a turn in the center of the heat pack.

They can drink salt water because their supraorbital gland filters excess salt from the bloodstream. The salt is excreted in a concentrated fluid from the nasal passages.

The Auk of the Northern Hemisphere is superficially similar to penguins. They are not related to the penguins at all, but considered by some to be a product of moderate convergent evolution.

Isabelline penguins

Isabelline Adélie Penguin on Gourdin Island.

Perhaps one in 50,000 penguins (of most species) are born with brown rather than black plumage. These are called isabelline penguins, possibly in reference to the legend that the archduchess Isabella of Austria vowed not to change her undergarments until her husband united the northern and southern Low Countries by taking the city of Ostend—which took three years to accomplish. Isabellinism is different from albinism. Isabelline penguins tend to live shorter lives than normal penguins, as they are not well-camouflaged against the deep, and are often passed over as mates.

Distribution and habitat

Although all penguin species are native to the southern hemisphere, they are not found only in cold climates, such as Antarctica. In fact, only a few species of penguin actually live so far south. At least 10 species live in the temperate zone; one, the Galápagos Penguin, lives as far north as the Galápagos Islands, but this is only made possible by the cold, rich waters of the Antarctic Humboldt Current that flows around these islands.

Several authors have suggested that penguins are a good example of Bergmann's Rule where larger bodied populations live at higher latitudes than smaller bodied populations. There is some disagreement about this, and several other authors have noted that there are fossil penguin species that contradict this hypothesis and that ocean currents and upwellings are likely to have had a greater effect on species diversity than latitude alone.

Major populations of penguins are found in: Antarctica, Australia, New Zealand, South America, and South Africa.

Behaviour

Chinstrap Penguins in Antarctica.

Breeding

Penguins for the most part breed in large colonies, the exceptions being the Yellow-eyed and Fiordland species; these colonies may range in size from as few as a 100 pairs for Gentoo Penguins, to several hundred thousand in the case of King, Macaroni and Chinstrap Penguins. Living in colonies results in a high level of social interaction between birds, which has led to a large repertoire of visual as well as vocal displays in all penguin species. *Agonistic* displays are those intended to confront or drive off, or alternately appease and avoid conflict with, other individuals.

Penguins form monogamous pairs for a breeding season, though the rate the same pair recouples varies drastically. Most penguins lay two eggs in a clutch, although the two largest species, the Emperor and the King Penguins, lay only one. With the exception of the Emperor Penguin, all penguins share the incubation duties. These incubation shifts can last days and even weeks as one member of the pair feeds at sea.

Penguins generally only lay one brood; the exception is the Little Penguin, which can raise two or three broods in a season.

Penguin eggs are smaller than any other bird species when compared proportionally to the weight of the parent birds; at 52 g (2 oz), the Little Penguin egg is 4.7% of its mothers' weight, and the 450 g (1 lb) Emperor Penguin egg is 2.3%. The relatively thick shell forms between 10 and 16 % of the weight of a penguin egg, presumably to minimise risk of breakage in an adverse nesting environment. The yolk, too, is large, and comprises 22–31 % of the egg. Some yolk often remains when a chick is born, and is thought to help sustain it if parents are delayed in returning with food.

When mothers lose a chick, they sometimes attempt to "steal" another mother's chick, usually unsuccessfully as other females in the vicinity assist the defending mother in keeping her chick. In some species, such as Emperor Penguins, young penguins assemble in large groups called crèches.

A penguin encounters a human during Antarctic summer.

Penguins and humans

Cook on the *Endurance* preparing a penguin for consumption

Penguins seem to have no special fear of humans, and have approached groups of explorers without hesitation. This is probably because penguins have no land predators in Antarctica or the nearby offshore islands. Instead, penguins are at risk at sea from predators such as the leopard seal. Typically, penguins do not approach closer than about 3 meters (10 ft) at which point they become nervous. This is also the distance that Antarctic tourists are told to keep from penguins (tourists are not supposed to approach closer than 3 meters, but are not expected to withdraw if the penguins come closer).

Chapter- 3

Procellariiformes

Procellariiformes
Temporal range: Eocene–Present
Possible Cretaceous record

Cape Petrel *Daption capense*

Scientific classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Aves
Infraclass:	Neognathae
Superorder:	Neoaves
Order:	**Procellariiformes**

Fürbringer, 1888

Families
Procellariidae
Diomedeidae
Hydrobatidae
Pelecanoididae

Diversity
4 Families, 23 Genera, 108 Species

Procellariiformes is an order of seabirds that comprises four families: the albatrosses, procellariids, storm-petrels and diving petrels. Formerly called **Tubinares** and still called **tubenoses** in English, they are often referred to collectively as the **petrels**, a term that has been applied to all Procellariiformes or more commonly all the families except the albatrosses. They are almost exclusively pelagic (feeding in the open ocean). They have a cosmopolitan distribution across the world's oceans, with the highest diversity being around New Zealand.

Procellariiformes are colonial, mostly nesting on remote predator-free islands. The larger species nest on the surface, while most smaller species nest in natural cavities and burrows. They exhibit strong philopatry, returning to their natal colony to breed and returning to the same nesting site over many years. Procellariiformes are monogamous and form long-term pair bonds which are formed over several years and may last for the life of the pair. Only a single egg is laid per nesting attempt, and usually only a single nesting attempt is made per year, although the larger albatrosses may only nest once every two years. Both parents participate in incubation and chick rearing. Incubation times are long compared to other birds, as are fledgling periods. Once a chick has fledged there is no further parental care.

Procellariiformes have had a long relationship with humans. They have been important food sources for many people, and continue to be hunted as such in some parts of the world. They have also been the subject of numerous cultural depictions, particularly albatrosses. Procellariiformes are one of the most endangered bird taxa, with many species threatened with extinction due to introduced predators in their breeding colonies, marine pollution and the danger of fisheries by-catch. Scientists, conservationists, fishermen and governments around the world are working to reduce the threats posed to them, and these efforts have led to the signing of the Agreement on the Conservation of Albatrosses and Petrels, a legally binding international treaty signed in 2001.

Etymology

Procellariiformes comes from the Latin word *procella* which means **a violent wind** or **a storm**, and *iformes* which is added to symbolize **order**. Therefore a violent wind or a storm refers to the fact that members of this order like stormy and windy weather.

Biology

Distribution and movements

The Procellariiformes have a cosmopolitan distribution across the world's oceans and seas, although at the levels of family and genus there are some clear patterns. Antarctic Petrels, *Thalassoica antarctica*, have to fly over 100 mi (160 km) to get to the ocean from their breeding colonies in Antarctica, and Northern Fulmars breed on the northeastern tip of Greenland, the furthest north piece of land. The most cosmopolitan family is the Procellariidae, although within that family there are some gaps in distribution. The gadfly petrels, *Pterodroma*, have a generally tropical and temperate distribution, whereas the fulmarine petrels are mostly polar with some temperate species. The majority of the fulmarine petrels, along with the prions, are confined to the southern hemisphere. The shearwaters have the most widespread distribution, although they are absent from the Pacific north of Japan as breeding birds.

The storm-petrels are almost as widespread as the procellariids, and fall into two distinct subfamilies; the Oceanitinae have a mostly southern hemisphere distribution and the Hydrobatinae are found mostly in the northern hemisphere. Amongst the albatrosses the majority of the family is restricted to the southern hemisphere, feeding and nesting in cool temperate areas, although one genus, *Phoebastria*, ranges across the north Pacific. The family is absent from the north Atlantic, although fossil records indicate they bred there once. Finally the diving-petrels are restricted to the southern hemisphere.

The various species within the order have a variety of migration strategies. Some species undertake regular trans-equatorial migrations, such as the Sooty Shearwater which annually migrates from its breeding grounds in New Zealand and Chile to the North Pacific off Japan, Alaska and California, an annual round trip of 64,000 km (40,000 mi), the longest measured annual migration of any bird. A number of other petrel species undertake trans-equatorial migrations, including the Wilson's Storm-petrel and the Providence Petrel, but no albatrosses cross do due to their reliance on wind assisted flight. There are other long-distant migrants within the order; Swinhoe's Storm-petrels breed in the western Pacific and migrates to the western Indian Ocean, and Bonin Petrels nesting in Hawaii migrate to the coast of Japan during the non-breeding season.

Morphology and flight

The Southern Royal Albatross is the largest of the Procellariiformes

Procellariiformes range in size from the very large Wandering Albatross, at 11 kg (24 lb) and a 3.6 m (12 ft) wingspan, to the tiny Least Storm-petrel, at 20 g (0.71 oz) and a 32 cm (13 in)wingspan. They have their nostrils enclosed in one or two tubes on their straight, deeply grooved bills with hooked tips. The beaks are made up from several plates. Wings are long and narrow; feet are webbed, and the hind toe is undeveloped or non-existent. Plumage is predominantly black, white and grey.

The order has a few unifying characteristics, starting with their tubular nasal passage which is used for olfaction. This ability to smell helps to locate patchily distributed prey at sea and may also help locate their nests within nesting colonies. The structure of the bill, which contains seven to nine distinct horny plates, is anothery unifying feature, although there are differences within the order. Petrels have a plate called Maxillary unguis that forms a hook on their upper bill. The smaller members of the order have a comb-like lower bill, made by the tomia plate, for plankton feeding. Finally, they have a stomach oil stored in their provemtriculus that can be used as a food source during their long flights and also as a defense mechanism.

Procellariiformes have a need to lower their salt content due to their drinking of ocean water. All birds have an enlarged nasal gland at the base of the bill, above they eyes. This gland is inactive in species that don't require it; however the Procellariiformes do require

its use. Scientists are uncertain as to its exact processes, but do know in general terms that it removes salt that forms a 5% saline solution that drips out of their nose or is forcibly ejected in some petrels.

The White-faced Storm-petrel moves across the water's surface in a series of bounding leaps.

Most albatrosses and procellariids use two techniques minimise exertion while flying, namely, dynamic soaring and slope soaring. The albatrosses and giant petrels share a morphological adaptation to aid in flight, a sheet of tendon which locks the wing when fully extended, allowing the wing to be kept up and out without any muscle effort. Amongst the Oceanitinae storm-petrels there are two unique flight patterns, one being surface pattering. In this they move across the water surface holding and moving their feet on the water's surface while holding steady above the water, and remaining stationary by hovering with rapid fluttering or by using the wind to anchor themselves in place. A similar flight method is thought to have been used by the extinct petrel family Diomedeoididae. The White-faced Storm-petrel possesses a unique variation on pattering, holding its wings motionless and at an angle into the wind it pushes itself off the water's surface in a succession of bounding jumps.

Most are unable to walk well on land, and many species visit their remote breeding islands only at night. The exceptions are the huge albatrosses, several of the gadfly petrels and shearwaters and the fulmar-petrels. The latter can disable even large predatory birds with their obnoxious stomach oil, which they can project some distance. This

stomach oil is a digestive residue created in the foregut of all tubenoses except the diving petrels, and is used mainly for storage of energy rich food as well as for defence.

Breeding behaviour

Breeding colonies

Christmas Shearwaters are one of the surface nesting tropical Procellariiformes.

All Procellariiformes are colonial, predominantly breeding on offshore or oceanic islands. The few species that nest on continents do so in inhospitable environments such as dry deserts or on Antarctica. These colonies can vary from the widely spaced colonies of the giant petrels to the dense 3.6 million strong colonies of Leach's Storm Petrels. For almost all species the need to breed is the only reason that Procellariiformes return to land at all. Some of the larger petrels have to nest on windswept locations as they require wind to take off and forage for food. Within the colonies pairs defend usually small territories (the giant petrels and some albatrosses can have very large territories) which is either the small area around the nest or a burrow. Competition between pairs can be intense, as can competition between species, particularly for burrows. Larger species of petrels will even kill the chicks and even adults of smaller species in disputes over burrows. Burrows and natural crevices are most commonly used by the smaller species; all the storm-petrels and diving-petrels are cavity nesters, as are many of the procellariids. The fulmarine petrels and some tropical gadfly petrels and shearwaters are surface nesters, as are all the albatrosses. Colonies are often composed of several different species of both petrels and other seabirds.

Procellariiformes show high levels of philopatry, both site fidelity and natal philopatry. Natal philopatry is the tendency of an individual bird to return to its natal colony to breed, often many years after leaving the colony as a chick. This tendency has been shown through ringing studies and mitochondrial DNA studies. In the ringing studies birds ringed as chicks are recapatured close to their original nests, a tendency which can be extreme at times; in Laysan Albatross the average distance between hatching site and the site where a bird established its own territory was 22 m (72 ft), and a study of Cory's Shearwaters nesting near Corsica found that of nine out of 61 male chicks that returned to breed at their natal colony actually bred in the burrow they were raised in. Mitochondrial DNA provides evidence of restricted gene flow between different colonies, strongly suggesting philopatry.

The other type of philopatry exhibited is site fidelity, where pairs of birds return to the same nesting site for a number of years. Among the most extreme examples known of this tendency was the fidelity of a ringed Northern Fulmar which returned to the same site for 25 years. The average number of birds returning to the same nesting sites is high in all species studied, with figures of around 91% for Bulwer's Petrels, and 85% of males and 76% of females for Cory's Shearwaters (after a successful breeding attempt).

Pair bonds and life history

Wandering Albatrosses performing their mating dances on the Kerguelen Islands.

Procellariiformes are monogamous breeders and form long term pair-bonds. These pair bonds take several years to develop in some species, particularly with the albatrosses.

Having formed they will last for many breeding seasons, in some cases for the life of the pair. Petrel courtship can be an elaborate affair. It reaches its extreme with the albatrosses, where pairs of albatrosses spend many years perfecting and elaborate mating dances. These dances are composed of synchronised performances of various actions such as preening, pointing, calling, bill clacking, staring, and combinations of such behaviours (like the sky-call). Each particular pair will develop their own individual version of the dance. The breeding behaviour of other Procellariiformes are less elaborate, although similar bonding behaviours are involved, particularly for the surface nesting procellariids. These can involve synchronised flights, mutual preening and calling. Calls are important for helping birds locate potential mates and distinguish between species and may also serve a function in helping individuals assess the quality of potential mates. After pair formation has occurred calls also serve to help them reunite, the ability of individuals to recognise their own mate has also been demonstrated in several species.

Procellariiformes are k-selected. Breeding is delayed for several years after fledging, sometimes for as long as eight or ten years in the case of larger species. Once they begin breeding they make only a single breeding attempt per nesting season, even if the egg is lost early on in the season they will seldom relay. Large amounts of effort are placed into laying a single (proportionally) large egg and raising a single chick. Procellariiformes are long-lived, the longest living albatross known survived for 51 years but was probably older, even the tiny storm-petrels are known to have survived for 30 years.

Nesting and chick rearing

A semi-precocial Wedge-tailed Shearwater chick with guarding parent.

The majority of Procellariiformes nest once a year and do so seasonally. Some tropical shearwaters, like the Christmas Shearwater, are able to nest on cycles slightly shorter than a year, and the large great albatrosses (genus *Diomedea*) nest in consecutive years. Most temperate and polar species nest over the spring-summer, although some albatrosses and procellariids nest over the winter. In the tropics some species breed throughout the year, but most nest in discreet periods. Procellariiformes return to the nesting colonies several months before laying, and attend their nesting sites regularly before copulation. Prior to laying females embark on a pre-laying exodus to build up reserves of energy to lay the comparably large egg.

When the female returns and lays the male takes the first incubation stint and the female returns to sea. Incubation is shared between both sexes. The duration of individual stints varies from just a few days to several weeks, during which the incubating bird can lose a considerable amount of weight. The incubation period varies from species to species, around 40 days for the smallest storm-petrels but longer for the largest species; for albatrosses it can be as long as 70 to 80 days, which is the longest incubation period of any bird.

Upon hatching the chicks are semi-precocial, having open eyes, a dense covering of white or grey down feathers, and the ability to move around the nesting site. After hatching the incubating adult remains with the chick for a number of days, a period known as the guard phase. In the case of most burrow-nesting species this is only until the chick is able to thermoregulate, usually two or three days. Diving-petrel chicks take longer to thermoregulate and have a longer guard phase than other burrow nesters. However, for surface nesting species, which have to deal with a greater range of weather and also have to content with predators like skuas and frigatebirds, and consequently have longer guard phases, as long as two weeks in procellariids and three weeks in albatrosses.

A Laysan Albatross feeds its chick. The parent pumps food from a modified foregut, the proventriculus, and the chick catches the meal in its lower mandible.

The chick is fed by both parents. Chicks are fed on fish, squid, krill and stomach oil. Stomach oil is oil composed of neutral dietary lipids that are the residue created by digestion of the prey items. As an energy source for chicks it has several advantages over undigested prey, its calorific value is around 9.6 kcal per gram, which is only slightly lower than the value for diesel oil. This can be a real advantage for species that range over huge distances to provide food for hungry chicks. The oil is also used in defence. All Procellariiformes create stomach oil except the diving-petrels.

The chick fledges between two and nine months almost twice as long as a gull of the same body mass. The reasons behind the length of time are associated with the distance from the breeding site to food. First, there are not a lot of predators at the nesting colonies, therefore there is no pressure to fledge quickly. Second, the time between feedings is long due to the distance and a chick the had a higher growth rate would stand a better chance of starving to death. The durations between feedings vary between species and during the stages of development. Small feeds are frequent during the guard phase, but afterwards become less frequent.

Relationship with humans

Role in culture

The most important family in terms of cultural importance is the albatrosses, which have been described by one author as "the most legendary of birds". Albatrosses have featured in poetry in the form of Samuel Taylor Coleridge's famous poem *The Rime of the Ancient Mariner*, which in turn gave rise to the usage of albatross as metaphor for a burden. There are few instances of petrels in culture, although there are sailors legends regarding the storm-petrels, which are considered to warn of oncoming storms. In general petrels were considered to be "soul birds", representing the souls of drowned sailors, and it was considered unlucky to touch them. However, there also has been the belief that albatrosses were good omens and to kill one would bring bad luck.

In Russian, many petrel species from the Hydrobatidae and Pelecanoididae families of the order Procellariiformes are known as *burevestnik*, which literally means 'the announcer of the storm'. When in 1901, the Russian writer Maxim Gorky turned to the imagery of Subantarctic avifauna to describe Russian society's attitudes to the coming revolution, he used a *storm-announcing* petrel as the lead character of a poem that soon became popular in the revolutionary circles as "the battle anthem of the revolution". Although the species called "stormy petrel" in English is not one of those to which the *burevestnik* name is applied in Russian (it, in fact, is known in Russian as an entirely un-romantic *kachurka*), the English translators uniformly used the "stormy petrel" image in their translations of the poem, usually known in English as *The Song of the Stormy Petrel*.

Exploitation

Albatrosses and petrels have been important food sources for humans for as long as people have been able to reach their remote breeding colonies. Amongst the earliest known examples of this is the remains of shearwaters and albatrosses along with those of other seabirds in 5,000 year old middens in Chile, although it is likely that they were exploited prior to this. Since then many other marine cultures, both subsistence and industrial, have exploited Procellariiformes, in some cases almost to extinction. Some cultures continue to harvest shearwaters (a practice known as muttonbirding); for example the Māori of New Zealand,who use a sustainable traditional method known as *kaitiakitanga*. In Alaska, residents of Kodiak Island harpoon Short-tailed Albatrosses, *Diomedea albatrus*, and until the late 1980s residents of Tristan Island in the Indian Ocean have been harvesting the eggs of the Yellow-nosed Mollymawks, *Diomedea chlororhynchos*, and Sooty Albatrosses, *Phoebetria fusca*. Albatrosses and petrels are also now tourist draws in some locations, such as Taiaroa Head. While such exploitation is non-consumptive, it can have deleterious effects that need careful management to protect both the birds and the tourism.

Threats and conservation

The poorly known New Zealand Storm-petrel was considered extinct for 150 years before being rediscovered in 2003

The albatrosses and petrels are "amongst the most severely threatened taxa worldwide". They face a variety of threats, the severity of which varies greatly from species to species. Several species are among the most common of seabirds, including the Wilson's Storm Petrel (an estimated 20 million individuals) and the Short-tailed Shearwater (an estimated 30 million individuals); while the total population of some other species barely reaches more than two hundred individuals. There are less than 200 Magenta Petrels breeding on the Chatham Islands, only 400 Zino's Petrels and only 80 Amsterdam Albatrosses. Only one species is thought to have become extinct since 1600, the Guadalupe Storm-petrel of Mexico, although a number of species had died out before this. Numerous species are very poorly known, the Fiji Petrel has only been seen a handful of times since its discovery and the breeding colonies of the New Zealand Storm-petrel, Hornby's Storm-petrel and Heinroth's Shearwater have never been located. So little is known about the New Zealand Storm-petrel that is was thought extinct for 150 years until its rediscovery in 2003, although this record is dwarfed by that of the Bermuda Petrel which was considered extinct for 330 years.

Black-browed Albatross hooked on a long-line.

The principal threat to the albatrosses and larger species of procellariids is long-line fishing. Bait set on hooks is attractive to foraging birds and many are hooked by the lines as they are set. As many as 100,000 albatrosses are hooked and drown each year on tuna lines set out by long-line fisheries. However bad this number is, before 1991 and the ban on drift-net fisheries, it was estimated that 500,000 seabirds a year died as a result. This has led to spectacular declines in some species, as Procellariiformes are slow breeders and cannot replace their numbers fast enough.

Exotic species introduced to the remote breeding colonies is also a threat to all types of Procellariiformes. These principally take the form of predators; most albatross and petrel species are clumsy on land and are unable to defend themselves from mammals such as rats, feral cats and pigs. This phenomenon, known as ecological naivete, has resulted in numerous declines in many species and has been strongly implicated in the extinction of the Guadalupe Storm-petrel. Introduced herbivores can also cause problems if they unbalance the ecology of the island; introduced rabbits destroyed the forest understory on Cabbage Tree Island off New South Wales; this both increased the vulnerability of the Gould's Petrels nesting on the island to natural predators and left them vulnerable to the sticky fruits of the birdlime tree (*Pisonia umbellifera*), a native plant. In the natural state these fruits lodge in the understory of the forest, but with the understory removed the fruits fall to the ground where the petrels move about, sticking to their feathers and making flight impossible.

This albatross bolus was found in the Hawaiian Islands includes flotsam that was ingested but successfully ejected along with other indigestible matter. If such flotsam cannot be ejected it may cause sickness and death.

In the past exploitation was a threat, although this is less of a threat now. Other threats the ingestion of plastic flotsam. Once swallowed, this plastic can cause a general decline in the fitness of the bird, or in some cases lodge in the gut and cause a blockage, leading to death by starvation. This can also be picked up by foraging adults and fed to chicks, stunting their development and reducing the chances of successfully fledging. Procellariids are also vulnerable to general marine pollution, as well as oil spills. Some species, such as the Barau's Petrel, the Newell's Shearwater and the Cory's Shearwater, which nest high up on large developed islands are victims of light pollution. Chicks that are fledging are attracted to streetlights and are unable to reach the sea. An estimated 20–40% of fledging Barau's Petrels and 45-60% of fledging Cory's Shearwater are attracted to the streetlights on Réunion and Tenerife, respectively.

Taxonomy and systematics

At one point (until the beginning of the 20th century), the family Hydrobatidae was named Procellariidae, and the family now called Procellariidae was rendered "Puffinidae." The order itself was called Tubinares. A major early work on this group is F. DuCane Godman's *Monograph of the Petrels*, five fascicles, 1907—1910., with portraits of figures by John Gerrard Keulemans.

In the Sibley-Ahlquist taxonomy, the tubenoses are included in a greatly enlarged order "Ciconiiformes". This taxonomic treatment is almost certainly erroneous, but the assumption of a close evolutionary relationship with other "higher waterbirds" – such as loons (Gaviiformes) and penguins (Sphenisciformes) – appears to be correct.

There are a total of around 125 living species of Procellariiformes worldwide, and the order is typically divided into four extant and one prehistorically extinct families:

- Family †Diomedeoididae (Early Oligocene – Early Miocene)
- Family Procellariidae (shearwaters, fulmarine petrels, gadfly petrels, and prions)
- Family Diomedeidae (albatrosses)
- Family Hydrobatidae (storm-petrels)
- Family Pelecanoididae (diving-petrels)

The Hydrobatidae's two subfamilies, Oceanitinae and Hydrobatinae, are probably better treated as distinct families.

Primodroma, a fossil procellariiform from the Early Eocene London Clay of England, may belong to the Hydrobatidae (perhaps specifically to the Oceanitinae) or maybe the Diomedeoididae.

A few rather fragmentary Late Cretaceous and Paleogene fossils have been occasionally allied with or even placed in the Procellariiformes. *Marinavis, Neogaeornis, Novacaesareala, Torotix* and *Tytthostonyx* seem to be "higher waterbirds" but cannot be reliably assigned to any of the modern lineages; rather, most of them appear to be still very close to the last common ancestor of Procellariiformes, cormorants, loons, pelicans, penguins, and perhaps also grebes, flamingos, storks, tropicbirds and waders. If they can be assigned to a modern order (which is highly doubtful), with the possible exception of *Marinavis* they would probably not be considered Procellariiformes. *Eopuffinus* and *Manu* on the other hand are more likely members of the Procellariiformes; the former might be an ancestral petrel, the latter an ancient albatross. As regards *Lonchodytes* (or rather its type species *L. estesi*), it is the best candidate for the most ancient procellariiform known to date; it pre-dates the evolutionary radiation that brought about the modern families and hence would occupy a basal position in the order. *Parascaniornis* on the other hand was formerly assigned to the Procellariiformes by some, but it is actually a hesperornithiform synonymous with *Baptornis*.

Evolution

Fossil records indicate that Procellariiformes have been around at least 60 million years, but a DNA-based study from 1997 states that they have been around into the Cretaceous Period and survived the Cretaceous–Tertiary extinction event. This Order was distinct from *Sphenisciformes*, Penguins, and *Gaviiformes*, Divers, before the extinction event. Fossil records are rare but 16 million year old fossils show that Albatrosses and Shearwaters haven't changed much since then. It is believed that they evolved first in the Southern Hemisphere, even though the majority of the fossils have been found in the

Northern Hemisphere. This is likely due to the fact that there is more land to find fossils in the north. DNA evidence has confirmed common ancestry for all Procellariiformes, however, the taxonomy within the order is complex and fluctuating. The fossil record of the diving-petrels goes back to the Miocene, with a species from that family being described in 2007. The most numerous fossils from the Paleogene are those from the extinct family Diomedeoididae, fossils of which have been found in Central Europe and Iran.

Chapter- 4

Pelecaniformes

"Pelecaniformes" Temporal range: Late Cretaceous–Recent

Brown Pelican (*Pelecanus occidentalis*)

Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Aves

Infraclass:	Neognathae
Order:	**Pelecaniformes** (disputed) Sharpe, 1891

Families
traditionally: Anhingidae Fregatidae Pelecanidae Phalacrocoracidae Sulidae

The **Pelecaniformes** are a (possibly invalid) order of medium-sized and large waterbirds found worldwide. As traditionally—but erroneously—defined, they encompass all birds that have feet with all four toes webbed. Hence, they were formerly also known by such names as **totipalmates** or **steganopodes**. Most have a bare throat patch (gular patch), and the nostrils have evolved into dysfunctional slits, forcing them to breathe through their mouths. They feed on fish, squid or similar marine life. Nesting is colonial, but individual birds are monogamous. The young are altricial, hatching from the egg helpless and naked in most. They lack a brood patch.

In the all-encompassing "steganopode" circumscription, the Pelecaniformes had some 50–60 living species. However, modern opinion considers the apparent similarities the result of convergent evolution, and based on a wealth of evidence splits the classically defined "Pelecaniformes" into several groups. Most lineages—frigatebirds, gannets, cormorants and anhingas—constitute indeed a natural group, for which the name Phalacrocoraciformes has been proposed. Tropicbirds are of unclear relationships, but appear to be a quite distinct lineage; they are typically placed in their own order. The pelicans (*Pelecanidae*), meanwhile, are linked to the storks (Ciconiidae) by two bizarre monotypic families, the Hammerkop (Scopidae) and the Shoebill (Balaenicipitidae). Indeed, they may be closer related to storks than these are to herons. To overcome this confusion, it has been proposed to merge the "core" Pelecaniformes into the Ciconiiformes.

Systematics and evolution

Sibley and Ahlquist's landmark DNA-DNA hybridisation studies led to them placing the families traditionally contained within the Pelecaniformes together with the grebes, cormorants, ibises and spoonbills, New World vultures, storks, penguins, albatrosses, petrels, and loons together as a sub-group within a greatly expanded order Ciconiiformes, a radical move which by now has been all but rejected: their "Ciconiiformes" merely assembled all early advanced land- and seabirds for which their research technique delivered insufficient phylogenetic resolution.

Recent research strongly suggests that the similarities between the Pelecaniformes as traditionally defined are the result of convergent evolution rather than common descent, and that the group is paraphyletic. All families in the traditional or revised Pelecaniformes except the Phalacrocoracidae have only a few handfuls of species at most, but many were more numerous in the early Neogene. Fossil genera and species are discussed in the respective family or genus accounts; one little-known prehistoric pelecaniforms, however, cannot be classified accurately enough to assign them to a family. This is *"Sula" ronzoni* from Early Oligocene rocks at Ronzon (France), which was initially believed to be a sea-duck and possibly is an ancestral pelecaniform.

The "pelecaniform" lineages appear to have originated around the end of the Cretaceous. Monophyletic or not, they appear to belong to a close-knit group of "higher waterbirds" which also includes groups such as penguins and Procellariiformes. It is interesting to note that there are quite a lot of fossil bones from around the K–Pg boundary which cannot be firmly placed with any of these orders and rather combine traits of several of them. This is of course only to be expected, if the theory that most if not all of these "higher waterbird" lineages originated around that time is correct. Of those apparently basal taxa, the following show some similarities to the traditional Pelecaniformes:

- *Lonchodytes* (Lance Creek Late Cretaceous of Wyoming, USA)
- *Torotix* (Late Cretaceous)
- *Tytthostonyx* (Late Cretaceous/Early Palaeocene)
- *Cladornis* (Deseado Early Oligocene of Patagonia, Argentina)
- *"Liptornis"*—a *nomen dubium*

The proposed Elopterygidae—supposedly a family of Cretaceous Pelecaniformes—are neither monophyletic nor does *Elopteryx* appear to be a modern bird.

List of "pelecaniform" families

- **Pelecanidae**: pelicans. Very large birds with throat pouches in which they catch and store fish while hunting.
- **Pelagornithidae**: pseudotooth birds. An extinct family of gigantic seabirds that looked similar to albatrosses, but had a large bill with tooth-like projections that enabled them to pick up slippery prey like fish or squids more easily. They may actually be Galloanserae closely related to waterfowl, not Neoaves like the other "pelecaniform" families.
- **Plotopteridae**: plotopterids or diving-"boobies". An extinct group of penguin-like seabirds. Possibly link penguins and (some?) pelecaniforms. Depending on how the remaining Pelecaniformes would be split up, the plotopterids might have to be placed in a monotypic order, as some similarities with penguins are possibly synapomorphies.
- **Fregatidae**: frigatebirds. A group of five closely related large birds with black and white plumage, very long wings, and parasitical hunting habits. Red throat patches are inflated in display. They are usuually placed in a monotypic suborder Fregatae, and this seems to be appropriate. If split off in the

Phalacrocoraciformes, it may also be simply treated as a basal (evolution) lineage thereof.

The following four families can be united as suborder **Sulae** (**Sulides** in older sources), and would make up the core of the Phalacrocoraciformes:

- **Sulidae**: gannets and boobies. Medium to large species which hunt by diving from the air into the sea (plunge diving). Long wings and bills, often coloured feet.
- **Phalacrocoracidae**: cormorants and shags. Medium to large with hooked bills and usually black or similar dark plumage. Plumage is not fully waterproof.
- **Anhingidae**: darters. Another small closely related group of four species, with long bills, snake-like necks and the ability to swim with their body submerged. Plumage is not fully waterproof.
- **Protoplotidae**: an extinct family which apparently is derived from the same ancestor as the darters, but is very badly known.

The **tropicbirds** (Phaethontidae) and their prehistoric relatives Prophaethontidae were traditionally placed in the Pelecaniformes, but molecular and morphological studies indicate they are not that close relatives. They have been placed in their own order Phaethontiformes. They are medium-sized birds, adapted to a marine lifestyle similar to frigatebirds. They are also noted for their aerobatic capabilities, appearing somewhat like large, slow, white hummingbirds in courtship flight. Adults have two long central tail feathers, no gular patch and normal nostrils. Hatchlings are covered in down. They have been included in the "Metaves" a proposed clade that is likely not monophyletic however; most evidence points towards a fairly close relationship with Procellariiformes and/or Charadriiformes.

Chapter- 5

Charadriiformes

Charadriiformes Temporal range: Late Cretaceous-Recent, 75–0 Ma	
	
Masked Lapwing (*Vanellus miles*)	
Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Aves
Subclass:	Neornithes
Infraclass:	Neognathae
Superorder:	Neoaves
Order:	**Charadriiformes** Huxley, 1867

Charadriiformes is a diverse order of small to medium-large birds. It includes about 350 species and has members in all parts of the world. Most Charadriiformes live near water and eat invertebrates or other small animals; however, some are pelagic (sea birds), some occupy deserts and a few are found in thick forest. They are very small, most of the time, but can be quite large.

Systematics

The order was formerly divided into three suborders:

- The **waders** (or "Charadrii"): typical shorebirds, most of which feed by probing in the mud or picking items off the surface in both coastal and freshwater environments.
- The **gulls** and their allies (or "Lari"): these are generally larger species which take fish from the sea. Several gulls and skuas will also take food items from beaches, or rob smaller species, and some have become adapted to inland environments.
- The **auks** (or "Alcae") are coastal species which nest on sea cliffs and "fly" underwater to catch fish.

The Sibley-Ahlquist taxonomy, which has been widely accepted in America, lumps all the Charadriiformes together with the seabirds and birds of prey into a greatly enlarged order Ciconiiformes. However, the resolution of the DNA-DNA hybridization technique used by Sibley & Ahlquist was not sufficient to properly resolve the relationships in this group, and indeed it appears as if the Charadriiformes consititute a single large and very distinctive lineage of modern birds of their own.

The auks, usually considered distinct because of their peculiar morphology, are more likely related to gulls, the "distinctness" being a result of adaptation for diving. Following recent research, a better arrangement may be as follows:

Families in taxonomic order

This is a list of the charadriiform families, presented in taxonomic order.

- **Suborder Scolopaci**: snipe-like waders
  - Family Scolopacidae: snipe, sandpipers, phalaropes, and allies
- **Suborder Thinocori**: aberrant charadriforms
  - Family Rostratulidae: painted snipe
  - Family Jacanidae: jacanas
  - Family Thinocoridae: seedsnipe
  - Family Pedionomidae: Plains Wanderer
- **Suborder Lari**: gulls and allies
  - Family Laridae: gulls
  - Family Rhynchopidae: skimmers
  - Family Sternidae: terns
  - Family Alcidae: puffins, guillemots, murres, and allies

    - Family Stercorariidae: skuas
    - Family Glareolidae: pratincoles and coursers
    - Family Dromadidae: Crab Plover
- **Suborder Turnici**: buttonquails
    - Family Turnicidae: buttonquails
- **Suborder Chionidi**: thick-knees and allies
    - Family Burhinidae: thick-knees
    - Family Chionididae: sheathbills
    - Family Pluvianellidae: Magellanic Plover
- **Suborder Charadrii**: plover-like waders
    - Family Ibidorhynchidae: Ibisbill
    - Family Recurvirostridae: avocets and stilts
    - Family Haematopodidae: oystercatchers
    - Family Charadriidae: plovers and lapwings

More conservatively, the Thinocori could be included in the Scolopaci, and the Chionidi in the Charadrii, or the Glareolidae could be placed in a suborder of their own. The buttonquails are of indeterminate, quite basal position in the Lari-Scolopaci *sensu lato* group. The arrangement as presented here is a consensus of the recent studies.

Evolution

That the Charadriiformes are an ancient group is also borne out by the fossil record. Much of the Neornithes' fossil record around the Cretaceous–Tertiary extinction event is made up of bits and pieces of birds which resemble this order. In many, this is probably due to convergent evolution brought about by semi-aquatic habits. Specimen VI 9901 (López de Bertodano Formation, Late Cretaceous of Vega Island, Antarctica) is probably a basal charadriiform somewhat reminiscent of a thick-knee. However, more complete remains of undisputed charadriiforms are known only from the mid-Paleogene onwards. Present-day orders emerged around the Eocene-Oligocene boundary, roughly 35-30 mya. Basal or unresolved charadriiforms are:

- *"Morsoravis"* (Late Paleocene/Early Eocene of Jutland, Denmark) - a *nomen nudum*?
- *Jiliniornis* (Huadian Middle Eocene of Huadian, China) - charadriid?
- *Boutersemia* (Early Oligocene of Boutersem, Belgium) - glareolid?
- *Turnipax* (Early Oligocene) - turnicid?
- *Elorius* (Early Miocene Saint-Gérand-le-Puy, France)
- *"Larus" desnoyersii* (Early Miocene of SE France) - larid? stercorarid?
- *"Larus" pristinus* (John Day Early Miocene of Willow Creek, USA) - larid?
- Charadriiformes gen. et sp. indet. (Bathans Early/Middle Miocene of Otago, New Zealand) - charadriid? scolopacid?
- Charadriiformes gen. et sp. indet. (Bathans Early/Middle Miocene of Otago, New Zealand) - charadriid? scolopacid?
- Charadriiformes gen. et sp. indet. (Bathans Early/Middle Miocene of Otago, New Zealand) - larid?

- Charadriiformes gen. et sp. indet. (Sajóvölgyi Middle Miocene of Mátraszõlõs, Hungary
- *"Totanus" teruelensis* (Late Miocene of Los Mansuetos, Spain) - scolopacid? larid?

The "transitional shorebirds" ("Graculavidae") are a generally Mesozoic form taxon formerly believed to constitute the common ancestors of charadriiforms, waterfowl and flamingos. They are now assumed to be mostly basal taxa of the charadriiforms and/or "higher waterbirds", which probably were two distinct lineages 65 mya already, and few if any are still believed to be related to the well-distinct weaterfowl. Taxa formerly considered graculavids are:

- **Laornithidae** - charadriiform? gruiform?
  - *Laornis* (Late Cretaceous?)
- **"Graculavidae"**
  - *Graculavus* (Lance Creek Late Cretaceous - Hornerstown Late Cretaceous/Early Palaeocene) - charadriiform?
  - *Palaeotringa* (Hornerstown Late Cretaceous?) - charadriiform?
  - *Telmatornis* (Navesink Late Cretaceous?) - charadriiform? gruiform?
  - *Scaniornis* - phoenicopteriform?
  - *Zhylgaia* - presbyornithid?
  - *Dakotornis*
  - "Graculavidae" gen. et sp. indet. (Gloucester County, USA)

Other wader- or gull-like birds *incertae sedis*, which may or may not be Charadriiformes, are:

- *Ceramornis* (Lance Creek Late Cretaceous)
- *"Cimolopteryx"* (Lance Creek Late Cretaceous)
- *Palintropus* (Lance Creek Late Cretaceous)
- *Torotix* (Late Cretaceous)
- *Volgavis* (Early Paleocene of Volgograd, Russia)
- *Eupterornis* (Paleocene of France)
- Neornithes incerta sedis (Late Paleocene/Early Eocene of Ouled Abdoun Basin, Morocco)
- *Fluviatitavis* (Early Eocene of Silveirinha, Portugal)

Chapter- 6

Pelican

Pelican
Temporal range: Oligocene-Recent, 30–0 Ma

Australian Pelican (*Pelecanus conspicillatus*)

Scientific classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Aves
Order:	Pelecaniformes
Family:	**Pelecanidae** Rafinesque, 1815
Genus:	***Pelecanus*** Linnaeus, 1758

Species

- *Pelecanus occidentalis*
- *Pelecanus thagus*
- *Pelecanus erythrorhynchos*
- *Pelecanus onocrotalus*
- *Pelecanus crispus*
- *Pelecanus rufescens*
- *Pelecanus philippensis*
- *Pelecanus conspicillatus*

A **pelican**, derived from the Greek word pelekys (meaning "axe" and applied to birds that cut wood with their bills or beaks), is a large water bird with a large throat pouch, belonging to the bird family **Pelecanidae**.

Along with the darters, cormorants, gannets, boobies, frigatebirds, and tropicbirds, pelicans make up the order Pelecaniformes. Modern pelicans, of which there are eight species, are found on all continents except Antarctica. They primarily inhabit warm regions, though breeding ranges reach 45° south (Australian Pelican, *P. conspicillatus*) and 60° North (American White Pelicans, *P. erythrorhynchos*, in western Canada). Birds of inland and coastal waters, they are absent from polar regions, the deep ocean, oceanic islands, and inland South America.

Description

An Australian Pelican gliding with its large wings extended

Pelicans are large birds with large pouched bills. The smallest is the Brown Pelican (*P. occidentalis*), small individuals of which can be as little as 2.75 kg (6 lb), 106 cm (42 in) long and can have a wingspan of as little as 1.83 m (6 ft). The largest is believed to be the Dalmatian Pelican (*P. crispus*), at up to 15 kg (33 lb), 183 cm (72 in) long, with a maximum wingspan of 3 metres [nearly 10 foot]. The Australian Pelican has the longest bill of any bird.

Pelicans swim well with their short, strong legs and their feet with all four toes webbed (as in all birds placed in the order Pelecaniformes). The tail is short and square, with 20 to 24 feathers. The wings are long and have the unusually large number of 30 to 35 secondary flight feathers. A layer of special fibers deep in the breast muscles can hold the wings rigidly horizontal for gliding and soaring. Thus they can exploit thermals to commute over 150 km (100 miles) to feeding areas.

Pelicans rub the backs of their heads on their preen glands to pick up their oily secretion, which they transfer to their plumage to waterproof it.

Sub-groups

The pelicans can be divided into two groups: those with mostly white adult plumage, which nest on the ground (Australian, Dalmatian, Great White, and American White Pelicans), and those with gray or brown plumage, which nest in trees (Pink-backed, Spot-billed, and Brown, plus the Peruvian Pelican, which nests on sea rocks). The Peruvian Pelican is sometimes considered conspecific with the Brown Pelican.

Feeding

A pelican showing an open throat pouch.

Brown Pelicans diving into the sea to catch fish in Jamaica

The diet of a Pelican usually consists of fish, but they also eat amphibians, crustaceans and on some occasions, smaller birds. They often catch fish by expanding the throat pouch. Then they must drain the pouch above the surface before they can swallow. This operation takes up to a minute, during which time other seabirds are particularly likely to steal the fish. Pelicans in their turn sometimes pirate prey from other seabirds.

The white pelicans often fish in groups. They will form a line to chase schools of small fish into shallow water, and then scoop them up. Large fish are caught with the bill-tip, then tossed up in the air to be caught and slid into the gullet head first.

The Brown Pelican of North America usually plunge-dives for its prey. Rarely, other species such as the Peruvian Pelican and the Australian Pelican practice this method.

Consumption of other birds is rare. In 2006, a pelican swallowed a living pigeon in St. James Park, London. According to tourists watching it, the pelican walked to the pigeon and grabbed it in its beak, hence starting the 20 minute struggle which ended when the victim was swallowed "head first down while flapping all the way down". This behavior has been also been observed at a zoo in Ukraine.

On the island of Malgas in South Africa, the biologist Marta de Ponte was the first to discover Great White Pelicans eating Cape Gannet chicks. The pelicans were then captured on film exhibiting this behaviour in the BBC documentary Life (BBC TV series). The same breed of pelican has been observed swallowing Cape cormorants, kelp gulls, swift terns and African penguins.

Reproduction

Pelicans are gregarious and nest colonially. The ground-nesting (white) species have a complex communal courtship involving a group of males chasing a single female in the air, on land, or in the water while pointing, gaping, and thrusting their bills at each other. They can finish the process in a day. The tree-nesting species have a simpler process in which perched males advertise for females.

In all species copulation begins shortly after pairing and continues for 3 to 10 days before egg-laying. The male brings the nesting material, ground-nesters (which may not build a nest) sometimes in the pouch and tree-nesters crosswise in the bill. The female then heaps the material up to form a simple structure.

A Pelican at San Diego Zoo

Both sexes incubate with the eggs on top of or below the feet. They may display when changing shifts. All species lay at least two eggs, and hatching success for undisturbed pairs can be as high as 95 percent, but because of competition between siblings or

outright siblicide, usually all but one nestling dies within the first few weeks (or later in the Pink-backed and Spot-billed species). The young are fed copiously. Before or especially after being fed, they may seem to have a seizure that ends in falling unconscious; the reason is not clearly known.

Parents of ground-nesting species have another strange behavior: they sometimes drag older young around roughly by the head before feeding them. The young of these species gather in "pods" or "crèches" of up to 100 birds in which parents recognize and feed only their own offspring. By 6 to 8 weeks they wander around, occasionally swimming, and may practice communal feeding.

Young of all species fledge 10 to 12 weeks after hatching. They may remain with their parents afterwards, but are now seldom or never fed. Overall breeding success is highly inconsistent.

Pairs are monogamous for a single season, but the pair bond extends only to the nesting area; mates are independent away from the nest.

Flock of pelicans on dock in Biloxi, Mississippi.

Populations

The Dalmatian Pelican and the Spot-billed Pelican are the rarest species, with the population of the former estimated at between 10,000 and 20,000 and that of the latter at 13,000 to 18,000. The most common is believed to be the Australian Pelican, with a population generally estimated at around 400,000 individuals. However, estimates for the species have varied wildly between 100,000 and 1,000,000 over the years, and it is possible that the White Pelican, the population of which is more consistently estimated at 270,000 and 290,000 individuals, is in fact the more common species. The brown pelican may be even more numerous with estimates of 650,000 birds throughout its range. It has been removed from the endangered species list.

Species

Brown Pelican
Pelecanus occidentalis

Peruvian Pelican
Pelecanus thagus

American White Pelican
Pelecanus erythrorhynchos

Great White Pelican
Pelecanus onocrotalus

Dalmatian Pelican
Pelecanus crispus

Pink-backed Pelican
Pelecanus rufescens

Australian Pelican
Pelecanus conspicillatus

From the fossil record it is known that pelicans have been around for over 30 million years, the earliest fossil *Pelecanus* being found in Oligocene deposits in France. A prehistoric genus has been named *Miopelecanus*, while *Protopelicanus* may be a pelicanid or pelecaniform – or a similar aquatic bird such as a pseudotooth bird (Pelagornithidae). The supposed Miocene pelican *Liptornis* from Argentina is a *nomen dubium*, being based on hitherto indeterminable fragments.

A number of fossil species are also known from the extant genus *Pelecanus*:

- *Pelecanus halieus* (Late Pliocene of Idaho, USA)

- *Pelecanus cadimurka*
- *Pelecanus cauleyi*
- *Pelecanus gracilis*
- *Pelecanus halieus*
- *Pelecanus intermedius*
- *Pelecanus lazerus*
- *Pelecanus odessanus*
- *Pelecanus schreiberi*
- *Pelecanus sivalensis*
- *Pelecanus tirarensis*

Environmental damage

Dead pelican in the largest pelican rookery in Louisiana, after the 2010 Gulf of Mexico petroleum disaster.

The Pelican environment suffered significant ecosystem damage from the 2010 Gulf of Mexico petroleum disaster. Dead pelicans were seen on Raccoon Island, the largest pelican rookery in Louisiana. Rebuilt after Hurricane Katrina, it was home to more than 60,000 pelicans, but since the oil spill mature pelicans are scarce. Instead, there are thousands of dead birds and emaciated and abandoned juvenile and baby birds.

Pelicans often travel in groups

Relief of a "pelican in her piety"

An Australian Pelican coming out of water

A Brown Pelican in flight

Brown Pelicans, Melbourne, Florida, USA.

Pelicans in the Danube Delta.

Eastern White Pelican, Blackpool Zoo.

Pink-backed Pelican, San Diego Wild Animal Park

White pelican, Lovech Zoo.

Pelican in Los Angeles, California

Brown pelican with fishing line stuck in beak, Long Beach, CA

Chapter- 7

Cetacea

Cetaceans Fossil range: 55–0 Ma Early Eocene - Present

Humpback Whale breaching
Scientific classification
Kingdom: Animalia
Phylum: Chordata
Class: Mammalia
Infraclass: Laurasiatheria
(unranked): Cetartiodactyla
Order: **Cetacea** Brisson, 1762
Suborders
Mysticeti Odontoceti †Archaeoceti
Diversity
Around 88 species

The order **Cetacea** includes the marine mammals commonly known as whales, dolphins, and porpoises. *Cetus* is Latin and is used in biological names to mean "whale"; its original meaning, "large sea animal", was more general. It comes from Ancient Greek κῆτος (*kētos*), meaning "whale" or "any huge fish or sea monster". In Greek mythology the monster Perseus defeated was called Ceto, which is depicted by the constellation of Cetus. Cetology is the branch of marine science associated with the study of cetaceans.

Cetaceans are the mammals best adapted to aquatic life. Their body is fusiform (spindle-shaped). The forelimbs are modified into flippers. The tiny hindlimbs are vestigial; they do not attach to the backbone and are hidden within the body. The tail has horizontal flukes. Cetaceans are nearly hairless, and are insulated from the cooler water they inhabit by a thick layer of blubber. Some species are noted for their high intelligence.

Respiration

A dolphin in the Strait of Gibraltar

Cetaceans breathe air. They surface periodically to exhale carbon dioxide and inhale a fresh supply of oxygen. During diving, a muscular action closes the blowholes (nostrils), which remain closed until the cetacean next breaks the surface; when it surfaces, the muscles open the blowholes and warm air is exhaled.

Cetaceans' blowholes have evolved to a position at the top of the head, simplifying breathing in sometimes rough seas. When the stale air, warmed from the lungs, is exhaled, it condenses as it meets colder external air. As with a terrestrial mammal breathing out on a cold day, a small cloud of 'steam' appears. This is called the 'blow' or 'spout' and varies by species in terms of shape, angle and height. Species can be identified at a distance using this characteristic.

Cetaceans can remain under water for much longer periods than other mammals, (approximately 7–30 minutes, varying by species) due to large physiological differences. Two studied advantages of cetacean physiology let this order (and other marine mammals) forage underwater for extended periods without breathing:

- Mammalian myoglobin concentrations in skeletal muscle have much variation. New Zealand white rabbits have 0.08 grams (0.0028 oz) +/- 0.6 grams (0.021 oz) myoglobin in 100 grams (3.5 oz) of wet muscle, whereas a Northern Bottlenose Whale has 6.34 grams (0.224 oz). Myoglobin, by nature, has a higher oxygen affinity than hemoglobin. The higher the myoglobin concentration in skeletal muscle, the longer the animal can stay underwater.

- Increased body size also increases maximum dive duration. Greater body size implies increased muscle mass and increased oxygen stores. Cetaceans also obey Kleiber's law, which states that mass and metabolic rate are inversely related. I.e., larger animals consume less oxygen than smaller animals per unit mass.

Vision, hearing and echolocation

Cetacean eyes are set on the side rather than the front of the head. This means that only cetaceans with pointed 'beaks' (such as dolphins) have good binocular vision forward and downward. Tear glands secrete greasy tears, which protect the eyes from the salt in the water. The lens is almost spherical, which is most efficient at focusing the minimal light that reaches deep water. Cetaceans make up for their generally poor vision (with the exception of the dolphin) with excellent hearing.

As with the eyes, cetacean ears are also small. Life in the sea accounts for the cetacean's loss of its external ears, whose function is to collect and focus airborne sound waves. However, water conducts sound better than air, so the external ear is unneeded: it is a tiny hole in the skin, just behind the eye. The highly developed inner ear can detect sounds from dozens of miles away and discern from which direction the sound comes.

Odontoceti are generally capable of echolocation. From this, Odontoceti can discern the size, shape, surface characteristics, distance and movement of an object. With this ability cetaceans can search for, chase and catch fast-swimming prey in total darkness. Echolocation is so advanced in most Odontoceti that they can distinguish between prey and non-prey (such as humans or boats); captive Odontoceti can be trained to distinguish between, for example, balls of different sizes or shapes. Mysticeti have little need of

echolocation, because they prey upon tiny fish such as krill that are impractical to locate with echolocation.

Cetaceans also use sound to communicate, whether it be groans, moans, whistles, clicks or the complex 'singing' of the Humpback Whale.

Feeding

The toothed whales such as the sperm whale, beluga, dolphins and porpoises, have teeth that they use for catching fish, squid or other marine life. They do not chew but swallow prey whole. When they catch large prey, such as when the orca (*Orcinus orca*) catches a seal, they bite off and swallow one chunk at a time.

Mysticeti instead have baleen plates made of keratin (the same substance as human fingernails) which hang from the upper jaw. These plates filter small animals (such as krill and fish) from the seawater. Cetaceans included in this group include the Blue, Humpback, Bowhead and Minke whales.

Not all Mysticeti feed on plankton: the larger species eat small shoaling fish, such as herring and sardine, called micronecton. The gray whale (*Eschrichtius robustus*), is a benthic feeder, primarily eating sea floor crustaceans.

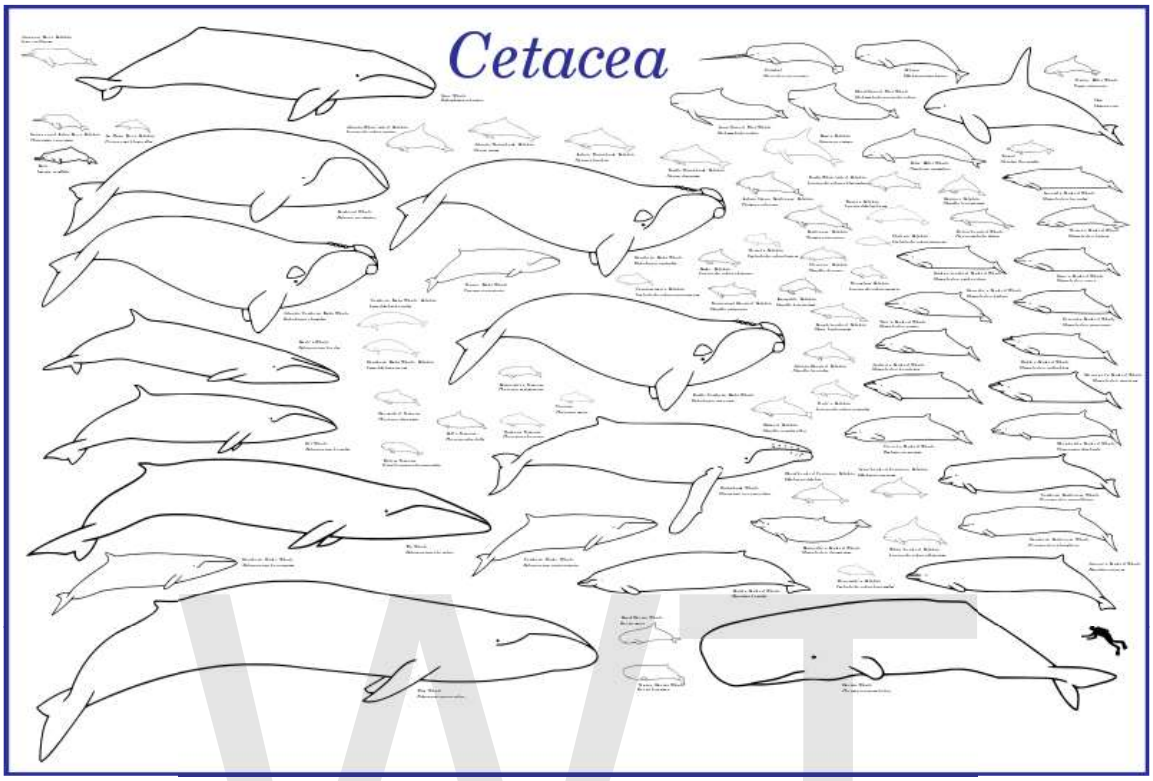
Mammalian nature

Cetaceans are mammals, that is, members of the class Mammalia. The closest living relatives of cetaceans are the even-toed ungulates, such as the hippopotamus and deer.

Mammalian characteristics include warm-bloodedness, breathing air through their lungs, and suckling their young, and growing hair, although very little of it.

Another way of distinguishing a cetacean from a fish is by the shape of the tail. Fish tails are vertical and move from side to side when the fish swims. Cetacea tails—called a fluke—are horizontal and move up and down, because cetacea spines bend in the same manner as a human spine.

Taxonomy



Size comparison of all known extant cetacean species. Note the human diver at lower right for scale.

The order Cetacea contains about ninety species, all marine except for four species of freshwater dolphins. The order contains two suborders, Mysticeti (baleen whales) and Odontoceti (toothed whales, which includes dolphins and porpoises). The species range in size from Commerson's Dolphin, smaller than a human, to the Blue Whale, the largest animal ever known to have lived.

Mysticeti vs Odontoceti

Fossils indicate that before evolving baleen, Mysticeti also had teeth, so defining the Odontoceti via teeth alone is problematic, and paleontologists have instead identified other features uniting fossil and modern odontocetes that are not shared by Mysticetes.

Characteristic	**Odontoceti**	**Mysticeti**
Feeding	Echolocation, fast	Filter feeder, not fast
Size	Smaller (except Sperm whale)	Larger
Blowhole	One	Two
Dentition	Teeth	Baleen plates
Melon	Ovoid, in anterior facial	Vestigial or none

	region	
Skull and facial tissue	Dorsally asymmetric	Symmetric
Sexual dimorphism	Some species have larger males	Females always larger
Mandible	Symphyseal	Nonsymphyseal
Pan bone of lower jaw	Yes	No
Maxillae projection	Outward over expanded supraorbital processes	Under eye orbit, with bony protuberance anterior to eye orbit
Tympanic bulla and periotic bone	Fused, equal sized	Larger, separate tympanic

Tree

The classification here closely follows Dale W. Rice, *Marine Mammals of the World: Systematics and Distribution* (1998), which has become the standard taxonomy reference in the field. There is very close agreement between this classification and that of *Mammal Species of the World: 3rd Edition* (Wilson and Reeder eds., 2005). Any differences are noted using the abbreviations "Rice" and "MSW3" respectively. Further differences due to recent discoveries are also noted.

Discussion of synonyms and subspecies are relegated to the relevant genus and species articles.

- **ORDER CETACEA**
  - **Suborder Mysticeti**: Baleen whales
    - Family Balaenidae: Right whales and Bowhead Whale
      - Genus *Balaena*
        - Bowhead Whale, *Balaena mysticetus*
      - Genus *Eubalaena*
        - North Atlantic Right Whale, *Eubalaena glacialis*
        - North Pacific Right Whale, *Eubalaena japonica*
        - Southern Right Whale, *Eubalaena australis*
    - Family Balaenopteridae: Rorquals
      - Subfamily Balaenopterinae
        - Genus *Balaenoptera*
          - Common Minke Whale, *Balaenoptera acutorostrata*
          - Antarctic Minke Whale, *Balaenoptera bonaerensis*
          - Sei Whale, *Balaenoptera borealis*
          - Bryde's Whale, *Balaenoptera brydei*
          - Eden's Whale *Balaenoptera edeni* - Rice lists this as a separate species, MSW3 does not

            - *Balaenoptera omurai* - MSW3 lists this is a synonym of Bryde's Whale but suggests this may be temporary.
            - Blue Whale, *Balaenoptera musculus*
            - Fin Whale, *Balaenoptera physalus*
        - Subfamily Megapterinae
            - Genus *Megaptera*
                - Humpback Whale, *Megaptera novaeangliae*
    - Family Eschrichtiidae
        - Genus *Eschrichtius*
            - Gray Whale, *Eschrichtius robustus*
    - Family Neobalaenidae: Pygmy Right Whale
        - Genus *Caperea*
            - Pygmy Right Whale, *Caperea marginata*
- **Suborder Odontoceti**: toothed whales
    - Family Delphinidae: Dolphin
        - Genus *Cephalorhynchus*
            - Commerson's Dolphin, *Cephalorhyncus commersonii*
            - Chilean Dolphin, *Cephalorhyncus eutropia*
            - Heaviside's Dolphin, *Cephalorhyncus heavisidii*
            - Hector's Dolphin, *Cephalorhyncus hectori*
        - Genus *Delphinus*
            - Long-beaked Common Dolphin, *Delphinus capensis*
            - Short-beaked Common Dolphin, *Delphinus delphis*
            - Arabian Common Dolphin, *Delphinus tropicalis*. Rice recognises this as a separate species. MSW3 does not.
        - Genus *Feresa*
            - Pygmy Killer Whale, *Feresa attenuata*
        - Genus *Globicephala*
            - Short-finned Pilot Whale, *Globicephala macrorhyncus*
            - Long-finned Pilot Whale, *Globicephala melas*
        - Genus *Grampus*
            - Risso's Dolphin, *Grampus griseus*
        - Genus *Lagenodelphis*
            - Fraser's Dolphin, *Lagenodelphis hosei*
        - Genus *Lagenorhynchus*
            - Atlantic White-sided Dolphin, *Lagenorhynchus acutus*
            - White-beaked Dolphin, *Lagenorhynchus albirostris*
            - Peale's Dolphin, *Lagenorhynchus australis*
            - Hourglass Dolphin, *Lagenorhynchus cruciger*

        - Pacific White-sided Dolphin, *Lagenorhynchus obliquidens*
        - Dusky Dolphin, *Lagenorhynchus obscurus*
    - Genus *Lissodelphis*
        - Northern Right Whale Dolphin, *Lissodelphis borealis*
        - Southern Right Whale Dolphin, *Lissodelphis peronii*
    - Genus *Orcaella*
        - Irrawaddy Dolphin, *Orcaella brevirostris*
            - Australian Snubfin Dolphin, *Orcaella heinsohni*. 2005 discovery, thus not recognized by Rice or MSW3 and subject to revision.
    - Genus *Orcinus*
        - Killer Whale, *Orcinus orca*
    - Genus *Peponocephala*
        - Melon-headed Whale, *Peponocephala electra*
    - Genus *Pseudorca*
        - False Killer Whale, *Pseudorca crassidens*
    - Genus *Sotalia*
        - Tucuxi, *Sotalia fluviatilis*
        - Costero, *Sotalia guianensis*
    - Genus *Sousa*
        - Pacific Humpback Dolphin, *Sousa chinensis*
        - Indian Humpback Dolphin, *Sousa plumbea*
        - Atlantic Humpback Dolphin, *Sousa teuszii*
    - Genus *Stenella*
        - Pantropical Spotted Dolphin, *Stenella attenuata*
        - Clymene Dolphin, *Stenella clymene*
        - Striped Dolphin, *Stenella coeruleoalba*
        - Atlantic Spotted Dolphin, *Stenella frontalis*
        - Spinner Dolphin, *Stenella longirostris*
    - Genus *Steno*
        - Rough-toothed Dolphin, *Steno bredanensis*
    - Genus *Tursiops* - Rice and MSW3 tentatively agree on this classification
        - Indian Ocean Bottlenose Dolphin, *Tursiops aduncus*
        - Common Bottlenose Dolphin, *Tursiops truncatus*
- Family Monodontidae
    - Genus *Delphinapterus*
        - Beluga, *Delphinapterus leucas*
    - Genus *Monodon*
        - Narwhal, *Monodon monoceros*
- Family Phocoenidae: Porpoises
    - Genus *Neophocaena*

        - Finless Porpoise, *Neophocaena phocaenoides*
    - Genus *Phocoena*
        - Spectacled Porpoise, *Phocoena dioptrica*
        - Harbour Porpoise, *Phocoena phocaena*
        - Vaquita, *Phocoena sinus*
        - Burmeister's Porpoise, *Phocoena spinipinnis*
    - Genus *Phocoenoides*
        - Dall's Porpoise, *Phocoenoides dalli*
- Family Physeteridae: Sperm Whale family
    - Genus *Physeter*
        - Sperm Whale, *Physeter catodon* (syn. *P. macrocephalus*)
- Family Kogiidae - MSW3 treats *Kogia* as a member of Physeteridae
    - Genus *Kogia*
        - Pygmy Sperm Whale, *Kogia breviceps*
        - Dwarf Sperm Whale, *Kogia sima*
- **Superfamily Platanistoidea**: River dolphins
    - Family Iniidae
        - Genus *Inia*
            - Amazon River Dolphin, *Inia geoffrensis*
                - Bolivian River Dolphin, *Inia boliviensis*
    - † Family Lipotidae - MSW3 treats *Lipotes* as a member of *Iniidae*
        - † Genus *Lipotes*
            - † Baiji, *Lipotes vexillifer*
    - Family Pontoporiidae - MSW3 treats *Pontoporia* as a member of *Iniidae*
        - Genus *Pontoporia*
            - La Plata Dolphin, *Pontoporia blainvillei*
    - Family Platanistidae
        - Genus *Platanista*
            - Ganges and Indus River Dolphin, *Platanista gangetica*. MSW3 treats *Platanista minor* as a separate species, with common names Ganges River Dolphin and Indus River Dolphin, respectively.
- Family Ziphidae, Beaked whales
    - Genus *Berardius*
        - Arnoux's Beaked Whale, *Berardius arnuxii*
        - Baird's Beaked Whale (North Pacific Bottlenose Whale), *Berardius bairdii*
    - Subfamily Hyperoodontidae
        - Genus *Hyperoodon*

        - Northern Bottlenose Whale, *Hyperoodon ampullatus*
        - Southern Bottlenose Whale, *Hyperoodon planifrons*
    - Genus *Indopacetus*
        - Indo-Pacific Beaked Whale (Longman's Beaked Whale), *Indopacetus pacificus*
    - Genus *Mesoplodon*, Mesoplodont Whale
        - Sowerby's Beaked Whale, *Mesoplodon bidens*
        - Andrews' Beaked Whale, *Mesoplodon bowdoini*
        - Hubbs' Beaked Whale, *Mesoplodon carlhubbsi*
        - Blainville's Beaked Whale, *Mesoplodon densirostris*
        - Gervais' Beaked Whale, *Mesoplodon europaeus*
        - Ginkgo-toothed Beaked Whale, *Mesoplodon ginkgodens*
        - Gray's Beaked Whale, *Mesoplodon grayi*
        - Hector's Beaked Whale, *Mesoplodon hectori*
        - Layard's Beaked Whale, *Mesoplodon layardii*
        - True's Beaked Whale, *Mesoplodon mirus*
        - Perrin's Beaked Whale, *Mesoplodon perrini*. This species was recognised in 2002 and as such is listed by MSW3 but not Rice.
        - Pygmy Beaked Whale, *Mesoplodon peruvianus*
        - Stejneger's Beaked Whale, *Mesoplodon stejnegeri*
        - Spade Toothed Whale, *Mesoplodon traversii*
    - Genus *Tasmacetus*
        - Tasman Beaked Whale (Shepherd's Beaked Whale), *Tasmacetus shepherdi*
    - Genus *Ziphius*
        - Cuvier's Beaked Whale, *Ziphius cavirostris*

†Extinct

Chapter- 8

Whale

Whale

Humpback whale

Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Subclass:	Eutheria
Order:	Cetacea

Whale (origin Old English *hpæl*) is the common name for various marine mammals of the order Cetacea. The term *whale* sometimes refers to all cetaceans, but more often it excludes dolphins and porpoises, which belong to suborder *Odontoceti* (toothed whales). This suborder also includes the sperm whale, killer whale, pilot whale, and beluga whale. The other Cetacean suborder *Mysticeti* (baleen whales), are filter feeders that eat small organisms caught by straining seawater through a comblike structure found in the mouth called baleen. This suborder includes the blue whale, the humpback whale, the bowhead

whale and the minke whale. All Cetacea have forelimbs modified as fins, a tail with horizontal flukes, and nasal openings (blowholes) on top of the head.

Whales range in size from the blue whale, the largest animal known to have ever existed at 35 m (115 ft) and 150 tonnes (150 LT; 170 ST), to various pygmy species, such as the pygmy sperm whale at 3.5 m (11 ft).

Whales collectively inhabit all the world's oceans and number in the millions, with annual population growth rate estimates for various species ranging from 3-13%. For centuries, whales have been hunted for meat and as a source of raw materials. By the middle of the 20th century, however, industrial whaling had left many species seriously endangered, leading to the end of whaling in all but a few countries.

Taxonomy

Cetaceans are divided into two suborders:

- The largest suborder, Mysticeti (baleen whales) are characterized by baleen, a sieve-like structure in the upper jaw made of keratin, which it uses to filter plankton from the water.
- Odontoceti (toothed whales) bear sharp teeth for hunting. Odontoceti also include dolphins and porpoises.

Both cetaceans and artiodactyl are now classified under the super-order Cetartiodactyla which includes both whales and hippopotamuses. Whales are the hippopotamus's closest living relatives.

Evolution

Ambulocetus natans - a primitive whale

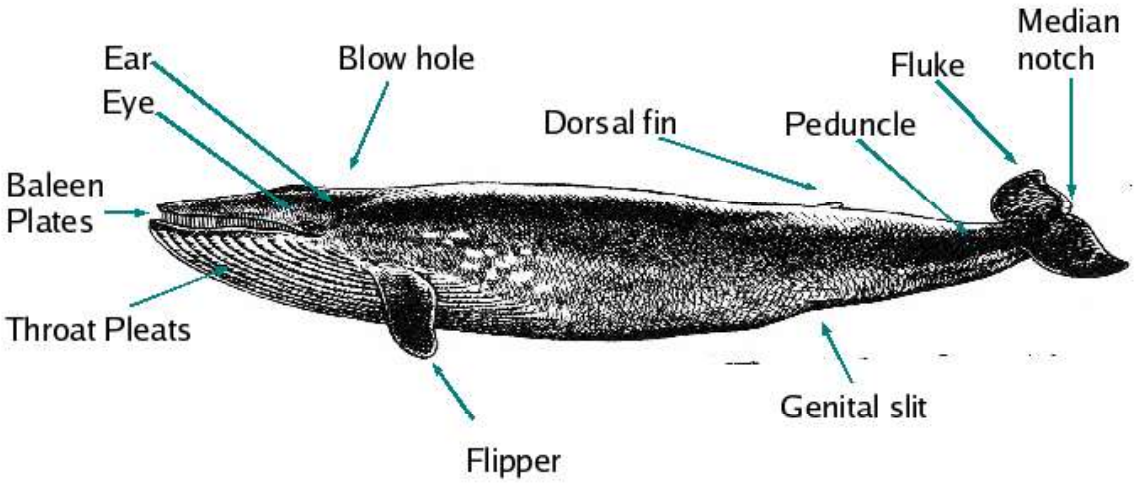
All cetaceans, including whales, dolphins and porpoises, are descendants of land-living mammals of the Artiodactyl order (even-toed ungulates). Both descended from a common ancestor, the Indohyus (an extinct semi-aquatic deer-like ungulate) from which they split around 54 million years ago. Primitive whales probably first took to the sea about 50 million years ago and became fully aquatic about 5-10 million years later.

Anatomy

Like all mammals, whales breathe air, are warm-blooded, nurse their young with milk from mammary glands, and have body hair.

Beneath the skin lies a layer of fat called blubber, which stores energy and insulates the body. Whales have a spinal column, a vestigial pelvic bone, and a four-chambered heart. The neck vertebrae are typically fused, trading flexibility for stability during swimming.

Blowhole(s)



Features of a blue whale

Whales breathe via blowholes; baleen whales have two and toothed whales have one. These are located on the top of the head, allowing the animal to remain mostly submerged whilst breathing. Breathing involves expelling excess water from the blowhole, forming an upward spout, followed by inhaling air into the lungs. Spout shapes differ among species and can help with identification.

Appendages

The body shape is fusiform and the modified forelimbs, or fins, are paddle-shaped. The end of the tail is composed of two flukes, which propel the animal by vertical movement, as opposed to the horizontal movement of a fish tail. Although whales do not possess fully developed hind limbs, some (such as sperm whales and baleen whales) possess

discrete rudimentary appendages, which may even have feet and digits. Most species have a dorsal fin.

Dentition

Toothed whales, such as the sperm whale, possess teeth with cementum cells overlying dentine cells. Unlike human teeth, which are composed mostly of enamel on the portion of the tooth outside of the gum, whale teeth have cementum outside the gum. Only in larger whales, where the cementum has been worn away on the tip of the tooth, does enamel show.

Instead of teeth, Baleen whales have a row of plates on the upper side of their jaws that resemble the "teeth" of a comb.

Ears

The whale ear has specific adaptations to the marine environment. In humans, the middle ear works as an impedance matcher between the outside air's low impedance and the cochlear fluid's high impedance. In aquatic mammals such as whales, however, there is no great difference between the outer and inner environments. Instead of sound passing through the outer ear to the middle ear, whales receive sound through the throat, from which it passes through a low-impedance fat-filled cavity to the inner ear.

Life history/behavior

Reproduction

Males are called 'bulls', females, 'cows' and newborns, 'calves'. Most species do not maintain fixed partnerships and females have several mates each season.

The female delivers usually a single calf tail-first to minimize the risk of drowning. Whale cows nurse by actively squirting milk, so fatty that it has the consistency of toothpaste, into the mouths of their young. Nursing continues for more than a year in many species, and is associated with a strong bond between mother and calf. Reproductive maturity occurs typically at seven to ten years. This mode of reproduction produces few offspring, but increases survival probability.

Socialization

Whales are known to teach, learn, cooperate, scheme, and even grieve.

Sleep

A Humpback Whale breaching.

Unlike most animals, whales are conscious breathers. All mammals sleep, but whales cannot afford to become unconscious for long because they may drown. It is thought that only one hemisphere of the whale's brain sleeps at a time, so they rest but are never completely asleep.

Surfacing behavior

Many whales exhibit behaviors such as breaching and tail slapping that expose large parts of their bodies to the air.

Lifespan

Whale lifespans vary among species and are not well characterized. Whaling left few older individuals to observe directly. R.M. Nowak of Johns Hopkins University estimated that humpback whales may live as long as 77 years. In 2007, a 19th century lance fragment was found in a bowhead whale off Alaska, suggesting the individual could be between 115 and 130 years old. Aspartic acid racemization in the whale eye, combined with a harpoon fragment, indicated an age of 211 years for another male, which, if true would make bowheads the longest-lived extant mammal species. The accuracy of this technique has been questioned because racemization did not correlate well with other dating methods.

Vocalization

Some species, such as the humpback whale, communicate using melodic sounds, known as whale song. Sperm whales have only been heard making clicks, while toothed whales (Odontoceti) use echolocation that can generate about 20,000 watts of sound (+73 dBm or +43 dBw) and be heard for many miles. Whale vocalization is likely to serve many purposes, including echolocation, mating, and identification.

Ecology

Feeding

Whales are generally classed as predators, but their food ranges from microscopic plankton to very large animals.

Toothed whales eat fish and squid which they hunt by use of echolocation. Orcas sometimes eat other marine mammals, including whales.

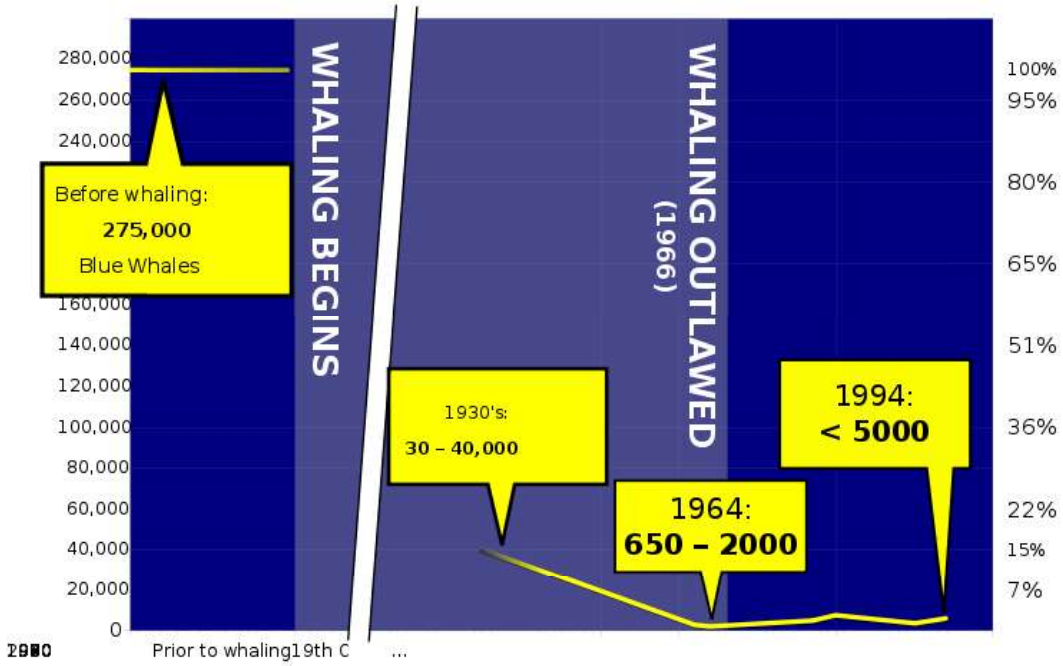
Baleen whales such as humpbacks and blues feed only in arctic waters, eating mostly krill. They imbibe enormous amounts of seawater which they expel through their baleen plates. The water is then expelled and the krill is retained on the plates and then swallowed. Whales do not drink seawater but indirectly extract water from their food by metabolizing fat.

Relation to humans

Whaling

Dutch whalers near Spitsbergen. *Abraham Storck, 1690*

World map of International Whaling Commission (IWC) members/non-members(member countries in blue)



World population graph of Blue Whales (Balaenoptera musculus)

Some species of large whales are listed as endangered by multinational organizations such as CITES along with governments and advocacy groups primarily due to whaling's impacts. They have been hunted commercially for whale oil, meat, baleen and ambergris (a perfume ingredient from the intestine of sperm whales) since the 17th century. At its peak in 1846, 736 vessels and 70,000 people were involved in the American whaling

industry. More than 2 million were taken in the early 20th century, and by the middle of the century, many populations were severely depleted.

The International Whaling Commission banned commercial whaling in 1986. The ban is not absolute, however, and some whaling continues under the auspices of scientific research (sometimes not proved) or aboriginal rights; current whaling nations are Norway, Iceland and Japan and the aboriginal communities of Siberia, Alaska and northern Canada.

Bycatch

Several species of small whales are caught as bycatch in fisheries for other species. In the Eastern Tropical Pacific tuna fishery, thousands of dolphins drowned in purse-seine nets, until preventive measures were introduced. Gear and deployment modifications, and eco-labelling (*dolphin-safe* or *dolphin-friendly* brands of tuna), have contributed to a reduction in dolphin mortality by tuna vessels. In many countries, small whales are still hunted for food, oil, meat or bait.

Naval sonar

Environmentalists speculate that advanced naval sonar endangers some cetaceans, including whales. In 2003 British and Spanish scientists suggested in *Nature* that the effects of sonar trigger whale beachings and to signs that such whales have experienced decompression sickness. Responses in Nature the following year discounted the explanation.

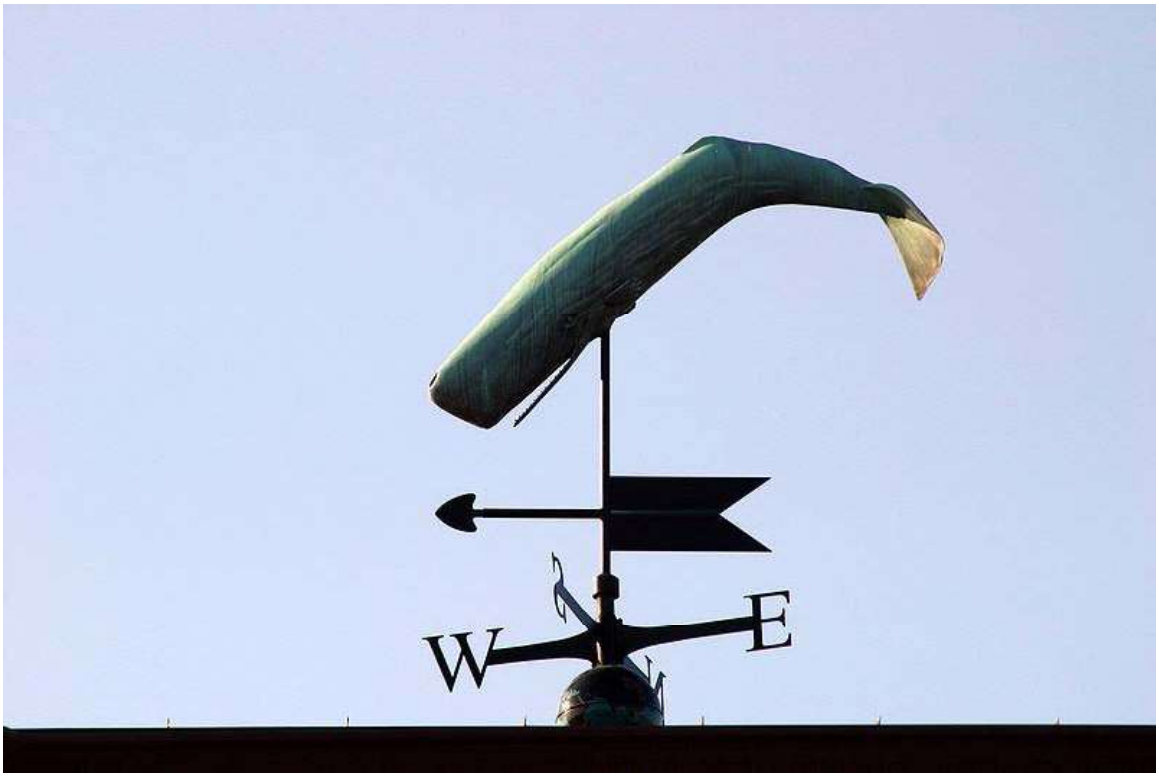
Mass whale beachings occur in many species, mostly beaked whales that use echolocation for deep diving. The frequency and size of beachings around the world, recorded over the last 1,000 years in religious tracts and more recently in scientific surveys, have been used to estimate the population of various whale species by assuming that the proportion of the total whale population beaching in any one year is constant. Beached whales can give other clues about population conditions, especially health problems. For example, bleeding around ears, internal lesions, and nitrogen bubbles in organ tissue suggest decompression sickness.

Following public concern, the U.S. Defense department was ordered by the 9th Circuit Court to strictly limit use of its Low Frequency Active Sonar during peacetime. Attempts by the UK-based Whale and Dolphin Conservation Society to obtain a public inquiry into the possible dangers of the Royal Navy's equivalent (the "2087" sonar launched in December 2004) failed as of 2008. The European Parliament has requested that EU members refrain from using the powerful sonar system until an environmental impact study has been carried out.

Other environmental disturbances

Other human activities have been suggested by marine biologists to adversely impact whale populations, such as collisions with ships and propellers, poisoning by waste contaminants and the unregulated use of fishing gear that catches anything that swims into it.

In mythology



Whale weather-vane atop the Nantucket Historical Association Whaling Museum displaying a Sperm Whale.

Whales were little understood for most of human history as they spend up to 90% of the lives underwater, only surfacing briefly to breathe. They also include the largest animals on the planet, so it is not surprising that many cultures, even those that have hunted them, hold them in awe and feature them in their mythologies.

In China, Yu-kiang, a whale with the hands and feet of a man was said to rule the ocean.

In the Tyrol region of Austria it was said that if a sunbeam were to fall on a maiden entering womanhood, she would be carried away in the belly of a whale.

Paikea, the youngest and favourite son of the chief Uenuku from the island of Mangaia in the present day Cook Islands in New Zealand was said by the Kati Kuri people of Kaikoura to have come from the Pacific Islands on the back of a whale many centuries

before. The novel and movie Whale Rider follow the trials of a girl named Paikia, who lives in such a culture.

The whale features in Inuit creation myths. When ‘Big Raven', a deity in human form, found a stranded whale, he was told by the Great Spirit where to find special mushrooms that would give him the strength to drag the whale back to the sea and thus return order to the world.

The Tlingit people of northern Canada said that the Orcas were created when the hunter Natsihlane carved eight fish from yellow cedar, sang his most powerful spirit song and commanded the fish to leap into the water.

In Icelandic legend a man threw a stone at a fin whale and hit the blowhole, causing the whale to burst. The man was told not to go to sea for twenty years but in the nineteenth year he went fishing and a whale came and killed him.

In East African legend King Sulemani asked God that He might permit him to feed all the beings on earth. A whale came and ate until there was no corn left and then told Sulemani that he was still hungry and that there were 70,000 more in his tribe. Sulemani then prayed to God for forgiveness and thanked the creature for teaching him a lesson in humility.

The King James Version of the Bible mentions whales four times: "And God created great whales" (Genesis 1:21); "Am I a sea, or a whale, that thou settest a watch over me? (Job 7:12); "Thou art like a young lion of the nations, and thou art as a whale in the seas (Ezekiel 32:2); and "For as Jonas [sic] was three days and three nights in the whale's belly; so shall the Son of man be three days and three nights in the heart of the earth" (Matthew 12:40). The story of Jonah being swallowed by a whale also is told in the Qur'an.

Some cultures associate divinity with whales, such as among Ghanaians and Vietnamese, who occasionally hold funerals for beached whales, a throwback to Vietnam's ancient sea-based Austro-asiatic culture.

Chapter- 9

Porpoise

Porpoises Fossil range: 15.970–0 Ma Miocene to Recent

Phocoena phocoena, Harbour Porpoise near Denmark
Scientific classification
Kingdom: Animalia
Phylum: Chordata
Class: Mammalia
Order: Cetacea
Suborder: Odontoceti
Superfamily: Delphinoidea
Family: **Phocoenidae** Gray, 1825

Porpoises (also called **mereswine**) are small cetaceans of the family **Phocoenidae**; they are related to whales and dolphins. They are distinct from dolphins, although the word "porpoise" has been used to refer to any small dolphin, especially by sailors and

fishermen. The most obvious visible difference between the two groups is that porpoises have flattened, spade-shaped teeth distinct from the conical teeth of dolphins, and shorter beaks.

The name derives from French *pourpois*, originally from Medieval Latin *porcopiscus* (*porcus* pig + *piscus* fish).

Porpoises, divided into six species, live in all oceans, mostly near the shore. Freshwater populations of the Finless Porpoise also exist. Probably the best known species is the Harbour Porpoise, which can be found across the Northern Hemisphere. Like all toothed whales, porpoises are predators, using sounds (echolocation in sonar form) to locate prey and to coordinate with others. They hunt fish, squid, and crustaceans.

Taxonomy and evolution

Porpoises, along with whales and dolphins, are descendants of land-living ungulates (hoofed animals) that first entered the oceans around 50 million years ago. During the Miocene (23 to 5 MYA), mammals were fairly modern. The cetaceans diversified, and fossil evidence suggests that porpoises diverged from dolphins and other cetaceans around 15 MYA. The oldest fossils are known from the shallow seas around the north Pacific, with animals spreading to the European coasts and southern hemisphere only much later, during the Pliocene.

Suborder Odontoceti Toothed whales

- Infraorder Delphinida
  - Superfamily Delphinoidea
    - Family **Phocoenidae: Porpoises**
      - Genus †*Haborophocoena*
        - *Haborophocoena toyoshimai*
      - Genus *Neophocaena*
        - Finless Porpoise, *Neophocaena phocaeniodes*
      - Genus †*Numataphocoena*
        - *Numataphocoena yamashitai*
      - Genus *Phocoena*
        - Harbour Porpoise, *Phocoena phocoena*
        - Vaquita, *Phocoena sinus*
        - Spectacled Porpoise, *Phocoena dioptrica*
        - Burmeister's Porpoise, *Phocoena spinipinnis*
      - Genus *Phocoenoides*
        - Dall's Porpoise, *Phocoenoides dalli*
      - Genus †*Septemriocetus*
        - *Septemriocetus bosselaersi*
      - Genus *Piscolithax*
        - *Piscolithax aenigmaticus*
        - *Piscolithax longirostris*

- *Piscolithax boreios*
- *Piscolithax tedfordi*

Recently discovered hybrids between male Harbour porpoises and female Dall's Porpoises indicate that the two species may actually be members of the same genus.

Physical characteristics

A Harbour Porpoise at an aquarium. In the wild, porpoises rarely jump out of the water.

Porpoises tend to be smaller but stouter than dolphins. They have small, rounded heads and blunt jaws instead of beaks. While dolphins have a round, bulbous "melon", porpoises do not. Their teeth are spade-shaped, whereas dolphins have conical teeth. In

addition, a porpoise's dorsal fin is generally triangular, rather than curved like that of many dolphins and large whales. Some species have small bumps, known as tubercles, on the leading edge of the dorsal fin. The function of these bumps is unknown.

These animals are the smallest cetaceans, reaching body lengths up to 2.5 metres (8.2 ft); the smallest species is the Vaquita, reaching up to 1.5 metres (4.9 ft). In terms of weight the lightest is the Finless Porpoise at 30 to 45 kilograms (66 to 99 lb) and the heaviest is Dall's Porpoise at 130 to 200 kilograms (290 to 440 lb). Because of their small size, porpoises lose body heat to the water more rapidly than other cetaceans. Their stout shape, which minimizes surface area, may be an adaptation to reduce heat loss. Thick blubber also insulates them from the cold. The small size of porpoises requires them to eat frequently, rather than depending on fat reserves.

Life history

Porpoises are relatively r-selected compared with dolphins: that is, they bear young more quickly than dolphins. Female Dall's and Harbour Porpoises often become pregnant with a single calf each year, and pregnancy lasts for about 11 months. Porpoises have been known to live 8–10 years although there are some that lived to be 20.

Behavior

"Rooster tail" spray around swimming Dall's Porpoises

Porpoises are predators of fish, squid, and crustaceans. Although they are capable of dives up to 200 m, they generally hunt in shallow coastal waters. They are found most commonly in small groups of fewer than ten individuals; a group is referred to as a pod. Rarely, some species form brief aggregations of several hundred animals. Like all toothed whales they are capable of echolocation for finding prey and group coordination. Porpoises are fast swimmers—Dall's porpoise is said to be one of the fastest cetaceans, with a speed of 55 km/h (34 mph). Porpoises tend to be less acrobatic and warier than dolphins.

Human impact

Accidental entanglement (bycatch) in fishing nets is the main threat to porpoises today. One of the most endangered cetacean species is the Vaquita, having a limited distribution in the Gulf of California, a highly industrialized area.

In some countries, porpoises are hunted for food or bait meat.

Porpoises are rarely held in captivity in zoos or oceanaria, as they are generally not as capable of adapting to tank life nor as easily trained as dolphins.

Chapter- 10

Dolphin

Bottlenose dolphin breaching in the bow wave of a boat

Dolphins are marine mammals that are closely related to whales and porpoises. There are almost forty species of dolphin in seventeen genera. They vary in size from 1.2 m (4 ft) and 40 kg (90 lb) (Maui's dolphin), up to 9.5 m (30 ft) and 10 tonnes (9.8 LT; 11 ST) (the orca or killer whale). They are found worldwide, mostly in the shallower seas of the continental shelves, and are carnivores, mostly eating fish and squid. The family Delphinidae is the largest in the Cetacean order, and evolved relatively recently, about ten million years ago, during the Miocene. Dolphins are among the most intelligent

animals, and their often friendly appearance and seemingly playful attitude have made them popular in human culture.

Etymology

The name is originally from Greek δελφίς (*delphís*), "dolphin", which was related to the Greek δελφύς (*delphus*), "womb". The animal's name can therefore be interpreted as meaning "a 'fish' with a womb". The name was transmitted via the Latin *delphinus* (the romanization of the later Greek δελφῖνος - *delphinos*), which in Middle Latin became *dolfinus* and in Old French *daulphin*, which reintroduced the *ph* into the word. The term **mereswine** has also historically been used.

The word is used in a few different ways. It can mean:

- any member of the family Delphinidae (oceanic dolphins),
- any member of the families Delphinidae and Platanistoidea (oceanic and river dolphins),
- any member of the suborder Odontoceti (toothed whales; these include the above families and some others),
- and is used casually as a synonym for bottlenose dolphin, the most common and familiar species of dolphin.

Here we, uses the second definition and does not describe porpoises (suborder Odontoceti, family Phocoenidae). Orcas and some closely related species belong to the Delphinidae family and therefore qualify as dolphins, even though they are called whales in common language. A group of dolphins is called a "school" or a "pod". Male dolphins are called "bulls", females "cows" and young dolphins are called "calves".

Taxonomy

Common dolphin

Bottlenose dolphin

Spotted Dolphin

Commerson's Dolphin

Dusky Dolphin

Killer Whales, also known as Orcas

The *Boto*, or Amazon River Dolphin

- Suborder Odontoceti, toothed whales
    - Family Delphinidae, oceanic dolphins
        - Genus *Delphinus*
            - Long-Beaked Common Dolphin, *Delphinus capensis*
            - Short-Beaked Common Dolphin, *Delphinus delphis*
        - Genus *Tursiops*
            - Common Bottlenose Dolphin, *Tursiops truncatus*
            - Indo-Pacific Bottlenose Dolphin, *Tursiops aduncus*
        - Genus *Lissodelphis*
            - Northern Rightwhale Dolphin, *Lissodelphis borealis*
            - Southern Rightwhale Dolphin, *Lissodelphis peronii*
        - Genus *Sotalia*
            - Tucuxi, *Sotalia fluviatilis*
            - Costero, *Sotalia guianensis*
        - Genus *Sousa*
            - Indo-Pacific Hump-backed Dolphin, *Sousa chinensis*
                - Chinese White Dolphin (the Chinese variant), *Sousa chinensis chinensis*
            - Atlantic Humpbacked Dolphin, *Sousa teuszii*
        - Genus *Stenella*
            - Atlantic Spotted Dolphin, *Stenella frontalis*
            - Clymene Dolphin, *Stenella clymene*
            - Pantropical Spotted Dolphin, *Stenella attenuata*
            - Spinner Dolphin, *Stenella longirostris*
            - Striped Dolphin, *Stenella coeruleoalba*
        - Genus *Steno*
            - Rough-Toothed Dolphin, *Steno bredanensis*
        - Genus *Cephalorhynchus*
            - Chilean Dolphin, *Cephalorhynchus eutropia*
            - Commerson's Dolphin, *Cephalorhynchus commersonii*
            - Heaviside's Dolphin, *Cephalorhynchus heavisidii*
            - Hector's Dolphin, *Cephalorhynchus hectori*
        - Genus *Grampus*
            - Risso's Dolphin, *Grampus griseus*
        - Genus *Lagenodelphis*
            - Fraser's Dolphin, *Lagenodelphis hosei*
        - Genus *Lagenorhynchus*
            - Atlantic White-Sided Dolphin, *Lagenorhynchus acutus*
            - Dusky Dolphin, *Lagenorhynchus obscurus*
            - Hourglass Dolphin, *Lagenorhynchus cruciger*
            - Pacific White-Sided Dolphin, *Lagenorhynchus obliquidens*
            - Peale's Dolphin, *Lagenorhynchus australis*
            - White-Beaked Dolphin, *Lagenorhynchus albirostris*
        - Genus *Orcaella*
            - Australian Snubfin Dolphin, *Orcaella heinsohni*
            - Irrawaddy Dolphin, *Orcaella brevirostris*

        - Genus *Peponocephala*
            - Melon-headed Whale, *Peponocephala electra*
        - Genus *Orcinus*
            - Killer Whale (Orca), *Orcinus orca*
        - Genus *Feresa*
            - Pygmy Killer Whale, *Feresa attenuata*
        - Genus *Pseudorca*
            - False Killer Whale, *Pseudorca crassidens*
        - Genus *Globicephala*
            - Long-finned Pilot Whale, *Globicephala melas*
            - Short-finned Pilot Whale, *Globicephala macrorhynchus*
        - Genus †Australodelphis
            - †*Australodelphis mirus*
    - Family *Platanistidae*
        - Ganges and Indus River Dolphin, *Platanista gangetica* with two subspecies
            - Ganges River Dolphin (or Susu), *Platanista gangetica gangetica*
            - Indus River Dolphin (or Bhulan), *Platanista gangetica minor*
    - Family *Iniidae*
        - Amazon River Dolphin (or Boto), *Inia geoffrensis*
    - Family *Lipotidae*
        - Baiji (or Chinese River Dolphin), *Lipotes vexillifer* (possibly extinct, since December 2006)
    - Family *Pontoporiidae*
        - La Plata Dolphin (or Franciscana), *Pontoporia blainvillei*

Six species in the family Delphinidae are commonly called "whales", but genetically are dolphins. They are sometimes called *blackfish*.

- Melon-headed Whale, *Peponocephala electra*
- Killer Whale (Orca), *Orcinus orca*
- Pygmy Killer Whale, *Feresa attenuata*

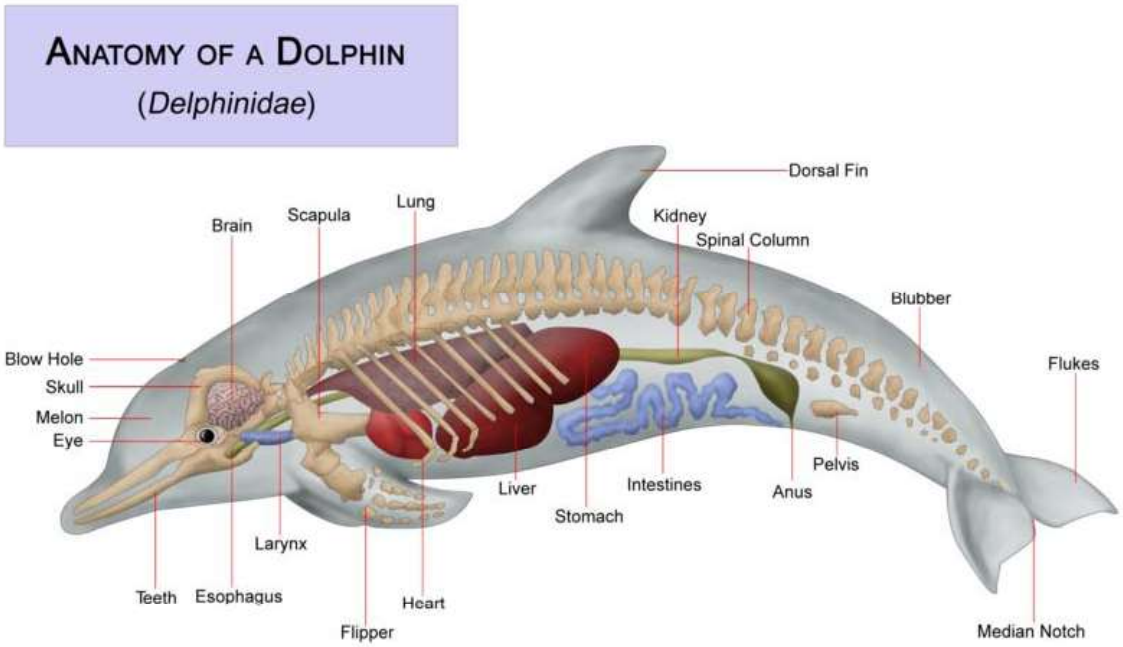
Wolphin Kawili'Kai at the Sea Life Park in Hawaii.

- False Killer Whale, *Pseudorca crassidens*
- Long-finned Pilot Whale, *Globicephala melas*
- Short-finned Pilot Whale, *Globicephala macrorhynchus*

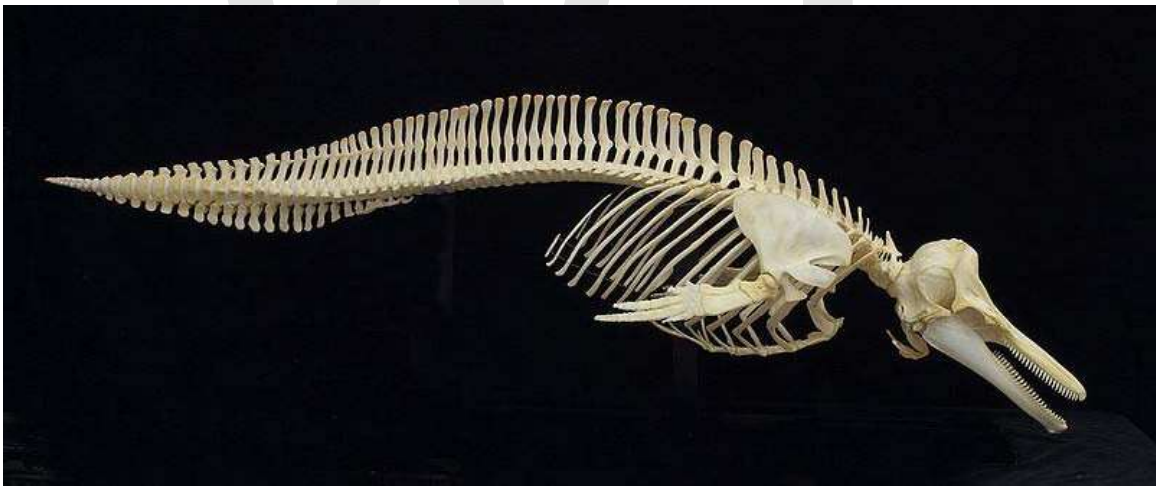
Hybridization

In 1933, three strange dolphins beached off the Irish coast; they appeared to be hybrids between Risso's and bottlenose dolphins. This mating was later repeated in captivity, producing a hybrid calf. In captivity, a bottlenose and a rough-toothed dolphin produced hybrid offspring. A common-bottlenose hybrid lives at SeaWorld California. Other dolphin hybrids live in captivity around the world or have been reported in the wild, such as a bottlenose-Atlantic spotted hybrid. The best known hybrid is the wolphin, a false killer whale-bottlenose dolphin hybrid. The wolphin is a fertile hybrid. Two wolphins currently live at the Sea Life Park in Hawaii; the first was born in 1985 from a male false killer whale and a female bottlenose. Wolphins have also been observed in the wild.

Evolution and anatomy



The anatomy of a dolphin, showing its skeleton, major organs, tail, and body shape



Pacific white-sided dolphin skeleton (missing pelvic bones), on exhibit at The Museum of Osteology, Oklahoma City, Oklahoma

Evolution

Dolphins, along with whales and porpoises, are descendants of terrestrial mammals, most likely of the Artiodactyl order. The ancestors of the modern day dolphins entered the water roughly fifty million years ago, in the Eocene epoch.

Hind limb buds are apparent on an embryo of a spotted dolphin in the fifth week of development as small bumps (hind limb buds) near the base of the tail. The pin is approximately 2.5 cm (1.0 in) long.

Modern dolphin skeletons have two small, rod-shaped pelvic bones thought to be vestigial hind limbs. In October 2006, an unusual bottlenose dolphin was captured in Japan; it had small fins on each side of its genital slit, which scientists believe to be a more pronounced development of these vestigial hind limbs.

Anatomy

Dolphins have a streamlined fusiform body, adapted for fast swimming. The tail fin, called the fluke, is used for propulsion, while the pectoral fins together with the entire tail section provide directional control. The dorsal fin, in those species that have one, provides stability while swimming.

Though it varies by species, basic coloration patterns are shades of grey, usually with a lighter underside, often with lines and patches of different hue and contrast.

The head contains the melon, a round organ used for echolocation. In many species, elongated jaws form a distinct beak; species such as the bottlenose have a curved mouth which looks like a fixed smile. Some species have up to 250 teeth. Dolphins breathe through a blowhole on top of their head. The trachea is anterior to the brain. The dolphin

brain is large and highly complex, and is different in structure from that of most land mammals.

Unlike most mammals, dolphins do not have hair, except for a few hairs around the tip of their rostrum which they lose shortly before or after birth. The only exception to this is the Boto river dolphin, which has persistent small hairs on the rostrum.

Dolphins' reproductive organs are located on the underside of the body. Males have two slits, one concealing the penis and one further behind for the anus. The female has one genital slit, housing the vagina and the anus. A mammary slit is positioned on either side of the female's genital slit.

A recent study at the U.S. National Marine Mammal Foundation revealed dolphins are the only animals other than humans that develop a natural form of type 2 diabetes, which may lead to a better understanding of the disease and new treatments for both humans and dolphins.

Senses

Most dolphins have acute eyesight, both in and out of the water, and they can hear frequencies ten times or more above the upper limit of adult human hearing. Though they have a small ear opening on each side of their head, it is believed hearing underwater is also, if not exclusively, done with the lower jaw, which conducts sound to the middle ear via a fat-filled cavity in the lower jaw bone. Hearing is also used for echolocation, which all dolphins have. Dolphin teeth are believed to function as antennae to receive incoming sound and to pinpoint the exact location of an object. The dolphin's sense of touch is also well-developed, with free nerve endings densely packed in the skin, especially around the snout, pectoral fins and genital area. However, dolphins lack an olfactory nerve and lobes, and thus are believed to have no sense of smell. They do have a sense of taste and show preferences for certain kinds of fish. Since dolphins spend most of their time below the surface, tasting the water could function like smelling, in that substances in the water can signal the presence of objects that are not in the dolphin’s mouth.

Though most dolphins do not have hair, they do have hair follicles that may perform some sensory function. The small hairs on the rostrum of the Boto river dolphin are believed to function as a tactile sense possibly to compensate for the Boto's poor eyesight.

Behavior

A pod of Indo-Pacific bottlenose dolphins in the Red Sea.

Dolphins are often regarded as one of Earth's most intelligent animals, though it is hard to say just how intelligent. Comparing species' relative intelligence is complicated by differences in sensory apparatus, response modes, and nature of cognition. Furthermore, the difficulty and expense of experimental work with large aquatic animals has so far prevented some tests and limited sample size and rigor in others. Compared to many other species, however, dolphin behavior has been studied extensively, both in captivity and in the wild.

Social behavior

Dolphins surfing at Snapper Rocks, Queensland, Australia

Dolphins are social, living in pods of up to a dozen individuals. In places with a high abundance of food, pods can merge temporarily, forming a **superpod**; such groupings may exceed 1,000 dolphins. Individuals communicate using a variety of clicks, whistles and other vocalizations. They make ultrasonic sounds for echolocation. Membership in pods is not rigid; interchange is common. However, dolphins can establish strong social bonds; they will stay with injured or ill individuals, even helping them to breathe by bringing them to the surface if needed. This altruism does not appear to be limited to their own species however. The dolphin *Moko* in New Zealand has been observed guiding a female Pygmy Sperm Whale together with her calf out of shallow water where they had

stranded several times. They have also been seen protecting swimmers from sharks by swimming circles around the swimmers or charging the sharks to make them go away.

Dolphins also display culture, something long believed to be unique to humans (and possibly other primate species). In May 2005, a discovery in Australia found Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) teaching their young to use tools. They cover their snouts with sponges to protect them while foraging. This knowledge is mostly transferred by mothers to daughters, unlike simian primates, where knowledge is generally passed on to both sexes. Using sponges as mouth protection is a learned behavior. Another learned behavior was discovered among river dolphins in Brazil, where some male dolphins use weeds and sticks as part of a sexual display.

Dolphins engage in acts of aggression towards each other. The older a male dolphin is, the more likely his body is to be covered with bite scars. Male dolphins engage in such acts of aggression apparently for the same reasons as humans: disputes between companions and competition for females. Acts of aggression can become so intense that targeted dolphins sometimes go into exile as a result of losing a fight.

Male bottlenose dolphins have been known to engage in infanticide. Dolphins have also been known to kill porpoises for reasons which are not fully understood, as porpoises generally do not share the same diet as dolphins, and are therefore not competitors for food supplies.

Reproduction and sexuality

Dolphin copulation happens belly to belly; though many species engage in lengthy foreplay, the actual act is usually brief, but may be repeated several times within a short timespan. The gestation period varies with species; for the small Tucuxi dolphin, this period is around 11 to 12 months, while for the orca, the gestation period is around 17 months. They usually become sexually active at a young age, even before reaching sexual maturity. The age of sexual maturity varies by species and gender.

Dolphins are known to have sex for reasons other than reproduction, sometimes also engaging in homosexual behavior. Various species sometimes engage in sexual behavior including copulation with other dolphin species. Sexual encounters may be violent, with male dolphins sometimes showing aggressive behavior towards both females and other males. Occasionally, dolphins behave sexually towards other animals, including humans.

Feeding

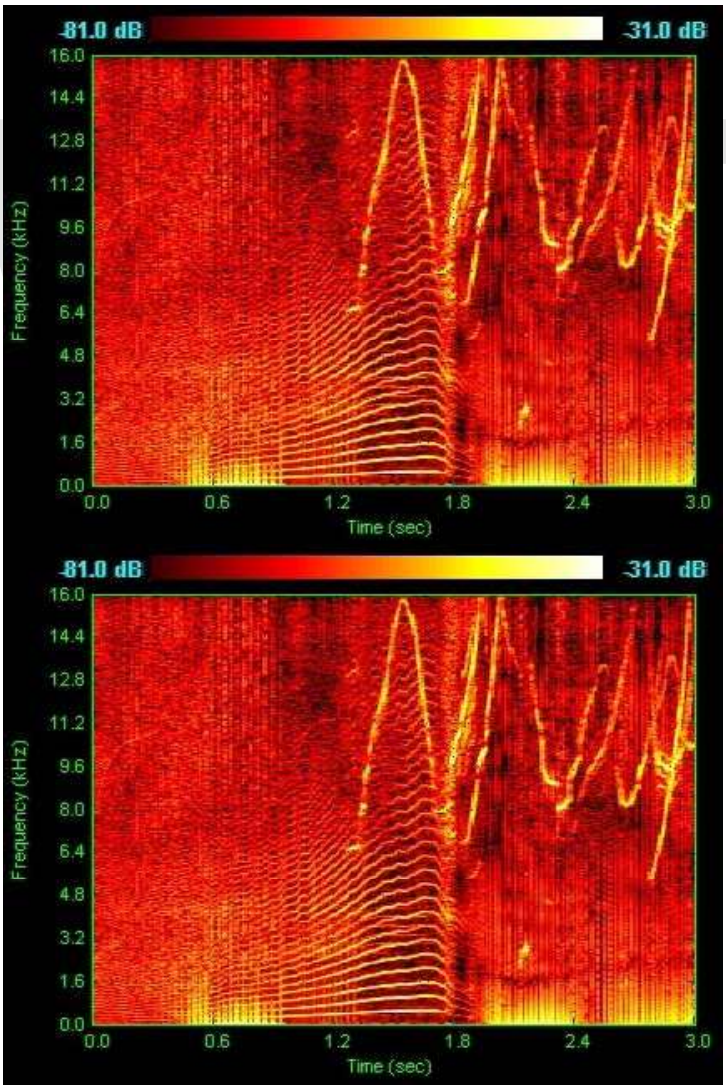
Various methods of feeding exist among and within species, some apparently exclusive to a single population. Fish and squid are the main food, but the false killer whale and the orca also feed on other marine mammals.

One common feeding method is herding, where a pod squeezes a school of fish into a small volume, known as a bait ball. Individual members then take turns plowing through

the ball, feeding on the stunned fish. Coralling is a method where dolphins chase fish into shallow water to more easily catch them. In South Carolina, the Atlantic bottlenose dolphin takes this further with "strand feeding", driving prey onto mud banks for easy access. In some places, orcas come to the beach to capture sea lions. Some species also whack fish with their flukes, stunning them and sometimes knocking them out of the water.

Reports of cooperative human-dolphin fishing date back to the ancient Roman author and natural philosopher Pliny the Elder. A modern human-dolphin partnership currently operates in Laguna, Santa Catarina, Brazil. Here, dolphins drive fish towards fishermen waiting along the shore and signal the men to cast their nets. The dolphins' reward is the fish that escape the nets.

Vocalizations



Spectrogram of dolphin vocalizations, with whistles, whines, and clicks are visible as upside down V's, horizontal striations, and vertical lines, respectively.

Dolphins are capable of making a broad range of sounds using nasal airsacs located just below the blowhole. Roughly three categories of sounds can be identified: frequency modulated whistles, burst-pulsed sounds and clicks. Dolphins communicate with their whistles and burst-pulsed sounds, though the nature and extent of that ability is not known. At least some dolphin species can identify themselves using a signature whistle. The clicks are directional and are for echolocation, often occurring in a short series called a click train. The click rate increases when approaching an object of interest. Dolphin echolocation clicks are amongst the loudest sounds made by marine animals.

Jumping and playing

Pacific white-sided dolphins breaching

Dolphins occasionally leap above the water surface, and sometimes perform acrobatic figures (e.g. the spinner dolphin). Scientists are not certain about the purpose(s) of the acrobatics. Possibilities include locating schools of fish by looking at above-water signs like feeding birds, communicating with other dolphins, dislodging parasites or simple amusement.

Play is an important part of dolphin culture. Dolphins play with seaweed and play-fight with other dolphins. At times they harass other local creatures, like seabirds and turtles. Dolphins enjoy riding waves and frequently surf coastal swells and the bow waves of boats, at times “leaping” between the dual bow waves of a moving catamaran. Occasionally, they playfully interact with swimmers. Captive dolphins have been observed in aquariums engaging in complex play behavior which involves the creation and manipulation of bubble rings.

Sleeping

Generally, dolphins sleep with only one brain hemisphere in slow-wave sleep at a time, thus maintaining enough consciousness to breathe and to watch for possible predators and other threats. Earlier sleep stages can occur simultaneously in both hemispheres. In captivity, dolphins seemingly enter a fully asleep state where both eyes are closed and there is no response to mild external stimuli. Respiration is automatic; a tail kick reflex keeps the blowhole above the water if necessary. Anesthetized dolphins initially show a tail kick reflex. Though a similar state has been observed with wild Sperm Whales, it is not known if dolphins in the wild reach this state. The Indus river dolphin has a different sleep method from other dolphin species. Living in water with strong currents and potentially dangerous floating debris, it must swim continuously to avoid injury. As a result, this species sleeps in very short bursts which last between 4 and 60 seconds.

Threats

Natural threats

Except for humans (discussed below), dolphins have few natural enemies. Some species or specific populations have none, making them apex predators. For most of the smaller species of dolphins, only a few of the larger sharks, such as the bull shark, dusky shark, tiger shark and great white shark are a potential risk, especially for calves. Some of the larger dolphinic species, especially orcas (killer whales), may also prey smaller dolphins, but this seems rare. Dolphins also suffer from a wide variety of diseases and parasites.

Human threats

Dead Atlantic white-sided dolphins in Hvalba on the Faroe Islands, killed in a drive hunt

Some dolphin species face an uncertain future, especially some river dolphin species such as the Amazon river dolphin, and the Ganges and Yangtze river dolphin, which are critically or seriously endangered. A 2006 survey found no individuals of the Yangtze river dolphin, which now appears to be functionally extinct.

Pesticides, heavy metals, plastics, and other industrial and agricultural pollutants that do not disintegrate rapidly in the environment concentrate in predators such as dolphins. Injuries or deaths due to collisions with boats, especially their propellers, are also common.

Various fishing methods, most notably purse seine fishing for tuna and the use of drift and gill nets, unintentionally kill many dolphins. Accidental by-catch in gill nets and incidental captures in antipredator nets that protect marine fish farms are common and pose a risk for mainly local dolphin populations. In some parts of the world, such as Taiji in Japan and the Faroe Islands, dolphins are traditionally considered as food, and are killed in harpoon or drive hunts. Dolphin meat is high in mercury, and may thus pose a health danger to humans when consumed.

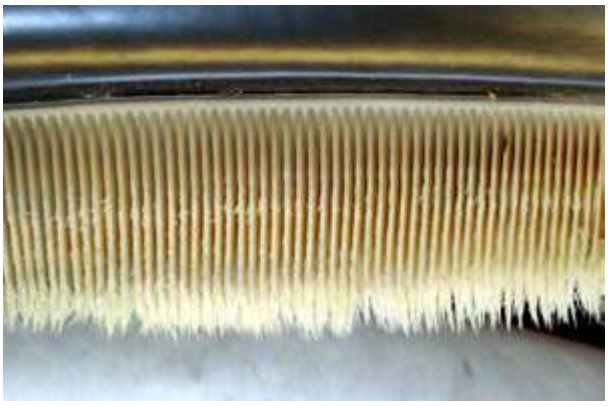
Dolphin safe labels attempt to reassure consumers fish and other marine products have been caught in a dolphin-friendly way. The original deal with "Dolphin safe" labels was brokered in the 1980s between marine activists and the major tuna companies, and involved decreasing incidental dolphin kills by up to 50% by changing the type of nets being used to catch the tuna. It should be noted that the dolphins are only netted while fishermen are in pursuit of smaller tuna. Albacore are not netted this way, which makes albacore the only truly dolphin-safe tuna.

Loud underwater noises, such as those resulting from naval sonar use, live firing exercises, or certain offshore construction projects, such as wind farms, may be harmful to dolphins, increasing stress, damaging hearing, and causing decompression sickness by forcing them to surface too quickly to escape the noise.

Chapter- 11

Baleen Whale

Baleen whales Fossil range: latest Eocene – Recent	
	
Humpback Whale breaching	
Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Order:	Cetacea
Suborder:	**Mysticeti** Cope, 1891



Baleen

The **baleen whales**, also called **whalebone whales** or **great whales**, form the **Mysticeti**, one of two suborders of the Cetacea (whales, dolphins, and porpoises). Baleen whales are characterized by having baleen plates for filtering food from water, rather than having teeth. This distinguishes them from the other suborder of cetaceans, the toothed whales or Odontoceti. Living Mysticeti species have teeth only during the embryonal phase. Fossil Mysticeti had teeth before baleen evolved.

The suborder contains four extant families and fifteen species.

Etymology

The taxonomic name *Mysticeti* apparently derives from a transmission error in early copies of Aristotle's *Historia Animalium* in which "*ο μυς το κητος*" ("the whale known as 'the mouse' or 'Gutter whale' ") was mistakenly run together as "*ο μυστικητος*" ("the Mysticetus"). An alternate name for the suborder is *Mystacoceti* (from Greek *μυσταξ* "moustache" + *κητος* "whale").

Anatomy

Baleen whales are generally larger than toothed whales, and females are bigger than males. This group includes the largest known animal species, the Blue Whale.

Humpback whale with two blowholes clearly visible

Baleen whales have two blowholes, causing a V-shaped blow.

Ecology and life history

Behavioral ecology

Solitary or in small groups called pods.

Breaching

In spite of their enormous size, baleen whales are able to leap completely out of the water. They can grow to 190,000 kilograms (420,000 lb) in weight and 33.5 metres (110 ft) in length. Particularly known for its acrobatics is the Humpback Whale, but other baleen whales also break through the water surface with their body or beat it loudly with their fins. Some believe that the male baleen whales try to show off in the presence of females to increase their mating success. Scientists speculate that baleen whales and other cetaceans may engage in breaching to dislodge parasites, or scratch irritated skin. Breaching, and other behaviors like lobtailing, are also used to stun or kill nearby fish or krill.

Importance to humans

From the 11th to the late 20th centuries, baleen whales were hunted commercially for their oil and baleen. Their oil was used to make margarine and cooking oils, whilst their baleen was used to stiffen corsets, as parasol ribs and to crease paper.

Evolutionary history

Parietobalaena palmeri (extinct) skull

Early baleen whales first appeared as far back as the early Oligocene, or perhaps the latest Eocene (39–29 million years ago; e.g., *Llanocetus*). Early baleen whales possessed teeth inherited from their ancestors, as opposed to baleen, in modern species. The Oligocene species *Aetiocetus cotylalveus* is considered the evolutionary link between toothed and baleen whales. This species was discovered by fossil collector Douglas Emlong in 1964 near Seal Rock State Recreation Site, Oregon, in a sandstone formation. In the early 1990s, the species *Janjucetus hunderi* was discovered in Victoria, Australia by a surfer and was described in 2006 by E. M. G. Fitzgerald. *Janjucetus* was a baleen whale with sharp teeth that hunted fish and squid as well as larger prey, potentially including sharks and dolphin-like cetaceans. These fossils hint that early baleen whales were predatory and eventually evolved into the gentler, toothless whales known today. A recent study identified palatal foramina (bony impressions of blood vessels that "feed" the baleen racks) in the palate of a toothed mysticete, *Aetiocetus weltoni*. The scientists involved indicated that this discovery implies that this whale previously possessed both teeth and baleen, and serves as an intermediate adaptive role between primitive toothed

mysticetes and more advanced toothless mysticetes. The first baleen-bearing, toothless baleen whales (such as *Eomysticetus* and *Micromysticetus*) appeared in the late Oligocene. Early baleen whales probably could not echolocate; no anatomical evidence preserved in the skulls and ear regions of any fossil baleen whales show any of the adaptations associated with echolocation as in toothed whales.

Taxonomic classification

The "†"'s denote extinct families and genera.

Suborder Mysticeti: Baleen whales

- Family †Aetiocetidae
  - † *Aetiocetus*
  - † *Ashorocetus*
  - † *Chonecetus*
  - † *Morawanocetus*
  - † *Willungacetus*
- Family †Aglaocetidae
  - † *Aglaocetus*
  - † *Isanacetus*
  - † *Pinocetus*
- Family Balaenidae: Right whales and Bowhead Whale
  - *Balaena* Bowhead whales
  - †*Balaenella*
  - †*Balaenotus*
  - †*Balaenula*
  - *Eubalaena*
  - *Eucetites*
  - †*Morenocetus*
- Family Balaenopteridae: Rorquals
  - †*Archaebalaenoptera*
  - *Balaenoptera*
  - †*Cetotheriophanes*
  - †*Diunatans*
  - †*Mauicetus*
  - *Megaptera*
  - †*Notiocetus*
  - †*Parabalaenoptera*
  - †*Plesiobalaenoptera*
  - †*Praemegaptera*
  - †*Protororqualus*
- †Family Cetotheriidae
  - †*Cephalotropis*
  - †*Cetotherium*
  - †*Herpetocetus*

    - †*Hibacetus*
    - †*Joumocetus*
    - †*Metopocetus*
    - †*Mixocetus*
    - †*Nannocetus*
    - †*Palaeobalaena*
    - †*Piscobalaena*
    - †*Plesiocetopsis*
    - †*Titanocetus*
- †Family Cetotheriopsidae
    - †*Cetotheriopsis*
    - †*Micromysticetus*
- †Family Diorocetidae
    - †*Amphicetus*
    - †*Diorocetus*
    - †*Plesiocetus*
    - †*Thinocetus*
    - †*Uranocetus*
- †Family Eomysticetidae
    - †*Eomysticetus*
- Family Eschrichtiidae
    - †*Archaeschrichtius*
    - †*Eschrichtioides*
    - *Eschrichtius* Grey whales
    - †*Gricetoides*
    - †*Megapteropsis*
- †Family Llanocetidae
    - †*Llanocetus*
- †Family Mammalodontidae
    - †*Janjucetus*
    - †*Mammalodon*
- Family Neobalaenidae: Pygmy Right Whale
    - *Caperea*, Pygmy Right Whale
- †Family Pelocetidae
    - †*Cophocetus*
    - †*Halicetus*
    - †*Parietobalaena*
    - †*Pelocetus*
    - †*Eobalaenoptera*
- Family *incertae sedis*
    - †*Amphitera*
    - †*Burtinopsis*
    - †*Idiocetus*
    - †*Imerocetus*
    - †*Isocetus*
    - †*Mesocetus*

- †*Mioceta*
- †*Otradnocetus*
- †*Peripolocetus*
- †*Piscocetus*
- †*Siphonocetus*
- †*Tiphyocetus*
- †*Tretulias*
- †*Ulias*

The earliest-known baleen whale is *Llanocetus*, discovered on Seymour Island, Antarctica, by E.D. Mitchell in 1989. The species lived during the Latest Eocene/Earliest Miocene, about 35 mya.

Chapter- 12

Toothed Whales

Beaked whale

Beaked whale Fossil range: Miocene–Recent

Ziphius cavirostris
Scientific classification
Kingdom: Animalia
Phylum: Chordata
Class: Mammalia
Order: Cetacea
Superfamily: **Ziphioidea**
Family: **Ziphiidae** Gray, 1850

Beaked whales are 21 species of toothed whales, members of the family *Ziphiidae* that are notable for their elongated snouts. They are the only marine mammals whose evolution is believed to have been shaped by a secondary sexual characteristic (the male's teeth). Beaked whales are the world's most extreme divers. They can dive for long periods—20 to 30 minutes is common, and 85 minute dives have been recorded—and to great depths: 1,899 metres (1,038 fathoms) and possibly more. To avoid getting decompression sickness—the potentially fatal build-up of nitrogen bubbles in body tissues—they must surface slowly.

Beaked whales are one of the least known groups of mammals because of their deep-sea habitat, mysterious habits, and apparent low abundance. Several species have yet to be formally described or named; others are known only from remains and have never been sighted alive. Only 3–4 of the 20-odd species are reasonably well-known. Baird's and Cuvier's Beaked Whales were subject to commercial exploitation, off the coast of Japan, while the Northern Bottlenose Whale was extensively hunted in the northern part of the North Atlantic late in the 19th and early in the 20th centuries.

Physical characteristics

Beaked whales are moderate in size, ranging from 4 to 13 metres (13 to 43 ft) and weighing from 1 to 15 tonnes (0.98 to 15 LT; 1.1 to 17 ST). Their key distinguishing feature is the presence of a 'beak', somewhat similar to many dolphins. Other distinctive features include a pair of converging grooves under the throat, and the absence of a notch in the tail fluke. Although Shepherd's Beaked Whale is an exception, most species have only one or two pairs of teeth, and even these do not erupt in females. Beaked whale species are often sexually dimorphic—one or the other sex is significantly larger. The adult males often possess a dramatically bulging forehead. However, aside from dentition and size, there are very few morphological differences between male and female beaked whales.

Individual species are very difficult to identify in the wild, since body form varies little from one species to another. The observer must rely on often subtle differences in size, color, forehead shape, and beak length.

Teeth

Beaked whales are unique among toothed whales in that most species only have one pair of teeth. Most species only have one pair of teeth in the lower jaw, and only males have this pair of tusk-like teeth. Males are presumed to use their teeth in combat for female reproductive rights. In females, the teeth do not develop and remain hidden in the gum tissues. This characteristic helps to distinguish beaked whale species from each other.

In December 2008, researchers from the Marine Mammal Institute at Oregon State University completed a DNA tree of all 21 known species of beaked whales. Among the results of this study was the conclusion that the male's teeth are actually a secondary sexual characteristic, similar to the antlers of male deer. Each species' teeth have a characteristically unique shape. Females are presumed to select mates based on the shape of the teeth, because the different species are otherwise quite similar in appearance. Females may also choose mates based on the size or shape of teeth or the scars they bear.

These teeth also play an important role in competing to control a harem. This is the only known instance of a secondary sexual characteristic having shaped the evolution of a marine mammal.

Taxonomy

Beaked whales comprise at least twenty species of small whale in the family **Ziphiidae**, which is one of the least-known families of large mammals: several species have been described only in the last two decades. Six genera have been identified.

The beaked whales are the second-largest family of Cetaceans (after the dolphins.) They were one of the first groups to diverge from the ancestral lineage. The earliest known beaked whale fossils date to the Miocene, about 20 million years ago.

- **ORDER CETACEA**
- **Suborder Odontoceti**: toothed whales
    - **Family Ziphiidae**
        - Subfamily Berardiinae
            - Genus †*Archaeoziphius*
            - Genus *Berardius*
                - *Berardius arnuxii*, Arnoux's beaked whale
                - *Berardius bairdii*, Baird's beaked whale
            - Genus †*Microberardius*
        - Subfamily Hyperoodontinae
            - Genus †*Africanacetus*
            - Genus *Hyperoodon*: Bottlenose whales
                - *Hyperoodon ampullatus*, Northern bottlenose whale
                - *Hyperoodon planifrons*, Southern bottlenose whale
            - Genus *Indopacetus*
                - *Indopacetus pacificus*, Longman's beaked whale
            - Genus *Mesoplodon*, Mesoplodont whales
                - *Mesoplodon bidens*, Sowerby's beaked whale
                - *Mesoplodon bowdoini*, Andrew's beaked whale
                - *Mesoplodon carlhubbsi*, Hubbs' beaked whale
                - *Mesoplodon densirostris*, Blainville's beaked whale
                - *Mesoplodon europaeus*, Gervais' beaked whale
                - *Mesoplodon ginkgodens*, Ginkgo-toothed beaked whale
                - *Mesoplodon grayi*, Gray's beaked whale
                - *Mesoplodon hectori*, Hector's beaked whale
                - *Mesoplodon layardii*, Strap-toothed whale
                - *Mesoplodon mirus*, True's beaked whale,
                - *Mesoplodon peruvianus*, pygmy beaked whale
                - *Mesoplodon perrini*, Perrin's beaked whale
                - *Mesoplodon stejnegeri*, Stejneger's beaked whale
                - *Mesoplodon traversii*, Spade toothed whale
        - Subfamily Ziphiinae
            - Genus †*Caviziphius*
            - Genus †*Izikoziphius*
            - Genus *Tasmacetus*

        - *Tasmacetus sheperdi*, Shepherd's beaked whale
    - Genus *Ziphius*
        - *Ziphius cavirostris*, Cuvier's beaked whale
- Subfamily *Incertae sedis*
    - Genus †*Nenga*
    - Genus †*Pterocetus*
    - Genus †*Xhosacetus*

Evolutionary history

As many as eight genera predate humans. Some included ancestors of giant beaked whales (*Berardius*), such as *Microberardius*. Cuvier's beaked whale (*Ziphius*) had many relatives, such as *Caviziphius*, *Archaeoziphius*, and *Izikoziphius*. They were probably preyed upon by predatory whales and sharks, including *Carcharocles megalodon*.

Recently, a large fossil ziphiid sample was discovered off of the South African coast, confirming that the extant ziphiid diversity might just be a remnant of a higher past diversity. After studying numerous fossil skulls off the shore of South Africa, researchers discovered the absence of functional maxillary teeth in all South African fossil ziphiids, which is evidence that suction feeding had already developed in several beaked whale lineages during the Miocene. Researchers also found fossil ziphiids with robust skulls, signaling that tusks were used for male-male interactions (speculated with extant beaked whales).

Ecology

Diving

Beaked whales are deep divers with extreme dive profiles They regularly dive deeper than 500 m to echolocate for food, and these deep dives are often followed by multiple shallower dives of less than 500 m. Based on currently available data, beaked whales are thought to spend much of their lives below water.

Deep diving mammals face a number of challenges related to extended breath holding and hydrostatic pressure. Cetaceans and pinnipeds that prolong apnea must optimize the size and use of their oxygen stores, and they must deal with the accumulation of lactic acid due to anaerobic metabolism. Beaked whales have several anatomical adaptations to deep diving: large spleens, livers, and body shape. Most cetaceans have small spleens. However, beaked whales have much larger spleens than delphinids and may have larger livers as well. These anatomical traits, which are important for filtering blood, could be adaptations to deep diving. Another notable anatomical adaptation among beaked whales is a slight depression in the body wall that allows a beaked whale to hold its pectoral flippers tightly against its body for increased streamlining.

The challenges of deep diving are also overcome by the unique diving physiology of beaked whales. Oxygen storage during dives is mostly achieved by blood hemoglobin

and muscle myoglobin. While the whale is diving, its heart rate slows and blood flow changes. This physiological dive response ensures that oxygen-sensitive tissues maintain a supply of oxygen, while those tissues that are tolerant to hypoxia receive less blood flow. Additionally, lung collapse obviates the exchange of lung gas with blood, likely minimizing the uptake of nitrogen by tissues.

Feeding

The throats of all beaked whales have a bilaterally paired set of grooves that are associated with their unique feeding mechanism, suction feeding. Instead of capturing prey with their teeth, beaked whales suck it into their oral cavity. Suction is aided by the throat grooves, which stretch and expand to accommodate food. Their tongue can move very freely. By suddenly retracting the tongue and distending the gular (throat) floor, pressure immediately drops within the mouth sucking the prey in with the water.

Dietary information is available from stomach contents analyses of stranded beaked whales and from whaling operations. Their preferred diet is primarily deep-water squid, but also benthic and benthopelagic fish and some crustaceans, mostly taken near the sea floor. In a recent study, gouge marks in the seafloor were interpreted to be a result of feeding activities by beaked whales.

In order to understand the hunting and foraging behavior of beaked whales, researchers utilized sound and orientation recording devices (DTAGs) on two species: Cuvier's beaked whale ("Ziphius cavirostris") and Blainville's beaked whale ("Mesoplodon densirostris"). These whales hunt by echolocation in deep water (where the majority of their prey is located) between approximately 200 and 1885 m and usually catch about 30 prey per dive. Cuvier's beaked whale must forage on average at 1070 m for 58 minutes and Blainville's beaked whales typically forage at 835 m deep for an average of 47 minutes.

Range and habitat

The family Ziphiidae is one of the most widespread families of cetaceans, ranging from the ice edges at both the north and south poles, to the equator in all the oceans. Specific ranges vary greatly by species; though beaked whales typically inhabit offshore waters that are at least 300 meters deep.

Beaked whales are known to congregate in deep waters off the edge of continental shelves, and bottom features like seamounts, canyons, escarpments, and oceanic islands including the Azores and the Canaries.

Life history

Very little is known about the life histories of beaked whales. The oldest beaked whale ever recorded was 84 years for a male Baird's beaked whale, and the oldest recorded female Baird's beaked whale is 54 years. For all other beaked whale species that have

been studied, the highest recorded age is between 27 and 39 years. Sexual maturity is reached between seven and 15 years of age in Baird's beaked whales and northern bottlenose whales. Gestation varies greatly between species, lasting 17 months for Baird's beaked whales and 12 months for the northern bottlenose whale. There is currently no data available on the reproductive rates of beaked whales.

It is difficult to determine group size of beaked whales, due to their inconspicuous surfacing behavior. Groups of beaked whales, defined as all individuals found in the same location at the same time, have been reported as ranging from 1 – 100 individuals. Nevertheless, some populations' group size has been estimated from repeated observations. For example, northern and southern bottlenose whales (*H. ampullatus* and *H. planifrons*), Cuvier's beaked whales and Blainville's beaked whales (*Mesoplodon densirostris*) have a reported maximum group size of 20 individuals, with the average ranging in size from 2.5 to 3.5 individuals. Berardius species and Longman's beaked whales (*Indopacetus pacificus*) are found in larger groups of up to 100 individuals.

There is not much information available about group composition of beaked whales. Only 3-4 species have been studied in any detail: northern bottlenose whales, Blainville's beaked whales, and Baird's beaked whales. Female northern bottlenose whales appear to form a loose network of social partners with no obvious long-term associations. In contrast to females, some male northern bottlenose whales have been repeatedly recorded together over several years and possibly form long-term associations. Studies of Blainville's beaked whales have revealed that groups usually consist of a number of females, calves and/or juvenile animals. These whales are assumed to live in "harem-like" groups, where several females and young are accompanied by a single male. Baird's beaked whales are known to occur in multi-male groups and in large groups, consisting of adult animals of both sexes.

Conservation

For many years most beaked whale species were insulated from anthropogenic impacts because of their remote habitat. However, there are now several issues of concern:

- Studies of stranded beaked whales show rising levels of toxic chemicals in their blubber.
- As a top predator beaked whales are, like raptors, particularly vulnerable to build-up of biocontaminants. They frequently ingest plastic bags (which do not break down and can be lethal).
- They more frequently become trapped in trawl nets, due to the expansion of deepwater fisheries.
- **Decompression sickness**:

A major conservation concern for beaked whales (family Ziphiidae) is that they appear to be vulnerable to modern sonar operations. This concern arises out of recent strandings that temporally and physically coincide with naval sonar exercises. Postmortem examinations of the stranded whales in concurrence with naval exercises have reported

the presence of hemorrhaging near the ears or gas and fat emboli, which could have a deleterious impact on beaked whales that is analogous to decompression sickness in humans. Gas and fat emboli have been shown cause nervous and cardiovascular system dysfunction, respiratory distress, pain, and disorientation in both humans and animals. In the inner ear, gas embolism can cause hemorrhages, leading to disorientation or vestibular dysfunction.

Breath-hold divers, like beaked whales, can develop decompression-related problems (the "bends") when they return to the surface after deep dives. This is a possible hypothesis for the mass strandings of pelagic beaked whales associated with sonar-related activities. To illustrate, a diving beaked whale may be surfacing from a deep dive and must pass vertically through varying received sound levels. Since the whale has limited remaining oxygen supplies at the end of a long dive, it probably has limited abilities to display any normal sound avoidance behavior. Instead, the whale must continue to swim towards the surface in order to replenish its oxygen stores. Avoiding sonar inevitably requires a change in behavior or surfacing pattern. Therefore, sonar in close proximity to groups of beaked whales has the potential to cause hemorrhaging or to disorient the animal, eventually leading to a stranding.

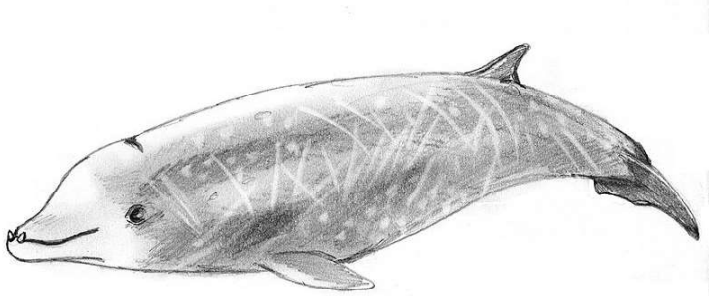
Current research reveals that two species of beaked whales are most affected by sonar: Cuvier's beaked whales (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales. These animals have been reported as stranding in correlation with military exercises in Greece, the Bahamas, Madeira, and the Canary Islands. The livers of these animals had the most damage.

Though some evidence indicates that sonar-related activities can actually lead to a form of decompression sickness in beaked whales, the topic is still up for debate. A significant limiting factor in determining the likelihood of bubble formation in whale tissues and the risk of decompression sickness is the lack of information on the normal diving patterns and surfacing patterns of beaked whales. More research is necessary to determine the extent of whale tissue damage caused by sonar exercises.

Four species are classified by the IUCN as "lower risk, conservation dependent": Arnoux's and Baird's Beaked Whales, and the Northern and Southern Bottlenose Whales. The status of the remaining species is unknown, preventing classification.

Cuvier's beaked whale

Cuvier's beaked whale



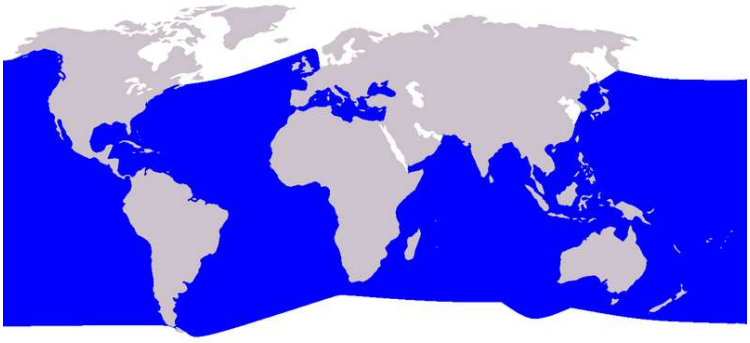
Size comparison against an average human

Conservation status

Least Concern (IUCN 3.1)

Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Order:	Cetacea
Family:	Ziphiidae
Subfamily:	Ziphiinae
Genus:	***Ziphius*** G. Cuvier, 1823

Binomial name
Ziphius cavirostris



Cuvier's Beaked Whale range

Cuvier's Beaked Whale (*Ziphius cavirostris*) is the most widely distributed of all the beaked whales. It is the only member of the genus ***Ziphius***. Another common name for the species is **Goose-beaked Whale** on account of the fact that its head is said to be shaped like the beak of a goose. Georges Cuvier first described it in 1823 from part of a skull found in France in 1804.

Physical description

Cuvier's Beaked Whale has a short beak in comparison with other species in its family, with a slightly bulbous melon. The melon is white or creamy in color and a white strip runs back to the dorsal fin about two-thirds of the way along the back. The rest of the body color varies by individual: some are dark grey; others a reddish-brown. Individuals commonly have white scars and patches caused by cookiecutter sharks. The dorsal fin varies in shape from triangular to highly falcate. The fluke of the whale is about one-quarter the body length. The whale grows up to about 7 meters (23 ft) in length and weighs 2–3 tonnes (2.0–3.0 LT; 2.2–3.3 ST). They live for forty years.

The Cuvier's Beaked Whale is difficult to distinguish from many of the mesoplodont whales at sea.

Range and habitat

Their range is known mainly from strandings. It is widespread across the Atlantic, Pacific and Indian Oceans. Individuals have been found as far north as the Shetland Islands and as far south as Tierra del Fuego. Deep waters are preferred in anything from cool to tropical habitats.

Because of identification difficulties, the global population is unknown.

Conservation

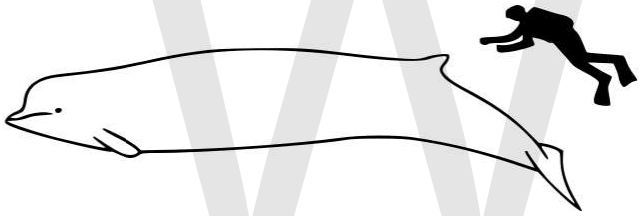
Japanese whalers in the past opportunistically killed Cuvier's. As with many other cetacean species many individuals are believed to be killed each year by gillnets.

Beaked Whales may also be sensitive to noise. A higher incidence of strandings has been recorded in noisy seas such as the Mediterranean. Multiple mass strandings (beachings) have occurred following operations by the Spanish Navy.

Bottlenose whale

Bottlenose whale

Size comparison of a Northern Bottlenose Whale against an average human



Size comparison of a Southern Bottlenose Whale against an average human

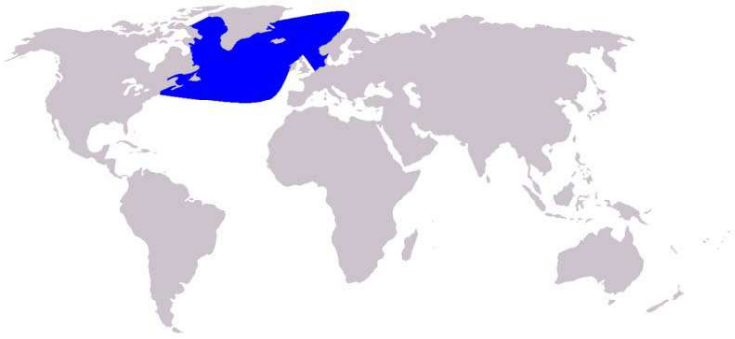
Conservation status

Least Concern (IUCN 3.1)

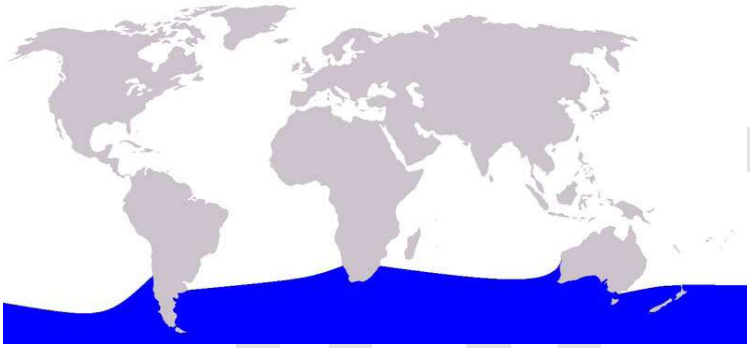
Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Order:	Cetacea
Family:	Ziphiidae
Subfamily:	Hyperoodontinae
Genus:	***Hyperoodon*** Lacépède, 1804

Species

- ***Hyperoodon planifrons*** (Forster, 1770)
- ***Hyperoodon ampullatus*** (Flower, 1882)



Northern Bottlenose Whale (*Hyperoodon ampullatus*) range



Southern Bottlenose Whale (*Hyperoodon planifrons*) range

A **bottlenose whale** is either of two species of whale, members of the ziphiid family. The two species—the **northern bottlenose whale** *Hyperoodon ampullatus* and the **southern bottlenose whale** *Hyperoodon planifrons*—are the sole members of the ***Hyperoodon*** genus. Whilst they are physically similar their stories over the past two hundred years are rather different. The southern bottlenose has been rarely observed, was seldom hunted, and is probably the most abundant whale in Antarctic waters. The northern species on the other hand was hunted heavily by Norway and Britain in the 19th and early 20th centuries.

Physical description

The two species are fairly rotund and measure 8–10 metres (26–33 ft) in length when adult. The melon is extremely bluff. The beak is long and white on males but grey on females. The dorsal fin is relatively small at 30–38 centimetres (12–15 in) and set behind the middle of the back. It is falcate (sickle-shaped) and usually tipped. The back is mid-to-dark grey in the Northern species and light-to-mid grey in the Southern. Both species have a lighter underside.

Weight estimates are hard to come by. For the northern bottlenose whale, 5,800–7,500 kilograms (13,000–17,000 lb) is given somewhat consistently. For the southern bottlenose whale, there is a single figure of 6–8 tonnes.

Population and distribution

The northern bottlenose whale is endemic to the North Atlantic Ocean and is found in cool and subarctic waters such as the Davis Strait, the Labrador Sea, the Greenland Sea and the Barents Sea. They prefer deep water. The total population is unknown but likely to be of the order of 10,000. "The Gully", a huge submarine canyon east of Nova Scotia, has a year-round population of around 160 whales.

The southern bottlenose whale has a circumpolar distribution in the Southern Ocean. It is found as far south as the Antarctic coast and as north as the tip of South Africa, New Zealand's North Island and the southern parts of Brazil. The global population is unknown.

Sightings of apparent bottlenose whales in tropical and subtropical waters probably belong to a poorly known species, Longman's beaked whale. The relationship of that species to other beaked whales has not been established.

There are many ways to tell the difference of males and females besides checking the underside. The males are normally a dark grey or black, and the females and calves are a white or very light gray.

On 20 January 2006, a northern bottlenose whale was spotted in Central London in the River Thames. The River Thames whale reached as far up river as Albert Bridge. It was moved onto a barge and rescuers hoped to take it out to sea, but it died following a convulsion on 21 January during its rescue. Its skeleton is now in the Natural History Museum in London.

The northern bottlenose whale, stranding in Nes, Hvalba 24 August 2009

Conservation

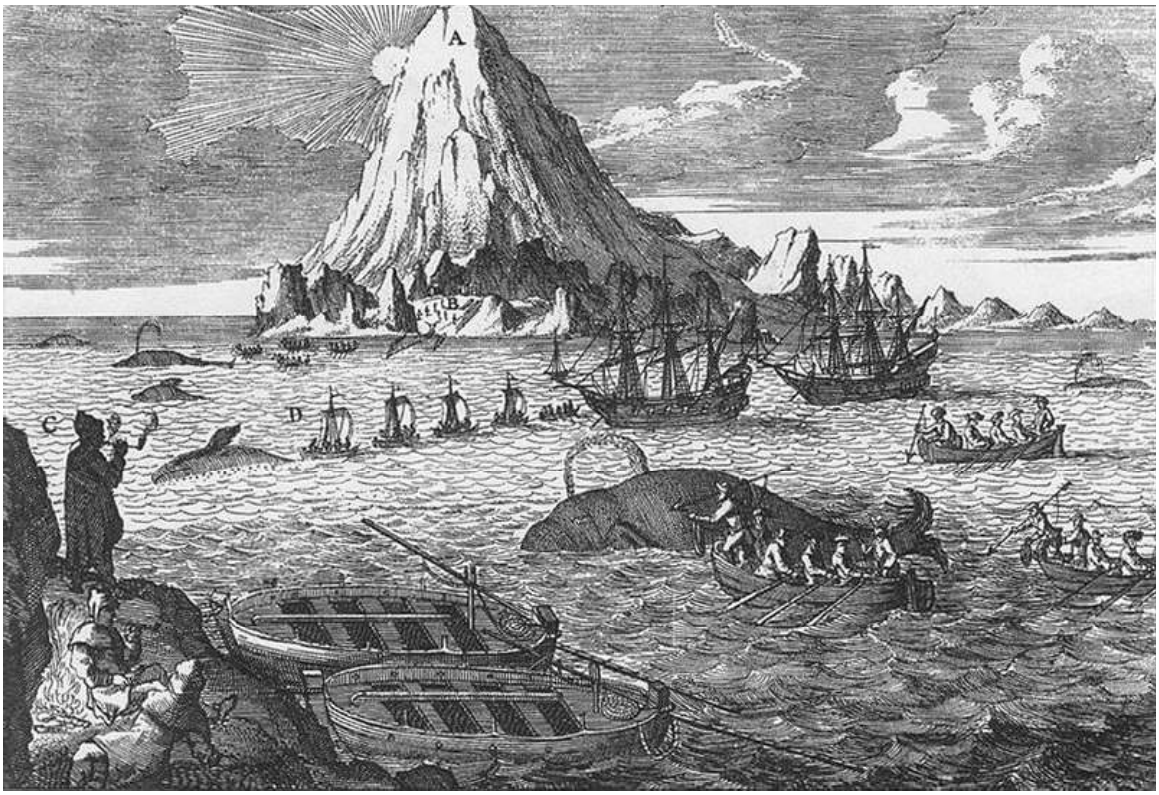
Prior to the beginning of whaling of northern bottlenoses it is estimated that there were 40,000–50,000 individuals in the North Atlantic. Between 1850 and 1973 88,000 individuals were caught, primarily by Norwegian and British whalers. The population is very likely to be much reduced compared to pre-whaling figures. Since whaling ended the primary concern to conservationists is the number of oil and gas developments around the Gully.

Norway stopped hunting the whale in 1973 but northern bottlenose whales are still hunted in the Faroe Islands, especially in the villages of Hvalba and Sandvík on Suðuroy.

The southern bottlenose whale is not believed to be threatened by human actions. The species has seldom been hunted. Forty-two were caught in the Antarctic by Soviet whalers between 1970 and 1982.

Chapter- 13

Whaling



Eighteenth century engraving showing Dutch whalers hunting bowhead whales in the Arctic

Engraving by J. H. Clark of the harpooning of a whale (c.1814)

Whaling is the hunting of whales. As technology increased and demand for the seemingly vast resources remained high, catches far exceeded the sustainable limit for whale stocks. In the late 1930s more than 50,000 whales were killed annually and by the middle of the century whale stocks were not being replenished. In 1986 the International Whaling Commission (IWC) banned commercial whaling so that stocks might recover.

While the moratorium has been successful in averting the extinction of whale species due to overhunting, contemporary whaling is subject to intense debate. Pro-whaling countries wish to lift the ban on stocks that they believe have recovered sufficiently to sustain limited hunting. Anti-whaling countries and environmental groups contend that those stocks remain vulnerable and that whaling is immoral and should remain banned.

History of whaling

Whaling began in prehistoric times and was initially confined to (near) coastal waters. Early whaling affected the development of widely disparate cultures—for example, in Norway and Japan. Although prehistoric hunting and gathering is generally considered to have had little ecological impact, early whaling in the Arctic may have altered freshwater ecology. The development of modern whaling techniques was spurred in the 19th century by the increase in demand for whale oil, sometimes known as "train oil" and in the 20th century by a demand for margarine and later meat.

A modern whaling vessel

Modern whaling

Whale oil is little used today and modern commercial whaling is done for food. The primary species hunted are the common minke whale and Antarctic minke whale, two of the smallest species of baleen whales. Recent scientific surveys estimate a population of 103,000 in the northeast Atlantic. With respect to the populations of Antarctic minke whales, as of January 2010, the IWC states that it is "unable to provide reliable estimates at the present time" and that a "major review is underway by the Scientific Committee."

International cooperation on whaling regulation began in 1931 and culminated in the signing of the International Convention for the Regulation of Whaling (ICRW) in 1946. Its aim is to:

> provide for the proper conservation of whale stocks and thus make possible the commercial whaling and the orderly development of the whaling industry.

The International Whaling Commission (IWC) was set up under the ICRW to decide hunting quotas and other relevant matters based on the findings of its Scientific Committee. Non-member countries are not bound by its regulations and conduct their own management programs.

The IWC voted on July 23, 1982, to establish a moratorium on commercial whaling beginning in the 1985–86 season. Since 1992, the IWC's Scientific Committee has

requested that it be allowed to give quota proposals for some whale stocks, but this has so far been refused by the Plenary Committee.

Canada

Canadian whaling is carried out in small numbers by various Inuit groups around the country and is managed by Fisheries and Oceans Canada. Harvested meat is sold through shops and supermarkets in northern communities where whale meat is a component of the traditional diet, but typically not in southern cities such as Vancouver, Toronto, or Montreal. The Whale and Dolphin Conservation Society says:

> Canada has pursued a policy of marine mammal management which appears to be more to do with political expediency rather than conservation.

While Canada left the IWC in 1982, the only species currently harvested by the Canadian Inuit that is covered by the IWC is the bowhead whale. As of 2004, the limit on bowhead whale hunting allows for the hunt of one whale every two years from the Hudson Bay-Foxe Basin population, and one whale every 13 years from the Baffin Bay-Davis Strait population. This is roughly one fiftieth of the bowhead whale harvest limits in Alaska.

Killed pilot whales on the beach in Hvalba, Faroe Islands

Faroe Islands

Around 950 long-finned pilot whales (*Globicephala melaena*, actually a species of dolphin) are slayed annually, mainly during the summer. Occasionally, other species are hunted as well, such as the northern bottlenose whale and Atlantic white-sided dolphin. The hunt is known as the Grindadráp.

Faroese whaling is regulated by Faroese authorities but not by the IWC, which does not regulate the catching of small cetaceans.

Most Faroese consider the hunt an important part of their culture and history and arguments about the topic raise strong emotions. Animal-rights groups criticize the hunt as being cruel and unnecessary. Hunters claim that most journalists lack knowledge of the catch methods used to capture and kill the whales or of the hunt's economic significance.

Greenland

Greenlandic Inuit whalers catch around 175 whales per year, making them the third largest hunt in the world after Norway and Japan, though their take is small compared to Japan's or Norway's, who averaged around 590 and 730 whales in 1998-2007.. March 2010 The IWC treats the west and east coasts of Greenland as two separate population areas and sets separate quotas for each coast. The far more densely populated west coast accounts for over 90 percent of the catch. In a typical year around 150 minke and 10 fin whales are taken from west coast waters and around 10 minkes are from east coast waters. In April 2009 Greenland landed its first bowhead whale in nearly forty years after being given a quota by the IWC in 2008 for two whales a year until 2012.

Icelandic whaling vessels

Minke whale meat kebabs, Reykjavik

Iceland

Iceland did not object to the 1986 IWC moratorium. Between 1986 and 1989 around 60 animals per year were taken under a scientific permit. However, under strong pressure from anti-whaling countries, who viewed scientific whaling as a circumvention of the moratorium, Iceland ceased whaling in 1989. Following the IWC's 1991 refusal to accept its Scientific Committee's recommendation to allow sustainable commercial whaling, Iceland left the IWC in 1992.

Iceland rejoined the IWC in 2002 with a reservation to the moratorium. Iceland presented a feasibility study to the 2003 IWC meeting for catches in 2003 and 2004. The primary aim of the study was to deepen the understanding of fish–whale interactions. Amid disagreement within the IWC Scientific Committee about the value of the research and its relevance to IWC objectives, no decision on the proposal was reached. However, under the terms of the convention the Icelandic government issued permits for a scientific catch. In 2003 Iceland resumed scientific whaling which continued in 2004 and 2005.

Iceland resumed commercial whaling in 2006. Its annual quota is 30 minke whales (out of an estimated 174,000 animals in the central and north-eastern North Atlantic) and nine

fin whales (out of an estimated 30,000 animals in the central and north-eastern North Atlantic).

Indonesia

Lamalera, on the south coast of the island of Lembata, and Lamakera on neighbouring Solor are the two remaining Indonesian whaling communities. The hunters obey religious taboos that ensure that they use every part of the animal. About half of the catch is kept in the village; the rest is bartered in local markets. In 1973, the UN's Food and Agriculture Organization (FAO) sent a whaling ship and a Norwegian whaler to modernize their hunt. This effort lasted three years, and was not successful. According to the FAO report, the Lamalerans "have evolved a method of whaling which suits their natural resources, cultural tenets and style."

Japan

When the commercial whaling moratorium was introduced by the IWC in 1982, Japan lodged an official objection. However, in response to US threats to cut Japan's fishing quota in US territorial waters under the terms of the Packwood-Magnuson Amendment, Japan withdrew its objection in 1987. However, according to the BBC, America went back on this promise, effectively destroying the deal. Since Japan could not resume commercial whaling, it began whaling on a scientific-research basis. Australia, Greenpeace, the Sea Shepherd Conservation Society and other groups dispute the Japanese claim of research "as a disguise for commercial whaling, which is banned."

The stated purpose of the research program is to establish the size and dynamics of whale populations. The Japanese government wishes to resume whaling in a sustainable manner under the oversight of the IWC, both for whale products (meat etc.) and to help preserve fishing resources by culling whales. Anti-whaling organizations claim that the research program is a front for commercial whaling, that the sample size is needlessly large and that equivalent information can be obtained by non-lethal means, for example by studying samples of whale tissue (such as skin) or faeces. The Japanese government sponsored Institute of Cetacean Research (ICR), which conducts the research, disagrees, stating that the information obtainable from tissue and/or faeces samples is insufficient and that the sample size is necessary in order to be representative.

Japan's scientific whaling program is controversial in anti-whaling countries. Countries opposed to whaling have passed non-binding resolutions in the IWC urging Japan to stop the program. Japan claims that whale stocks for some species are sufficiently large to sustain commercial hunting and blame filibustering by the anti-whaling side for the continuation of scientific whaling. Deputy whaling commissioner, Joji Morishita, told BBC News:

The reason for the moratorium [on commercial whaling] was scientific uncertainty about the number of whales. ... It was a moratorium for the sake of collecting data and that is why we started scientific whaling. We were asked to collect more data.

Japanese narrative screen showing a whale hunt off Wakayama

Norway

Norway registered an objection to the International Whaling Commission moratorium and is thus not bound by it. Commercial whaling ceased for a five year period to allow a small scientific catch for gauging the stock's sustainability and resumed 1993. Minke whales are the only legally hunted species. Catches have fluctuated between 487 animals in 2000 to 592 in 2007. The catch is made solely from the Northeast Atlantic minke whale population, which is estimated at 102,000.

Boy in Bequia in the Grenadines carrying meat of a humpback whale (2007)

A traditional whaling crew in Alaska

Russia

Russia had a significant whaling hunt of orcas along with Iceland and Japan. In 1970 a study published by Bigg M.A. following photographic recognition of orcas found a significant difference in the suspected ages of whale populations and their actual ages. Following this evidence, the Russians continued a scientific whale hunt, though the verisimilitude of the intentions of the hunt over the last 40 years are questioned. Currently Russians in Chukotka Autonomous Okrug in the Russian Far East are permitted under IWC regulation to take up to 140 gray whales from the North-East Pacific population each year.

Saint Vincent and the Grenadines

Natives of Saint Vincent and the Grenadines on the island of Bequia have a quota from the International Whaling Commission of up to four humpback whales per year using traditional hunting methods and equipment.

United States

In the United States, whaling is carried out by nine different indigenous Alaskan communities. The whaling program is managed by the Alaska Eskimo Whaling Commission which reports to the National Oceanic and Atmospheric Administration. The hunt takes around 50 bowhead whales a year from a population of about 10,500 in Alaskan waters. Conservationists fear this hunt is not sustainable, though the IWC Scientific Committee, the same group that provided the above population estimate, projects a population growth of 3.2% per year. The hunt also took an average of one or two gray whales each year until 1996. The quota was reduced to zero in that year due to sustainability concerns. A future review may result in the gray whale hunt being resumed. Bowhead whales weigh approximately 5-10 times as much as minke whales.

The Makah tribe in Washington State also reinstated whaling in 1999, despite protests from animal rights groups. They are currently seeking to resume whaling of the gray whale, a right recognized in the Treaty of Neah Bay.

Season	Catch
2003	48
2004	43
2005	68
2006	39
2007	63

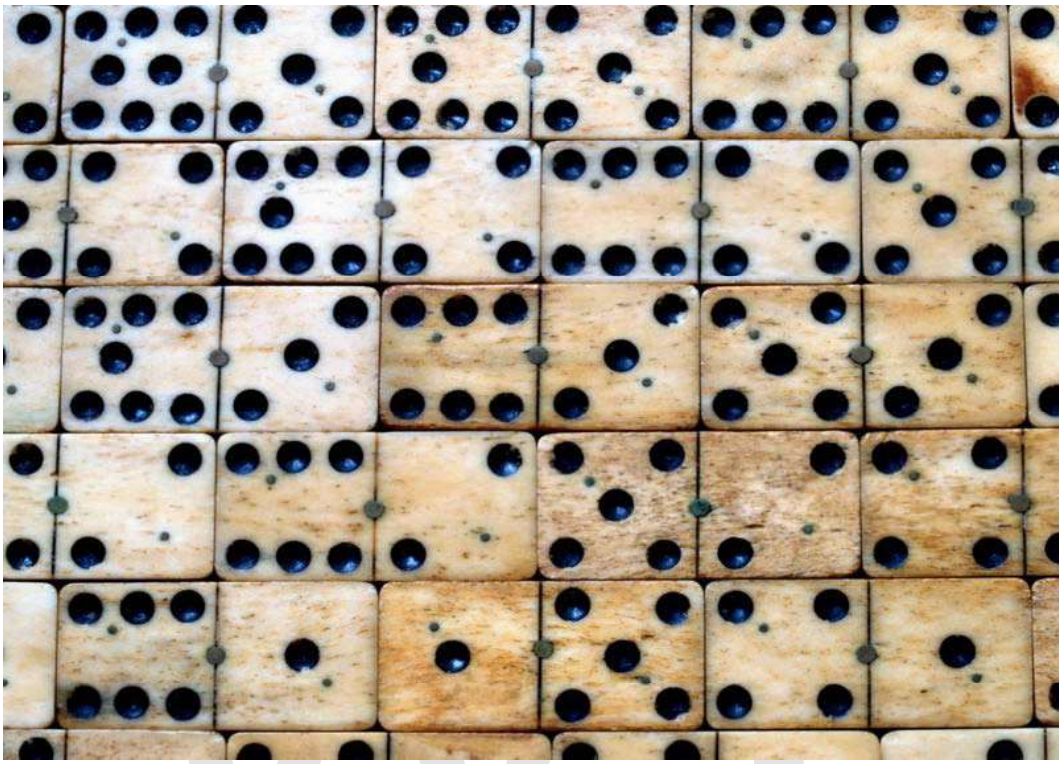
All catches in 2003–2007 were Bowhead whales.

Threats

The World Wide Fund for Nature says that 90% of all northern right whales killed are from ship collision, calling for restrictions on the movement of shipping in certain areas. By-catch also kills more animals than hunting. Some scientists believe pollution to be a factor. Moreover, since the IWC moratorium, there have been several instances of illegal whale hunting by IWC nations. In 1994, the IWC reported evidence from genetic testing of whale meat and blubber for sale on the open market in Japan in 1993. In addition to the legally-permitted minke whale, the analyses showed that the 10-25% tissues sample came from non minke, baleen whales, neither of which were then allowed under IWC rules. Further research in 1995 and 1996 shows significant drop of non-minke baleen whales sample to 2.5%. In a separate paper, Baker stated that "many of these animals certainly represent a bycatch (incidental entrapment in fishing gear)" and stated that DNA monitoring of whale meat is required to adequately track whale products.

It was revealed in 1994 that the Soviet Union had been systematically undercounting its catch. For example, from 1948 to 1973, the Soviet Union caught 48,477 humpback whales rather than the 2,710 it officially reported to the IWC. On the basis of this new information, the IWC stated that it would have to rewrite its catch figures for the last forty years. According to Ray Gambell, then Secretary of the IWC, the organization had

raised its suspicions with the former Soviet Union, but it did not take further action because it could not interfere with national sovereignty.



Dominoes made from whale bones

Controversy

Key elements of the debate over whaling include sustainability, ownership, national sovereignty, cetacean intelligence, suffering during hunting, the value of lethal sampling to establish catch quotas, the value of controlling whales' impact on fish stocks and the rapidly approaching extinction of a few whale species.

2010 IWC meeting

At the 2010 meeting of the International Whaling Commission in Morocco, representatives of the 88 member nations discussed whether or not to lift the 24 year ban on commercial whaling. Japan, Norway and Iceland have urged the organization to lift the ban. A coalition of anti-whaling nations has offered a compromise plan that would allow these countries to continue whaling, but with smaller catches and under close supervision. Their plan would also completely ban whaling in the Southern Ocean. More than 200 scientists and experts have opposed the compromise proposal for lifting the ban, and have also opposed allowing whaling in the Southern Ocean, which was declared a whale sanctuary in 1994. Opponents of the compromise plan want to see an end to all commercial whaling, but are willing to allow subsistence-level catches by indigenous peoples.