Seabirds

(birds that have adapted to life within the marine environment)

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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.

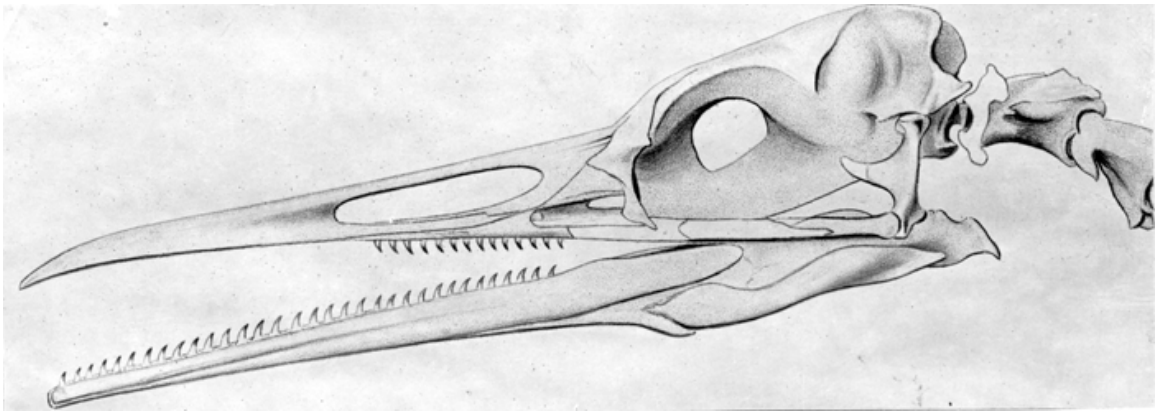
Classification of seabirds

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.

Adélie Penguin (*Pygoscelis adeliae*) feeding young. Like its relatives, a neatly bi-coloured species with a head marking.

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)

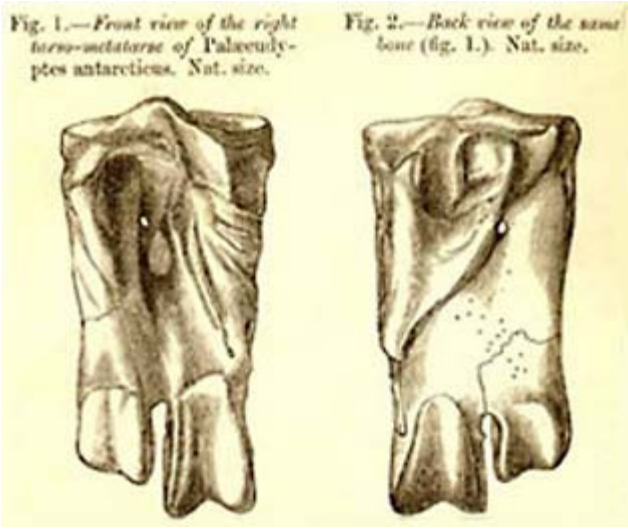
- *Spheniscus* – Banded penguins
  - Magellanic Penguin, *Spheniscus magellanicus*
  - Humboldt Penguin, *Spheniscus humboldti*
  - Galapagos Penguin, *Spheniscus mendiculus*
  - African Penguin, *Spheniscus demersus*
- *Megadyptes*
  - Yellow-eyed Penguin, *Megadyptes antipodes*
  - Waitaha Penguin, *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

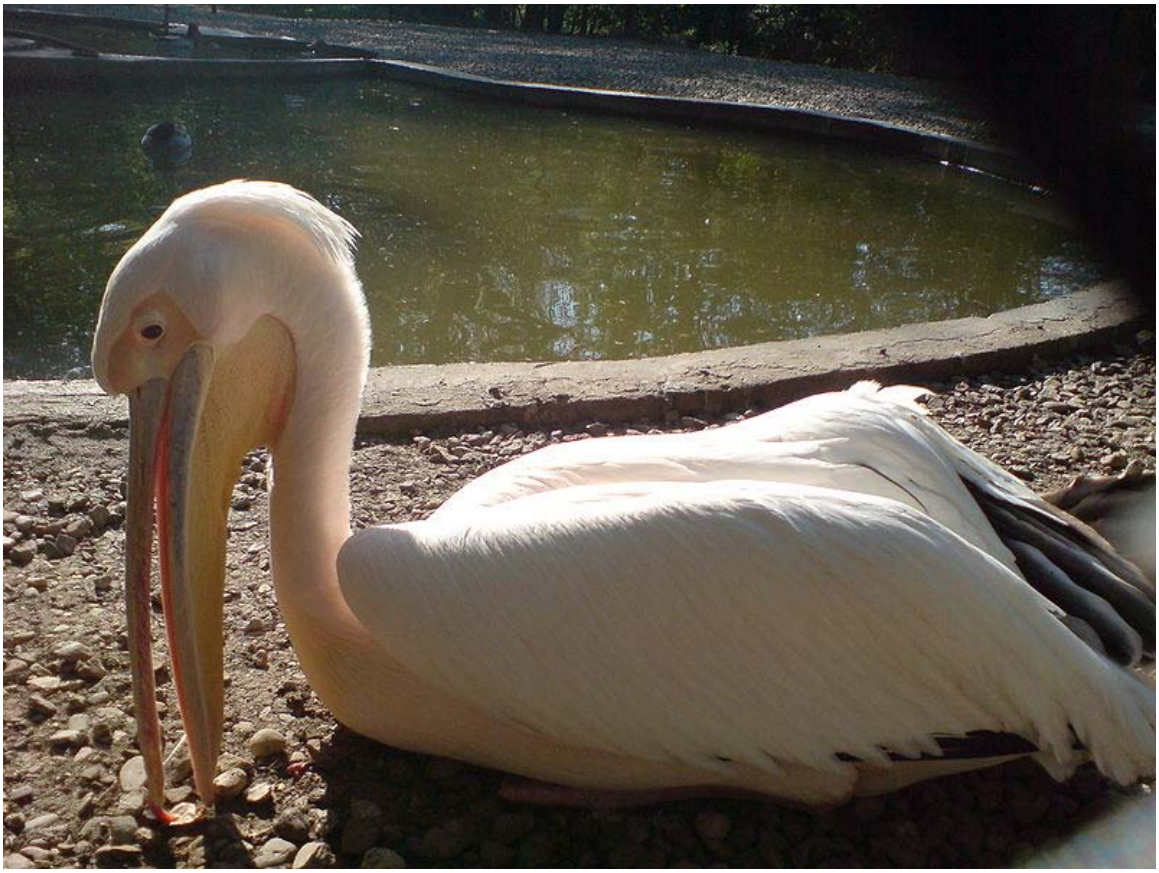
A Brown Pelican in flight

Brown Pelicans, Melbourne, Florida, USA.

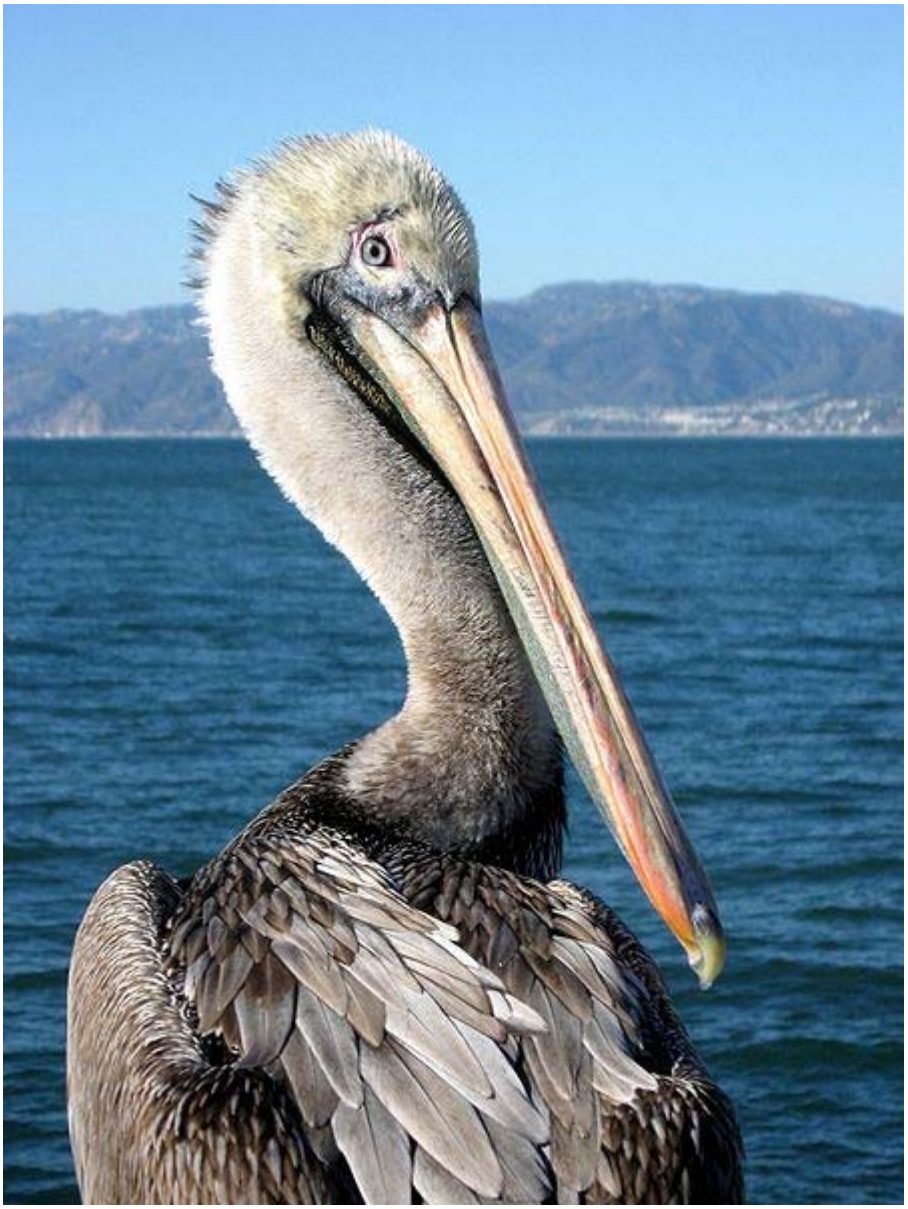
Pelicans in the Danube Delta.

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

Albatross

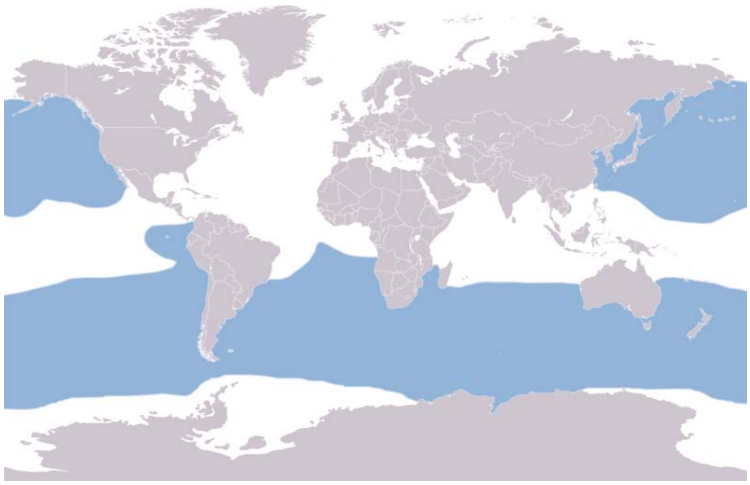
Albatross Temporal range: Oligocene–recent Oligocene–recent

Short-tailed Albatross (*Phoebastria albatrus*)
Scientific classification
Kingdom: Animalia
Phylum: Chordata
Class: Aves
Subclass: Neornithes
Infraclass: Neoaves

Order:	Procellariiformes
Family:	**Diomedeidae** G.R. Gray 1840

Genera

Diomedea
Thalassarche
Phoebastria
Phoebetria



Global range (In blue)

Albatrosses, of the biological family **Diomedeidae**, are large seabirds allied to the procellariids, storm-petrels and diving-petrels in the order Procellariiformes (the tubenoses). They range widely in the Southern Ocean and the North Pacific. They are absent from the North Atlantic, although fossil remains show they once occurred there too and occasional vagrants turn up.

Albatrosses are among the largest of flying birds, and the great albatrosses (genus *Diomedea*) have the largest wingspans of any extant birds. The albatrosses are usually regarded as falling into four genera, but there is disagreement over the number of species.

Albatrosses are highly efficient in the air, using dynamic soaring and slope soaring to cover great distances with little exertion. They feed on squid, fish and krill by either scavenging, surface seizing or diving. Albatrosses are colonial, nesting for the most part on remote oceanic islands, often with several species nesting together. Pair bonds between males and females form over several years, with the use of 'ritualised dances', and will last for the life of the pair. A breeding season can take over a year from laying to fledging, with a single egg laid in each breeding attempt.

Of the 21 species of albatrosses recognised by the IUCN, 19 are threatened with extinction. Numbers of albatrosses have declined in the past due to harvesting for feathers, but today the albatrosses are threatened by introduced species such as rats and feral cats that attack eggs, chicks and nesting adults; by pollution; by a serious decline in

fish stocks in many regions largely due to overfishing; and by long-line fishing. Long-line fisheries pose the greatest threat, as feeding birds are attracted to the bait, become hooked on the lines, and drown. Identified stakeholders such as governments, conservation organisations and people in the fishing industry are all working toward reducing this bycatch.

Biology

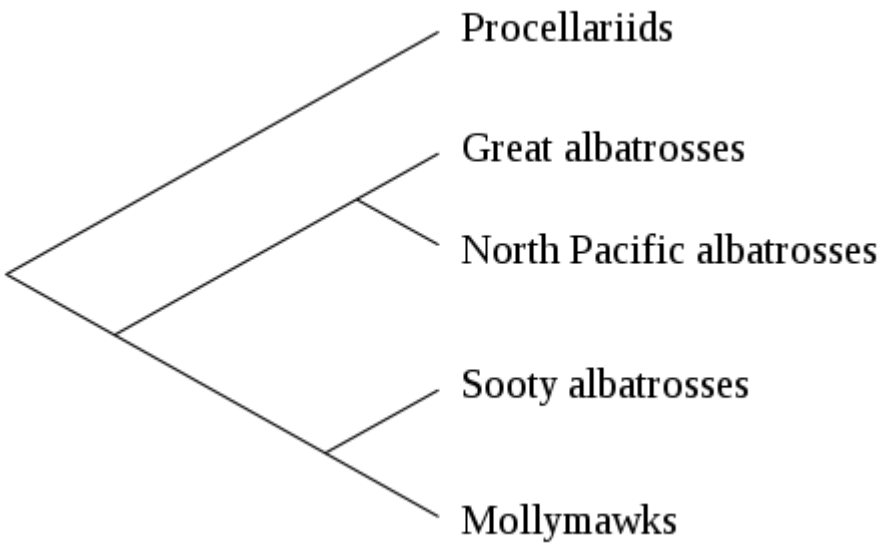
Taxonomy and evolution

The albatrosses comprise between 13 and 24 species (the number of species is still a matter of some debate, 21 being the most commonly accepted number) in 4 genera. The four genera are the great albatrosses (*Diomedea*), the mollymawks (*Thalassarche*), the North Pacific albatrosses (*Phoebastria*), and the sooty albatrosses or sooties (*Phoebetria*). Of the four genera, the North Pacific albatrosses are considered to be a sister taxon to the great albatrosses, while the sooty albatrosses are considered closer to the mollymawks.

The taxonomy of the albatross group has been a source of a great deal of debate. The Sibley-Ahlquist taxonomy places seabirds, birds of prey and many others in a greatly enlarged order Ciconiiformes, whereas the ornithological organisations in North America, Europe, South Africa, Australia and New Zealand retain the more traditional order Procellariiformes. The albatrosses can be separated from the other Procellariiformes both genetically and through morphological characteristics, size, their legs and the arrangement of their nasal tubes.

Within the family the assignment of genera has been debated for over a hundred years. Originally placed into a single genus, *Diomedea*, they were rearranged by Reichenbach into four different genera in 1852, then lumped back together and split apart again several times, acquiring 12 different genus names in total (though never more than eight at one time) by 1965 (*Diomedea*, *Phoebastria*, *Thalassarche*, *Phoebetria*, *Thalassageron*, *Diomedella*, *Nealbatrus*, *Rhothonia*, *Julietata*, *Galapagornis*, *Laysanornis*, and *Penthirenia*).

By 1965, in an attempt to bring some order back to the classification of albatrosses, they were lumped into two genera, *Phoebetria* (the sooty albatrosses which most closely seemed to resemble the procellarids and were at the time considered "primitive") and *Diomedea* (the rest). Though there was a case for the simplification of the family (particularly the nomenclature), the classification was based on the morphological analysis of Elliott Coues in 1866, and paid little attention to more recent studies and even ignored some of Coues's suggestions.



Phylogenetic relationships of the 4 albatross genera. Based on Nunn et al. 1996.

More recent research by Gary Nunn of the American Museum of Natural History (1996) and other researchers around the world studied the mitochondrial DNA of all 14 accepted species, finding that there were four, not two, monophyletic groups within the albatrosses. They proposed the resurrection of two of the old genus names, *Phoebastria* for the North Pacific albatrosses and *Thalassarche* for the mollymawks, with the great albatrosses retaining *Diomedea* and the sooty albatrosses staying in *Phoebetria*. Both the British Ornithologists' Union and the South African authorities split the albatrosses into four genera as Nunn suggested, and the change has been accepted by the majority of researchers.

While there is some agreement on the number of genera, there is less agreement on the number of species. Historically, up to 80 different taxa have been described by different researchers; most of these were incorrectly identified juvenile birds.

Based on the work on albatross genera, Robertson and Nunn went on in 1998 to propose a revised taxonomy with 24 different species, compared to the 14 then accepted. This interim taxonomy elevated many established subspecies to full species, but was criticised for not using, in every case, peer reviewed information to justify the splits. Since then further studies have in some instances supported or disproved the splits; a 2004 paper analysing the mitochondrial DNA and microsatellites agreed with the conclusion that the Antipodean Albatross and the Tristan Albatross were distinct from the Wandering Albatross, per Robertson and Nunn, but found that the suggested Gibson's Albatross, *Diomedea gibsoni*, was not distinct from the Antipodean Albatross. For the most part, an interim taxonomy of 21 species is accepted by the IUCN and many other researchers, though by no means all—in 2004 Penhallurick and Wink called for the number of species to be reduced to 13 (including the lumping of the Amsterdam Albatross with the

Wandering Albatross), although this paper was itself controversial. On all sides, there is the widespread agreement on the need for further research to clarify the issue.

Three birds on Midway Atoll, 1958

Sibley and Ahlquist's molecular study of the evolution of the bird families has put the radiation of the Procellariiformes in the Oligocene period (35–30 million years ago), though this group probably originated earlier, with a fossil sometimes attributed to the order, a seabird known as *Tytthostonyx*, being found in late Cretaceous rocks (70 mya). The molecular evidence suggests that the storm-petrels were the first to diverge from the ancestral stock, and the albatrosses next, with the procellarids and diving petrels separating later. The earliest fossil albatrosses were found in Eocene to Oligocene rocks, although some of these are only tentatively assigned to the family and none appear to be particularly close to the living forms. They are *Murunkus* (Middle Eocene of Uzbekistan), *Manu* (early Oligocene of New Zealand), and an undescribed form from the Late Oligocene of South Carolina. Similar to the last was *Plotornis*, formerly often considered a petrel but now accepted as an albatross. It is from the Middle Miocene of France, a time when the split between the four modern genera was already underway as evidenced by *Phoebastria californica* and *Diomedea milleri*, both being mid-Miocene species from Sharktooth Hill, California. These show that the split between the great albatrosses and the North Pacific albatrosses occurred by 15 mya. Similar fossil finds in the southern hemisphere put the split between the sooties and mollymawks at 10 mya. The fossil record of the albatrosses in the northern hemisphere is more complete than that of the southern, and many fossil forms of albatross have been found in the North Atlantic, which today has no albatrosses. The remains of a colony of Short-tailed Albatrosses have

been uncovered on the island of Bermuda, and the majority of fossil albatrosses from the North Atlantic have been of the genus *Phoebastria* (the North Pacific albatrosses); one, *Phoebastria anglica*, has been found in deposits in both North Carolina and England. Due to convergent evolution in particular of the leg and foot bones, remains of the prehistoric pseudotooth birds (Pelagornithidae) may be mistaken for those of extinct albatrosses; *Manu* may be such a case, and quite certainly the supposed giant albatross femur from the Early Pleistocene Dainichi Formation at Kakegawa (Japan) actually is from one of the last pseudotooth birds.

Morphology and flight

Unlike most Procellariiformes, albatrosses, like this Black-footed Albatross, can walk well on land.

The albatrosses are a group of large to very large birds; they are the largest of the procellariiformes. The bill is large, strong and sharp-edged, the upper mandible terminating in a large hook. This bill is composed of several horny plates, and along the sides are the two "tubes", long nostrils that give the order its former name. The tubes of all albatrosses are along the sides of the bill, unlike the rest of the Procellariiformes where the tubes run along the top of the bill. These tubes allow the albatrosses to have an acute sense of smell, an unusual ability for birds. Like other Procellariiformes they use this olfactory ability while foraging in order to locate potential food sources. The feet have no hind toe and the three anterior toes are completely webbed. The legs are strong for Procellariiformes, in fact, almost uniquely amongst the order in that they and the giant petrels are able to walk well on land.

Albatrosses, along with all 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 their 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 birds.

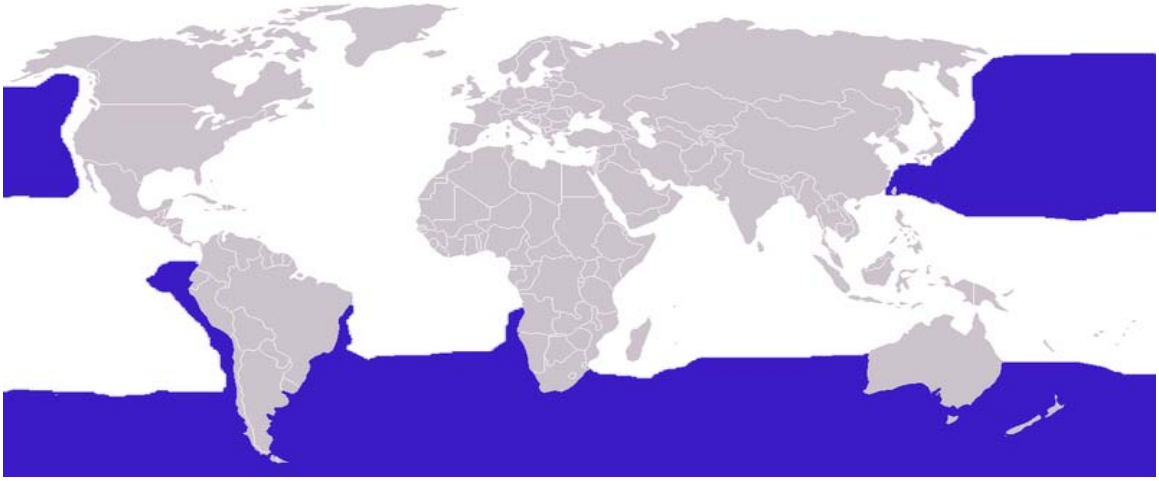
The adult plumage of most of the albatrosses is usually some variation of dark upper-wing and back, white undersides, often compared to that of a gull. Of these, the species range from the Southern Royal Albatross which is almost completely white except for the ends and trailing edges of the wings in fully mature males, to the Amsterdam Albatross which has an almost juvenile-like breeding plumage with a great deal of brown, particularly a strong brown band around the chest. Several species of mollymawks and North Pacific albatrosses have face markings like eye patches or have grey or yellow on the head and nape. Three albatross species, the Black-footed Albatross and the two sooty albatrosses, vary completely from the usual patterns and are almost entirely dark brown (or dark grey in places in the case of the Light-mantled Albatross). Albatrosses take several years to get their full adult breeding plumage.

The wingspans of the largest great albatrosses (genus *Diomedea*) are the largest of any bird, exceeding 340 cm (11.2 ft), although the other species' wingspans are considerably smaller (1.75 m (5.7 ft)). The wings are stiff and cambered, with thickened streamlined leading edges. Albatrosses travel huge distances with two techniques used by many long-winged seabirds, dynamic soaring and slope soaring. Dynamic soaring involves repeatedly rising into wind and descending downwind thus gaining energy from the vertical wind gradient. Slope soaring uses the rising air on the windward side of large waves. Albatross have high glide ratios, around 22:1 to 23:1, meaning that for every metre they drop, they can travel forward 22 metres. They are aided in soaring by a shoulder-lock, a sheet of tendon that locks the wing when fully extended, allowing the wing to be kept outstretched without any muscle expenditure, a morphological adaptation they share with the giant petrels.

Taking off is one of the main times albatrosses use flapping in order to fly, and is the most energetically demanding part of a journey.

Albatrosses combine these soaring techniques with the use of predictable weather systems; albatrosses in the southern hemisphere flying north from their colonies will take a clockwise route, and those flying south will fly counterclockwise. Albatrosses are so well adapted to this lifestyle that their heart rates while flying are close to their basal heart rate when resting. This efficiency is such that the most energetically demanding aspect of a foraging trip is not the distance covered, but the landings, take-offs and hunting they undertake having found a food source. This efficient long-distance travelling underlies the albatross's success as a long-distance forager, covering great distances and expending little energy looking for patchily distributed food sources. Their adaptation to gliding flight makes them dependent on wind and waves, however, as their long wings are ill-suited to powered flight and most species lack the muscles and energy to undertake sustained flapping flight. Albatrosses in calm seas are forced to rest on the ocean's surface until the wind picks up again. The North Pacific albatrosses can use a flight style known as flap-gliding, where the bird progresses by bursts of flapping followed by gliding. When taking off, albatrosses need to take a run up to allow enough air to move under the wing to provide lift.

Distribution and range at sea



The distribution of albatrosses across the world.

Most albatrosses range in the southern hemisphere from Antarctica to Australia, South Africa and South America. The exceptions to this are the four North Pacific albatrosses, of which three occur exclusively in the North Pacific, from Hawaii to Japan, California and Alaska; and one, the Waved Albatross, breeds in the Galapagos Islands and feeds off the coast of South America. The need for wind in order to glide is the reason albatrosses are for the most part confined to higher latitudes; being unsuited to sustained flapping flight makes crossing the doldrums extremely difficult. The exception, the Waved Albatross, is able to live in the equatorial waters around the Galapagos Islands because of the cool waters of the Humboldt Current and the resulting winds.

Albatrosses range over huge areas of ocean and regularly circle the globe.

It is not known for certain why the albatrosses became extinct in the North Atlantic, although rising sea levels due to an interglacial warming period are thought to have submerged the site of a Short-tailed Albatross colony that has been excavated in

Bermuda. Some southern species have occasionally turned up as vagrants in the North Atlantic and can become exiled, remaining there for decades. One of these exiles, a Black-browed Albatross, returned to gannet colonies in Scotland for many years in a lonely attempt to breed.

The use of satellite tracking is teaching scientists a great deal about the way albatrosses forage across the ocean in order to find food. They undertake no annual migration, but disperse widely after breeding, in the case of southern hemisphere species, often undertaking circumpolar trips. There is also evidence that there is separation of the ranges of different species at sea. A comparison of the foraging niches of two related species that breed on Campbell Island, the Campbell Albatross and the Grey-headed Albatross, showed the Campbell Albatross primarily fed over the Campbell Plateau whereas the Grey-Headed Albatross fed in more pelagic, oceanic waters. Wandering Albatrosses also react strongly to bathymetry, feeding only in waters deeper than 1000 m (3281 ft); so rigidly did the satellite plots match this contour that one scientist remarked, "It almost appears as if the birds notice and obey a 'No Entry' sign where the water shallows to less than 1000 m". There is also evidence of different ranges for the two sexes of the same species; a study of Tristan Albatrosses breeding on Gough Island showed that males foraged to the west of Gough and females to the east.

Diet

The albatross diet is predominantly cephalopods, fish, crustaceans, and offal, although they will also scavenge carrion and feed on other zooplankton. It should be noted that for most species, a comprehensive understanding of diet is only known for the breeding season, when the albatrosses regularly return to land and study is possible. The importance of each of these food sources varies from species to species, and even from population to population; some concentrate on squid alone, others take more krill or fish. Of the two albatross species found in Hawaii, one, the Black-footed Albatross, takes mostly fish while the Laysan feeds on squid.

Light-mantled Albatrosses regularly dive in order to feed and can dive to below 12 m.

The use of dataloggers at sea that record ingestion of water against time (providing a likely time of feeding) suggest that albatross predominantly feed during the day. Analysis of the squid beaks regurgitated by albatrosses 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 albatross, suggesting that, for some species (like the Wandering Albatross), scavenged squid may be an important part of the diet. The source of these dead squid is a matter of debate; some certainly comes from squid fisheries, but in nature it primarily comes from the die-off that occurs after squid spawning and the vomit of squid-eating whales (sperm whales, pilot whales and Southern Bottlenose Whales). The diet of other species, like the Black-browed Albatross or the Grey-headed Albatross, is rich with smaller species of squid that tend to sink after death, and scavenging is not assumed to play a large role in their diet. Also the Waved Albatross has been observed practicing kleptoparasitism, harassing boobies in order to steal their food, making it the only member of its order to do regularly.

Until recently it was thought that albatross were predominantly surface feeders, swimming at the surface and snapping up squid and fish pushed to the surface by currents, predators or death. The deployment of capillary depth recorders, which record the maximum dive depth undertaken by a bird (between attaching it to a bird and recovering it when it returns to land), has shown that while some species, like the Wandering Albatross, do not dive deeper than a metre, some species, like the Light-mantled Albatross, have a mean diving depth of almost 5 m and can dive as deep as 12.5 m. In addition to surface feeding and diving, they have now also been observed plunge diving from the air to snatch prey.

Breeding and dancing

Wandering Albatrosses are colonial but have large widely spaced territories. Here a pair performs their famous breeding dance.

Albatrosses are colonial, usually nesting on isolated islands; where colonies are on larger landmasses, they are found on exposed headlands with good approaches from the sea in several directions, like the colony on the Otago Peninsula in Dunedin, New Zealand. Many Buller's Albatrosses and Black-footed Albatrosses nest under trees in open forest. Colonies vary from the very dense aggregations favoured by the mollymawks (Black-browed Albatross colonies on the Falkland Islands have densities of 70 nests per 100 m^2) to the much looser groups and widely spaced individual nests favoured by the sooty and great albatrosses. All albatross colonies are on islands that historically were free of land mammals. Albatrosses are highly philopatric, meaning they will usually return to their natal colony to breed. This tendency to return to their point of origin to breed is so strong that a study of Laysan Albatross showed that the average distance between hatching site and the site where a bird established its own territory was 22 m (72 ft).

Like most seabirds, albatrosses are K-selected with regard to their life history, meaning they live much longer than other birds, they delay breeding for longer, and invest more effort into fewer young. Albatrosses are very long lived; most species survive upwards of 50 years, the oldest recorded being a Northern Royal Albatross that was ringed as an adult and survived for another 51 years, giving it an estimated age of 61. Given that most

albatross ringing projects are considerably younger than that, it is thought likely that other species will prove to live that long and even longer.

Sky-pointing is one of the stereotyped actions of Laysan Albatross breeding dances.

Albatrosses reach sexual maturity slowly, after about five years, but even once they have reached maturity, they will not begin to breed for another couple of years (even up to 10 years for some species). Young non-breeders will attend a colony prior to beginning to breed, spending many years practising the elaborate breeding rituals and "dances" that the family is famous for. Birds arriving back at the colony for the first time already have the stereotyped behaviours that compose albatross language, but can neither "read" that behaviour as exhibited by other birds nor respond appropriately. After a period of trial and error learning, the young birds learn the syntax and perfect the dances. This language is mastered more rapidly if the younger birds are around older birds.

The repertoire of behaviour involves synchronised performances of various actions such as preening, pointing, calling, bill clacking, staring, and combinations of such behaviours (like the sky-call). When a bird first returns to the colony it will dance with many partners, but after a number of years the number of birds an individual will interact with drops, until one partner is chosen and a pair is formed. They then continue to perfect an individual language that will eventually be unique to that one pair. Having established a pair bond that will last for life, however, most of that dance will never be used ever again.

Albatrosses are held to undertake these elaborate and painstaking rituals to ensure that the appropriate partner has been chosen and to perfect partner recognition, as egg laying and chick rearing is a huge investment. Even species that can complete an egg-laying cycle in under a year seldom lay eggs in consecutive years. The great albatrosses (like the Wandering Albatross) take over a year to raise a chick from laying to fledging. Albatrosses lay a single subelliptical egg, white with reddish brown spots, in a breeding season; if the egg is lost to predators or accidentally broken, then no further breeding attempts are made that year. The larger eggs weigh from 200–510 g (7.1–18 oz). The "divorce" of a pair is a rare occurrence, due to the diminished life-time reproductive success it causes, and usually only happens after several years of breeding failure.

An albatross chick at Northwest Hawaiian Islands National Monument, Midway Atoll.

All the southern albatrosses create large nests for their egg, utilizing grass, shrubs, soil, peat, and even penguin feathers, whereas the three species in the north Pacific make more rudimentary nests. The Waved Albatross, on the other hand, makes no nest and will even move its egg around the pair's territory, as much as 50 m (160 ft), sometimes causing it to lose the egg. In all albatross species, both parents incubate the egg in stints that last between one day and three weeks. Incubation lasts around 70 to 80 days (longer for the larger albatrosses), the longest incubation period of any bird. It can be an energetically demanding process, with the adult losing as much as 83 g (2.9 oz) of body weight a day.

After hatching, the chick, which is semi-altricial, is brooded and guarded for three weeks until it is large enough to defend and thermoregulate itself. During this period the parents feed the chick small meals when they relieve each other from duty. After the brooding period is over, the chick is fed in regular intervals by both parents. The parents adopt alternative patterns of short and long foraging trips, providing meals that weigh around

12% of their body weight (around 600 g (21 oz)). The meals are composed of both fresh squid, fish and krill, as well as stomach oil, an energy-rich food that is lighter to carry than undigested prey items. This oil is created in a stomach organ known as a proventriculus from digested prey items by most tubenoses, and gives them their distinctive musty smell.

Albatrosses brood young chicks until they are large enough to thermoregulate.

Albatross chicks take a long time to fledge. In the case of the great albatrosses, it can take up to 280 days; even for the smaller albatrosses, it takes anywhere between 140 and 170 days. Like many seabirds, albatross chicks will gain enough weight to be heavier than their parents, and prior to fledging they use these reserves to build up body condition (particularly growing all their flight feathers), usually fledging at the same weight as their parents. Between 15% and 65% of those fledged survive to breed. Albatross chicks fledge on their own and receive no further help from their parents, who return to the nest after fledging, unaware their chick has left. Studies of juveniles dispersing at sea have suggested an innate migration behaviour, a genetically coded navigation route, which helps young birds when they are first out at sea.

Albatrosses and humans

Etymology

The name *albatross* is derived from the Arabic *al-câdous* or *al-ġaṭṭās* (a pelican; literally, "the diver"), which travelled to English via the Portuguese form *alcatraz* ("gannet"), which is also the origin of the name of the former prison, Alcatraz. The *OED* notes that the word *alcatraz* was originally applied to the frigatebird; the modification to *albatross* was perhaps influenced by Latin *albus*, meaning "white", in contrast to frigatebirds which are black. In modern Portuguese, the word used for the bird, *albatroz,* is in turn derived from English albatross.

They were once commonly known as **Goonie birds** or **Gooney birds**, particularly those of the North Pacific. In the southern hemisphere, the name **mollymawk** is still well

established in some areas, which is a corrupted form of *malle-mugge*, an old Dutch name for the Northern Fulmar. The name *Diomedea*, assigned to the albatrosses by Linnaeus, references the mythical metamorphosis of the companions of the Greek warrior Diomedes into birds. Finally, the name for the order, *Procellariiformes*, comes from the Latin word *procella* meaning **a violent wind** or **a storm**.

In culture

Albatrosses have been described as "the most legendary of all birds". An albatross is a central emblem in *The Rime of the Ancient Mariner* by Samuel Taylor Coleridge; a captive albatross is also a metaphor for the poète maudit in a poem of Charles Baudelaire. It is from the Coleridge poem that the usage of albatross as a metaphor is derived; someone with a burden or obstacle is said to have 'an albatross around their neck', the punishment given in the poem to the mariner who killed the albatross. In part due to the poem, there is a widespread myth that sailors believe it disastrous to shoot or harm an albatross; in truth, however, sailors regularly killed and ate them, but they were often regarded as the souls of lost sailors. The Maori used the wing bones of the albatross to carve flutes.

Birdwatching

Albatrosses are popular birds for birdwatchers and their colonies popular destinations for ecotourists. Regular birdwatching trips are taken out of many coastal towns and cities, like Monterey, Kaikoura, Wollongong, Sydney, Port Fairy, Hobart and Cape Town, to see pelagic seabirds, and albatrosses are easily attracted to these sightseeing boats by the deployment of fish oil and burley into the sea. Visits to colonies can be very popular; the Northern Royal Albatross colony at Taiaroa Head in New Zealand attracts 40,000 visitors a year, and more isolated colonies are regular attractions on cruises to sub-Antarctic islands.

Threats and conservation

In spite of often being accorded legendary status, albatrosses have not escaped either indirect or direct pressure from humans. Early encounters with albatrosses by Polynesians and Aleut Indians resulted in hunting and in some cases extirpation from some islands (such as Easter Island). As Europeans began sailing the world, they too began to hunt albatross, "fishing" for them from boats to serve at the table or blasting them for sport. This sport reached its peak on emigration lines bound for Australia, and only died down when ships became too fast to fish from, and regulations stopped the discharge of weapons for safety reasons. In the 19th century, albatross colonies, particularly those in the North Pacific, were harvested for the feather trade, leading to the near extinction of the Short-tailed Albatross.

This Black-browed Albatross has been hooked on a long-line.

Of the 21 albatross species recognised by IUCN on their Red List, 19 are threatened, and the other two are *near threatened*. Two species (as recognised by the IUCN) are considered critically endangered: the Amsterdam Albatross and the Chatham Albatross. One of the main threats is commercial long-line fishing, as the albatrosses and other seabirds which will readily feed on offal are attracted to the set bait become hooked on the lines and drown. An estimated 100,000 albatross per year are killed in this fashion. Unregulated pirate fisheries exacerbate the problem.

On Midway Atoll, collisions between Laysan Albatross and aircraft have resulted in human and bird deaths as well as severe disruptions in military flight operations. Studies were made in the late 1950s and early 1960s that examined the results of control methods such as the killing of birds, the leveling and clearing of land to eliminate updrafts and the destruction of annual nesting sites. Tall structures such as traffic control and radio towers killed 3000 birds in flight collisions during 1964-1965 before the towers were taken down. Closure of Naval Air Facility Midway Island in 1993 eliminated the problem of collisions with military aircraft. Recent reductions in human activity on the island have helped reduce bird deaths, though lead paint pollution near military buildings continues to poison birds by ingestion. Albatross plumes were popular in the early 20th century. In 1909 alone over 300,000 albatrosses were killed on Midway Island and Laysan Island for their plumes.

Another threat to albatrosses is introduced species, such as rats or feral cats, which directly attack the albatross or its chicks and eggs. Albatrosses have evolved to breed on islands where land mammals are absent but have not developed defences against them. Even species as small as mice can be detrimental; on Gough Island the chicks of Tristan Albatrosses are attacked and eaten alive by introduced house mice. Introduced species can have other indirect effects: cattle overgrazed essential cover on Amsterdam Island threatening the Amsterdam Albatross; on other islands introduced plants reduce potential nesting habitat.

The remains of this Laysan Albatross chick show the plastic ingested before death, including a bottle cap and lighter.

Ingestion of plastic flotsam is another problem, one faced by many seabirds. The amount of plastic in the seas has increased dramatically since the first record in the 1960s, coming from waste discarded by ships, offshore dumping, litter on beaches and waste washed to sea by rivers. It is impossible to digest and takes up space in the stomach or gizzard that should be used for food, or can cause an obstruction that starves the bird directly. Studies of birds in the North Pacific have shown that ingestion of plastics results in declining body weight and body condition. This plastic is sometimes regurgitated and fed to chicks; a study of Laysan Albatross chicks on Midway Atoll showed large amounts of ingested plastic in naturally dead chicks compared to healthy chicks killed in accidents. While not the direct cause of death, this plastic causes physiological stress and causes the chick to feel full during feedings, reducing its food intake and the chances of survival.

Scientists and conservationists (most importantly BirdLife International and their partners, who run the Save the Albatross campaign) are working with governments and fishermen to find solutions to the threats albatrosses face. 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 using bird scarers can all reduce the seabird by-catch. For example, a collaborative study between scientists and fishermen in New Zealand successfully tested an underwater setting device for long-liners which set the lines below the reach of vulnerable albatross species. The use of some of these techniques in the Patagonian Toothfish fishery in the Falkland Islands is thought to have reduced the

number of Black-browed Albatross taken by the fleet in the last 10 years. Conservationists have also worked on the field of island restoration, removing introduced species that threaten native wildlife, which protects albatrosses from introduced predators.

One important step towards protecting albatrosses and other seabirds is the 2001 treaty the Agreement on the Conservation of Albatrosses and Petrels, which came into force in 2004 and has been ratified by thirteen countries, Australia, Argentina, Brazil and Chile Ecuador, New Zealand, Spain, South Africa, France, Peru, Uruguay and the United Kingdom. The treaty requires these countries to take specific actions to reduce by-catch, pollution and to remove introduced species from nesting islands.

Species

Current thinking divides the albatrosses into four genera. The number of species is a matter of some debate. The IUCN and BirdLife International among others recognise the interim taxonomy of 22 extant species, other authorities retain the more traditional 14 species, and one recent paper proposed a reduction to 13:

- Great albatrosses (*Diomedea*)
  - Wandering Albatross *D. exulans*
  - Antipodean Albatross *D. (exulans) antipodensis*
  - Amsterdam Albatross *D. (exulans) amsterdamensis*
  - Tristan Albatross *D. (exulans) dabbenena*
  - Northern Royal Albatross *D. (epomorpha) sanfordi*
  - Southern Royal Albatross *D. epomophora*
- North Pacific albatrosses (*Phoebastria*)
  - Waved Albatross *P. irrorata*
  - Short-tailed Albatross *P. albatrus*
  - Black-footed Albatross *P. nigripes*
  - Laysan Albatross *P. immutabilis*
- Mollymawks (*Thalassarche*)
  - Black-browed Albatross *T. melanophris*
  - Campbell Albatross *T. (melanophris) impavida*
  - Shy Albatross *T. cauta*
  - White-capped Albatross *T. steadi*
  - Chatham Albatross *T. (cauta) eremita*
  - Salvin's Albatross *T. (cauta) salvini*
  - Grey-headed Albatross *T. chrysostoma*
  - Atlantic Yellow-nosed Albatross *T. chlororhynchos*
  - Indian Yellow-nosed Albatross *T. (chlororhynchos) carteri*
  - Buller's Albatross *T. bulleri*
- Sooty albatrosses (*Phoebetria*)
  - Sooty Albatross *P. fusca*
  - Light-mantled Albatross *P. palpebrata*.

Chapter- 8

Fulmar and Shearwater

Fulmar

Fulmar

Northern Fulmar
Scientific classification
Kingdom: Animalia
Phylum: Chordata
Class: Aves
Order: Procellariiformes
Family: Procellariidae

Genus: ***Fulmarus***
(Stephens & Shaw, 1826)

Species
Fulmarus glacialis Northern Fulmar
Fulmarus glacialodes Southern Fulmar
†*Fulmarus miocaenus*
†*Fulmarus hammeri*

Fulmars are seabirds of the family Procellariidae. The family consists of two extant species and two that are extinct.

Taxonomy

As members of Procellaridae and then the order Procellariiformes, they share certain traits. First, they have nasal passages that attach to the upper bill called naricorns. Although the nostrils on the Albatross are on the sides of the bill. The bills of Procellariiformes are also unique in that they are split into between 7 and 9 horny plates. Finally, they produce a stomach oil made up of wax esters and triglycerides that is stored in the proventriculus. This is used against predators as well as an energy rich food source for chicks and for the adults during their long flights. It will matt the plumage of avian predators, and can lead to their death. They also have a salt gland that is situated above the nasal passage and helps desalinate their bodies, due to the high amount of ocean water that they imbibe. It excretes a high saline solution from their nose.

Two prehistoric species have been described from fossil bones found on the Pacific coast of California: *Fulmarus miocaenus* from the Middle and *Fulmarus hammeri* from the Late Miocene.

Etymology

The genus name *Fulmarus* is derived from the Old Norse word *full* meaning **foul**, and *mar* meaning **gull**. This **foul-gull** is in reference to their stomach oil.

Description

The two Fulmars are closely related seabirds occupying the same niche in different oceans. The **Northern Fulmar**, *Fulmarus glacialis*, or just **Fulmar** lives in the north Atlantic and north Pacific, whereas the **Southern Fulmar**, *F. glacialoides*, is, as its name implies, a bird of the southern oceans. These birds look superficially like gulls, but are unrelated, and are in fact petrels. The northern species is grey and white with a yellow bill, 43–52 cm (17–20 in) in length with a 102–112 cm (40–44 in) wingspan. The southern form is a paler bird with dark wing tips, 45–50 cm (18–20 in) long, with a 115–120 cm (45–47 in) wingspan.

Behavior

Breeding

Both recent species breed on cliffs, laying a single white egg. Unlike many small to medium birds in the Procellariiformes, they are neither nocturnal breeders, nor do they use burrows; their eggs are laid on the bare rock or in shallow depressions lined with plant material.

In Britain, Northern Fulmars historically bred on St. Kilda, and spread into northern Scotland in the 19th century, and to the rest of the United Kingdom by 1930. For example, establishment of colonies at the Fowlsheugh Reserve in Scotland was one of the first areas to be developed for new permanent Fulmar breeding areas.

The expansion has continued further South; the Fulmar can now often be seen in the English Channel and in France along the Northern and Western coasts, with breeding pairs or small colonies in Nord, Picardy, Normandy and along the Atlantic coast in Britanny.

Feeding

They are highly pelagic outside the breeding season, like most tubenoses, feeding on fish, oil or offal. Recent studies in the North Sea have shown them especially susceptible to plastic discards. The range of these species increased greatly last century due to the availability of fish offal from commercial fleets, but may contract because of less food from this source and climatic change. The population increase has been especially notable in the British Isles.

Like other petrels, their walking ability is limited, but they are strong fliers, with a stiff wing action quite unlike the gulls. They look bull-necked compared to gulls, and have short stubby bills. They are long-lived, with a lifespan of 40 years not uncommon.

Shearwater

Shearwaters

Great Shearwater

Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Aves
Subclass:	Neornithes
Infraclass:	Neoaves
Order:	Procellariiformes
Family:	Procellariidae
Tribe:	Shearwater

Genera
Calonectris
Puffinus
Pseudobulweria
Lugensa
Procellaria
Bulweria

Diversity
6 Genera and 37 Species

Shearwaters are medium-sized long-winged seabirds. There are more than 30 species of shearwaters, a few larger ones in the genus *Calonectris* and many smaller species in the genus *Puffinus*. The *Procellaria* petrels and Bulweria were believed to belong to this group, but are only distantly related based on more recent studies, while the *Pseudobulweria* and *Lugensa* "petrels" are more closely related (Bretagnolle *et al.*, 1998; Nunn & Stanley, 1998). The genus *Puffinus* can be divided into a group of small species close to *Calonectris* and a few larger ones more distantly related to both (Austin, 1996). One thing that can be agreed upon about taxonomy of Procellariidae is that it is in a state of flux.

These birds are most common in temperate and cold waters. They are pelagic outside the breeding season.

These tubenose birds fly with stiff wings and use a “shearing” flight technique to move across wave fronts with the minimum of active flight. Some small species, like Manx Shearwater are cruciform in flight, with their long wings held directly out from their bodies.

Many are long-distance migrants, perhaps most spectacularly Sooty Shearwaters, which cover distances in excess of 14,000 km (8,700 mi) from their breeding colony on the Falkland Islands (52°S 60°W) north to 65°-70°N in the North Atlantic Ocean off north Norway. Short-tailed Shearwaters perform an even longer "figure of 8" loop migration in the Pacific Ocean from Tasmania to as far north as the Arctic Ocean off northwest Alaska.

They are also extraordinarily long-lived. A Manx Shearwater breeding on Copeland Island, Northern Ireland, is currently (2003/2004) the oldest known wild bird in the world: ringed as an adult (at least 5 years old) in July 1953, it was retrapped in July 2003, at least 55 years old. Manx Shearwaters migrate over 10,000 km (6,200 mi) to South America in winter, using waters off southern Brazil and Argentina, so this bird has covered a *minimum* of 1,000,000 km (620,000 mi) on migration alone.

Shearwaters come to islands and coastal cliffs only to breed. They are nocturnal at the colonial breeding sites, preferring moonless nights to minimize predation. They nest in burrows and often give eerie contact calls on their night-time visits. They lay a single white egg.

They feed on fish, squid, and similar oceanic food. Some will follow fishing boats to take scraps, notably Sooty Shearwater; these species also commonly follow whales to feed on fish disturbed by them. Their primary technique for feeding is diving and some species diving as much as 70 m (230 ft) under water.

Shearwaters are part of the family Procellariidae, which also includes fulmarine petrels, prions, and gadfly petrels.

List of species

Unimak Pass shearwater flock

- *Calonectris*
  - *Calonectris diomedea*, **Cory's Shearwater**
  - *Calonectris edwardsii*, **Cape Verde Shearwater**
  - *Calonectris leucomelas* , **Streaked Shearwater**

- *Puffinus*
  - "Puffinus" group – smaller species, closely related to *Calonectris*
  - *Puffinus nativatis*, **Christmas Shearwater**
  - *Puffinus puffinus*, **Manx Shearwater**
  - *Puffinus yelkouan*, **Yelkouan Shearwater**
  - *Puffinus mauretanicus*, **Balearic Shearwater**
  - *Puffinus huttoni*, **Hutton's Shearwater**
  - *Puffinus opisthomelas*, **Black-vented Shearwater**
  - *Puffinus auriculatus*, **Townsend's Shearwater**
  - *Puffinus newelli*, **Hawaiian Shearwater** or **Newell's Shearwater**
  - *Puffinus gavia*, **Fluttering Shearwater**
  - *Puffinus assimilis*, **Little Shearwater**
  - *Puffinus baroli*, **North Atlantic Little Shearwater**
  - *Puffinus lherminieri*, **Audubon's Shearwater**

        - *Puffinus (lherminieri) baroli*, **North Atlantic Little Shearwater**, not agreed upon as to whether a ssp. or sp.
        - *Puffinus (lherminieri) bailloni*, **Tropical Shearwater** or **Baillon's Shearwater**, not agreed upon as to whether a ssp. or sp.
    - *Puffinus heinrothi*, **Heinroth's Shearwater**
    - *Puffinus bannermani*, **Bannerman's Shearwater**
    - *Puffinus persicus*, **Persian Shearwater**
    - "Neonectris" group – larger species, a distinct lineage
    - *Puffinus creatopus*, **Pink-footed Shearwater**
    - *Puffinus carneipes*, **Flesh-footed Shearwater**
    - *Puffinus gravis*, **Great Shearwater**
    - *Puffinus pacificus*, **Wedge-tailed Shearwater**
    - *Puffinus bulleri*, **Buller's Shearwater**
    - *Puffinus griseus*, **Sooty Shearwater**
    - *Puffinus tenuirostris*, **Short-tailed Shearwater** or **Mutton bird**
    - †*Puffinus olsoni*, **Lava Shearwater** or **Olson's Shearwater** (extinct)

- *Pseudobulweria*
    - *Pseudobulweria macgillivrayi*, **Fiji Petrel**
    - *Pseudobulweria rostrata*, **Tahiti Petrel**
    - *Pseudobulweria becki*, **Beck's Petrel**
    - *Pseudobulweria aterrima*, **Mascarene Petrel**

- *Lugensa*
    - *Lugensa brevirostris*, **Kerguelen Petrel**

- *Bulweria*
    - *Bulweria bulwerii*, **Bulwer's Petrel**
    - *Bulweria fallax*, **Jouanin's Petrel**
    - *Bulweria bifax*, **Small St. Helena Petrel**

- *Procellaria*
    - *Procellaria cinerea*, **Grey Petrel**
    - *Procellaria aequinoctialis*, **White-chinned Petrel**
    - *Procellaria conspicillata*, **Spectacled Petrel**
    - *Procellaria parkinsoni*, **Parkinson's Petrel**
    - *Procellaria westlandica*, **Westland Petrel**

Chapter- 9

Gadfly Petrel and Diving-Petrel

Gadfly petrel

Gadfly Petrels

Black-capped Petrel

Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Aves

Subclass:	Neornithes
Infraclass:	Neoaves
Order:	Procellariiformes
Family:	Procellariidae
Genus:	***Pterodroma*** Bonaparte, 1856

Diversity

1 Genus and 33 Species

The **gadfly petrels** are seabirds in the bird order Procellariiformes. These medium to large petrels feed on food items picked from the ocean surface.

The short, sturdy bills of the ***Pterodroma*** species in this group, about 35 altogether, are adapted for soft prey taken at the surface; they have twisted intestines for digesting marine animals which have unusual biochemistries.

Their complex wing and face marking are probably for interspecific recognition.

These birds nest in colonies on islands and are pelagic when not breeding. One white egg is laid usually in a burrow or on open ground. They are nocturnal at the breeding colonies.

Species in taxonomic order

The taxonomy of the gadfly petrels is being reformed at the moment. Several genera have been split off over time, as they are closer to the procellarine and *Puffinus* shearwaters. Some subspecies have been raised to full species rank. The arrangement given here is traditional, but annotates the changes proposed by Austin (1998) and Bretagnolle *et al.* (1998).

- *Genus Pterodroma*
  - *Pterodroma baraui*, **Barau's Petrel**
  - *Pterodroma arminjoniana*, **Trindade Petrel**
    - *Pterodroma (arminjoniana) heraldica*, **Herald Petrel**recognized by the IOC, however the SACC has not recognized the split as of yet.
    - Split from *Pterodroma arminjoniana*
  - *Pterodroma externa*, **Juan Fernandez Petrel**
  - *Pterodroma neglecta*, **Kermadec Petrel**
  - *Pterodroma phaeopygia*, **Galapagos Petrel**
  - *Pterodroma sandwichensis*, **Hawaiian Petrel**
  - *Pterodroma atrata*, **Henderson Petrel**
  - *Pterodroma alba*, **Phoenix Petrel**
  - *Pterodroma feae*, **Fea's Petrel**

        - *Pterodroma (feae) desertae*, **Deserta's Petrel** The IOC is contemplating a split.
    - *Pterodroma madeira*, **Zino's Petrel** or **Madeira Petrel**
    - *Pterodroma* sp., **Canary Islands Petrel**, (prehistoric) – possibly extirpated population of extant species
    - *Pterodroma mollis*, **Soft-plumaged Petrel**
    - *Pterodroma cahow*, **Bermuda Petrel**
    - *Pterodroma hasitata*, **Black-capped Petrel**
    - *Pterodroma caribbaea*, **Jamaica Petrel**, (possibly extinct)
    - *Pterodroma incerta*, **Atlantic Petrel**
    - *Pterodroma lessonii*, **White-headed Petrel**
    - *Pterodroma magentae*, **Magenta Petrel**
    - *Pterodroma macroptera*, **Great-winged Petrel**
    - *Pterodroma solandri*, **Providence Petrel**
    - *Pterodroma ultima*, **Murphy's Petrel**
    - *Pterodroma* cf. *leucoptera*, **Mangareva Petrel**, (possibly extinct)
    - *Pterodroma cervicalis*, **White-necked Petrel**
    - *Pterodroma occulta*, **Falla's Petrel** or **Vanuatu Petrel**
        - Split from *Pterodroma cervicalis*
    - *Pterodroma* sp., **Chatham Extinct Petrel**, (prehistoric)
    - *Pterodroma* sp., **Henderson Island Petrel**, (prehistoric)
    - *Pterodroma jugabilis*, **O‘ahu Petrel**, (prehistoric)
    - *Pterodroma rupinarum*, **Large Saint Helena Petrel**, (extinct)
- *Subgenus* Cookilaria
    - *Pterodroma cookii*, **Cook's Petrel**
    - *Pterodroma pycrofti*, **Pycroft's Petrel**
    - *Pterodroma defilippiana*, **Mas a Tierra Petrel** or **De Filippi's Petrel**
    - *Pterodroma longirostris*, **Stejneger's Petrel**
    - *Pterodroma nigripennis*, **Black-winged Petrel**
    - *Pterodroma axillaris*, **Chatham Petrel**
    - *Pterodroma hypoleuca*, **Bonin Petrel**
    - *Pterodroma inexpectata*, **Mottled Petrel**
    - *Pterodroma leucoptera*, **Gould's Petrel**
    - *Pterodroma brevipes*, **Collared Petrel**
        - *Pterodroma brevipes magnificens*, maybe a full species **Magnificient Petrel** *Pterodroma magnificens*

A Pleistocene fossil from Aldabra, Indian Ocean, was described as *Pterodroma kurodai*. Biogeographically, it could belong into any genus.

Diving-petrel

Diving-petrel

Peruvian Diving-petrel, *Pelecanoides garnotii*

Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Aves
Order:	Procellariiformes
Family:	**Pelecanoididae** G.R. Gray, 1871
Genus:	***Pelecanoides*** Lacépède, 1799

Species
Pelecanoides garnotii *Pelecanoides magellani* *Pelecanoides georgicus* *Pelecanoides urinatrix*

The **diving-petrels** are seabirds in the bird order Procellariiformes. There are four very similar species all in the family **Pelecanoididae** and genus ***Pelecanoides*** (Lacépède, 1799), distinguished only by small differences in the coloration of their plumage and their bill construction.

Diving-petrels are auk-like small petrels of the southern oceans. The resemblances with the auks are due to convergent evolution, since both families feed by pursuit diving, although some researchers have in the past suggested that the similarities are due to relatedness. Amongst the Procellariiformes the diving petrels are the family most adapted

to life in the sea rather than flying over it, and are generally found closer inshore than other families in the order.

Diving-petrels are plankton feeders, taking mostly crustacean prey such as krill, copepods and the amphipod *Themisto gaudichaudii*, also taking small fish and squid. They have several adaptations for obtaining their prey including short powerful wings, a gular pouch for storing food, and their nostrils open upwards rather than forward pointing as it is in other tubenoses.

Description and morphology

The diving-petrels are small petrels that measure between 19-23 cm (7.5-9 in) and weigh between 120-200 g (4-7 oz). They are highly uniform in appearance, and very difficult to separate when seen at sea. They are best separated by the size and shape of their short bills. The plumage is shining black on the top and white on the underside. Their wings are short, particularly with regards to overall body size, and used in a highly characteristic whirring flight. This flight is low over the water and diving petrels will fly through the crests of waves without any interruption of their flight path. In the water these wings are half folded and used as paddles to propel the bird after its prey.

Breeding

These birds nest in colonies on islands. One white egg is laid in a burrow in turf or soft soil that's usually covered with vegetation, feathers, or small rocks. They are nocturnal at the breeding colonies. It has a long period of parental care (around 45 - 60 days) in the burrow, but once the chick fledges out to sea it is on its own.

Status and conservation

Of the four species two, the Peruvian Diving-petrel and the Magellan Diving-petrel, have highly restricted ranges around South America's coasts, whilst the Common Diving-petrel and the South Georgia Diving-petrel range widely across the southern oceans, breeding on islands off New Zealand, sub-Antarctic islands in the Indian Ocean, and islands in the south Atlantic (like Tristan da Cunha).

Diving-petrels are amongst the world's most numerous birds, with Common and South Georgia Diving-petrels numbering several million pairs each. The Peruvian Diving-petrel, on the other hand, is threatened by guano extraction, introduced species and climate change, and is listed as an endangered species.

Systematics and evolution

Some studies published on the phylogeny of the petrels suggests that the diving-petrels are actually members of the family Procellariidae, and some taxonomic works treat them as such.

The four species are:

- Peruvian Diving-petrel *Pelecanoides garnotii*
- Magellan Diving-petrel *Pelecanoides magellani*
- South Georgia Diving-petrel *Pelecanoides georgicus*
- Common Diving-petrel *Pelecanoides urinatrix*

The evolution and systematics of these birds is not well researched. Several populations were described as distinct species and while most of them are only subspecies, some may indeed be distinct. The prehistoric fossil record was long limited to very fragmentary remains described as *P. cymatotrypetes* found in Early Pliocene deposits of Langebaanweg, South Africa; while this bird apparently was close to the Common Diving-petrel, no members of the genus are known from South African waters today.

In 2007, a humerus piece from New Zealand was described as *P. miokuaka*. This was found in Early/Middle Miocene deposits and just as may be expected, it far more resembles diving-petrels than any other known bird, but presents a less apomorphic condition.

Chapter- 10

Booby and Frigatebird

Booby

Booby

Blue-footed Booby displaying by raising a foot
Scientific classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Aves
Order:	Pelecaniformes
Family:	Sulidae
Genus:	***Sula*** Brisson, 1760

Species

- *Sula nebouxii*
- *Sula variegata*
- *Sula dactylatra*
- *Sula granti*
- *Sula sula*
- *Sula leucogaster*

A **booby** is a seabird in the genus ***Sula***, part of the Sulidae family. Boobies are closely related to the gannets (*Morus*), which were formerly included in *Sula*.

Description

Boobies are large birds with long pointed wings and long bills. They hunt fish by diving from a height into the sea and pursuing their prey underwater. Facial air sacs under their skin cushion the impact with the water. Boobies are colonial breeders on islands and coasts. They normally lay one or more chalky-blue eggs on the ground or sometimes in a tree nest.

Name

Their name was possibly based on the Spanish slang term *bubi*, meaning "dunce", as these tame birds had a habit of landing on board sailing ships, where they were easily captured and eaten. Owing to this, boobies are often mentioned as having been caught and eaten by shipwrecked sailors, notably Captain Bligh of the *Bounty* and his adherents, during their famous voyage after being set adrift by Fletcher Christian and his followers.

Systematics and evolution

Red-footed Booby and Nazca Booby

Red-footed Booby, *Sula sula*

Five of the six extant Sulidae species called *boobies* are in the genus *Sula*, while the three gannets are usually treated in the genus *Morus*. Abbott's Booby was formerly included in *Sula* but is now placed in a monotypic genus *Papasula* which represents an ancient lineage perhaps closer to *Morus*.

Some authorities consider that all nine species should be considered congeneric in *Sula*. However, they are readily told apart, by means of osteology. The distinct lineages of gannets and boobies are known to have existed in such form, since at least the Middle Miocene, c.15 mya (Olson 1985).

The fossil records of boobies are not as well documented as those of the gannets; possibly because the species of boobies were less numerous in the late Miocene to Pliocene, when gannets had their highest diversity or because of the more tropical distribution of boobies, many fossil species have simply not been found yet, as most localities are in continental North America or Europe.

Frigatebird

Frigatebirds

Magnificent Frigatebird

Scientific classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Aves
Order:	Pelecaniformes
Family:	**Fregatidae** Degland & Gerbe, 1867
Genus:	***Fregata*** Lacépède, 1799

Species

- *Fregata magnificens*
- *Fregata aquila*
- *Fregata andrewsi*
- *Fregata minor*
- *Fregata ariel*

Range map

The **frigatebirds** are a family, **Fregatidae**, of seabirds. There are five species in the single genus ***Fregata***. They are also sometimes called Man of War birds or Pirate birds. Since they are related to the pelicans, the term "frigate pelican" is also a name applied to them. They have long wings, tails and bills and the males have a red gular pouch that is inflated during the breeding season to attract a mate.

Frigatebirds are pelagic piscivores which obtain most of their food on the wing. A small amount of their diet is obtained by robbing other seabirds, a behavior that has given the family its name, and by snatching seabird chicks. Frigatebirds are seasonally monogamous, and nest colonially. A rough nest is constructed in low trees or on the ground on remote islands. A single egg is laid each breeding season. The duration of parental care in frigatebirds is the longest of any bird.

Biology

Morphology

Frigatebirds are large, with iridescent black feathers (the females have a white underbelly), with long wings (male wingspan can reach 2.3 metres) and deeply-forked tails. The males have inflatable red-coloured throat pouches called "gular pouches", which they inflate to attract females during the mating season.

Frigatebirds are found over tropical oceans and ride warm updrafts. Therefore, they can often be spotted riding weather fronts and can signal changing weather patterns.

These birds do not swim and cannot walk well, and cannot take off from a flat surface. Having the largest wingspan to body weight ratio of any bird, they are essentially aerial, able to stay aloft for more than a week, landing only to roost or breed on trees or cliffs.

As members of Pelecaniformes, frigatebirds have the key characteristics of all four toes being connected by the web, a gular sac (also called gular skin), and a furcula that is fused to the breastbone. Although there is definitely a web on the frigatebird foot, the webbing is reduced and part of each toe is free. Frigatebirds produce very little oil and therefore do not land in the ocean. The gular sac is used as part of a courtship display and is, perhaps, the most striking frigatebird feature.

Female Magnificent Frigatebird in Antigua

Breeding behavior

They generally lay one white egg per clutch. Both parents take turns feeding for the first three months but then only the mother feeds the young for another eight months. It takes so long to rear a chick that frigatebirds cannot breed every year. It is typical to see juveniles as big as their parents waiting to be fed. When they sit waiting for endless hours in the hot sun, they assume an energy-efficient posture in which their head hangs down, and they sit so still that they seem dead. But when the parent returns, they will wake up,

bob their head, and scream until the parent opens its mouth. The hungry juvenile plunges its head down the parent's throat and feeds at last.

Distribution and identifying characteristics differ among frigatebird species, and thus are addressed in species-specific articles.

Feeding

Frigatebirds obtain most of their food by snatching it from the ocean surface. In this case an immature Great Frigatebird is snatching a Sooty Tern chick dropped by another frigatebird

Frigatebirds' feeding habits are pelagic. Lacking the ability to take off from water, they snatch prey from the ocean surface or beach using their long, hooked bills. They catch fish, baby turtles and similar items in this way. Frigatebirds will rob other seabirds such as boobies, tropicbirds, and shearwaters of their catch, using their speed and manoeuvrability to outrun and harass their victims until they regurgitate their stomach contents. Although frigatebirds are renowned for their kleptoparasitic feeding behavior, 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%.

Species

- **Genus *Fregata***
  - Magnificent Frigatebird or Man O'War, *Fregata magnificens*.
  - Ascension Frigatebird, *Fregata aquila*.

- Christmas Island Frigatebird, *Fregata andrewsi*.
- Great Frigatebird, *Fregata minor*.
- Lesser Frigatebird, *Fregata ariel*.

Chapter- 11

Cormorant

Cormorants and shags Temporal range: Late Cretaceous? – Recent	
	
Little Pied Cormorant *Phalacrocorax melanoleucos*	
Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Aves
Subclass:	Neornithes
Infraclass:	Neoaves
Order:	Pelecaniformes
Suborder:	Sulae
Family:	**Phalacrocoracidae** Reichenbach, 1850
Genus:	***Phalacrocorax*** Brisson, 1760

Synonyms

Australocorax Lambrecht, 1931
Compsohalieus B. Brewer & Ridgway, 1884
Cormoranus Baillon, 1834
Dilophalieus Coues, 1903
Ecmeles Gistel, 1848
Euleucocarbo Voisin, 1973
Halietor Heine, 1860
Hydrocorax Vieillot, 1819 (*non* Brisson, 1760: preoccupied)
Hypoleucus Reichenbach, 1852
Leucocarbo Bonaparte, 1857
Microcarbo Bonaparte, 1856
Miocorax Lambrecht, 1933
Nannopterum Sharpe, 1899
Nesocarbo Voisin, 1973
Notocarbo Siegel-Causey, 1988
Pallasicarbo Coues, 1903
Paracorax Lambrecht, 1933
Poikilocarbo Boetticher, 1935
Pliocarbo Tugarinov, 1940
Stictocarbo Bonaparte, 1855
Viguacarbo Coues, 1903

The bird family **Phalacrocoracidae** is represented by some 40 species of **cormorants and shags**. Several different classifications of the family have been proposed recently, and the number of genera is disputed.

Names

There is no consistent distinction between cormorants and shags. The names "cormorant" and "shag" were originally the common names of the two species of the family found in Great Britain, *Phalacrocorax carbo* (now referred to by ornithologists as the Great Cormorant) and *P. aristotelis* (the European Shag). "Shag" refers to the bird's crest, which the British forms of the Great Cormorant lack. As other species were discovered by English-speaking sailors and explorers elsewhere in the world, some were called cormorants and some shags, depending on whether they had crests or not. Sometimes the same species is called a cormorant in one part of the world and a shag in another, e.g., the Great Cormorant is called the Black Shag in New Zealand (the birds found in Australasia have a crest that is absent in European members of the species). Van Tets (1976) proposed to divide the family into two genera and attach the name "Cormorant" to one and "Shag" to the other, but this flies in the face of common usage and has not been widely adopted.

The scientific genus name is latinized Ancient Greek, from *φαλακρός* (*phalakros*, "bald") and *κόραξ* (*korax*, "raven"). This is often thought to refer to the creamy white patch on the cheeks of adult Great Cormorants, or the ornamental white head plumes prominent in Mediterranean birds of this species, but is certainly not a unifying characteristic of cormorants. "Cormorant" is a contraction derived from Latin *corvus marinus*, "sea raven". Indeed, "sea raven" or analogous terms were the usual terms for cormorants in Germanic languages until after the Middle Ages. The French explorer André Thévet commented in 1558 that "...the beak [is] similar to that of a cormorant or other corvid," which demonstrates that the erroneous belief that the birds were related to ravens lasted at least to the 16th century.

Characteristics

Two Double-crested Cormorants and one fish

Imperial Shags in Beagle Channel

Great Cormorants nesting on an island at Walthamstow Reservoirs

Cormorants and shags are medium-to-large seabirds. They range in size from the Pygmy Cormorant (*Phalacrocorax pygmaeus*), at as little as 45 cm (18 in) and 340 g (12 oz), to the Flightless Cormorant (*Phalacrocorax harrisi*), at a maximum size 100 cm (40 in) and 5 kg (11 lb). The recently-extinct Spectacled Cormorant (*Phalacrocorax perspicillatus*) was rather larger, at an average size of 6.3 kg (14 lb). The majority, including nearly all Northern Hemisphere species, have mainly dark plumage, but some Southern Hemisphere species are black and white, and a few (e.g. the Spotted Shag of New Zealand) are quite colourful. Many species have areas of coloured skin on the face (the lores and the gular skin) which can be bright blue, orange, red or yellow, typically becoming more brightly coloured in the breeding season. The bill is long, thin, and sharply hooked. Their feet have webbing between all four toes, as in their relatives.

They are coastal rather than oceanic birds, and some have colonised inland waters - indeed, the original ancestor of cormorants seems to have been a fresh-water bird, judging from the habitat of the most ancient lineage. They range around the world, except for the central Pacific islands.

All are fish-eaters, dining on small eels, fish, and even water snakes. They dive from the surface, though many species make a characteristic half-jump as they dive, presumably to give themselves a more streamlined entry into the water. Under water they propel themselves with their feet. Some cormorant species have been found, using depth gauges, to dive to depths of as much as 45 metres.

After fishing, cormorants go ashore, and are frequently seen holding their wings out in the sun. All cormorants have preen gland secretions that are used ostensibly to keep the feathers waterproof. Some sources state that cormorants have waterproof feathers while others say that they have water *permeable* feathers. Still others suggests that the outer plumage absorbs water but does not permit it to penetrate the layer of air next to the skin. The wing drying action is seen even in the flightless cormorant but commonly in the Antarctic shags and red-legged cormorants. Alternate functions suggested for the spread-wing posture include that it aids thermoregulation, digestion, balances the bird or indicates presence of fish. A detailed study of the Great Cormorant concludes that it is without doubt to dry the plumage.

Cormorants are colonial nesters, using trees, rocky islets, or cliffs. The eggs are a chalky-blue colour. There is usually one brood a year. The young are fed through regurgitation. They typically have deep, ungainly bills, showing a greater resemblance to those of the pelicans', to which they are related, than is obvious in the adults.

Systematics

The cormorants are a group traditionally placed within the Pelecaniformes or, in the Sibley-Ahlquist taxonomy, the expanded Ciconiiformes. This latter group is certainly not a natural one, and even after the tropicbirds have been recognized as quite distinct, the remaining Pelecaniformes seem not to be entirely monophyletic. Their relationships and delimitation - apart from being part of a "higher waterfowl" clade which is similar but not

identical to Sibley and Ahlquist's "pan-Ciconiiformes" - remain mostly unresolved. Notwithstanding, all evidence agrees that the cormorants and shags are closer to the darters and Sulidae (gannets and boobies), and perhaps the pelicans and/or even penguins, than to all other living birds.

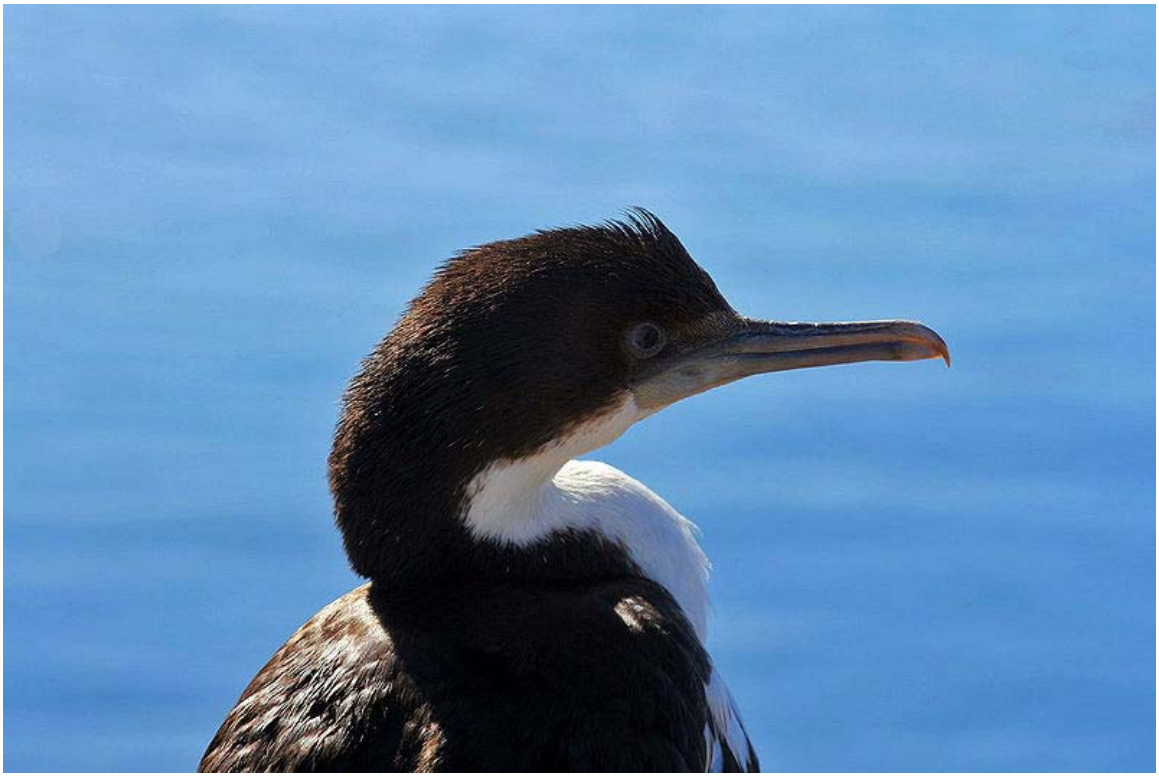
In recent years, three preferred treatments of the cormorant family have emerged: either to leave all living cormorants in a single genus, ***Phalacrocorax***, or to split off a few species such as the Imperial Shag complex (in *Leucocarbo*) and perhaps the Flightless Cormorant. Alternatively, the genus may be disassembled altogether and in the most extreme case be reduced to the Great, White-breasted and Temminck's Cormorants.

Pending a thorough review of the Recent and prehistoric cormorants, the single-genus approach is followed here for three reasons: First, it is preferable to tentatively assigning genera without a robust hypothesis. Second, it makes it easier to deal with the fossil forms, the systematic treatment of which has been no less controversial than that of living cormorants and shags. Third, this scheme is also used by the IUCN, making it easier to incorporate data on status and conservation. In accordance with the treatment there, the Imperial Shag complex is here left unsplit too, but the King Shag complex is split up.

Several evolutionary groups are still recognizable. However, combining the available evidence suggests that there has also been a great deal of convergent evolution; for example the "cliff shags" are a convergent paraphyletic group. The proposed division into *Phalacrocorax sensu stricto* (or subfamily **Phalacrocoracinae**) "cormorants" and *Leucocarbo sensu lato* (or **Leucocarboninae**) "shags" does indeed have some degree of merit - though not as originally intended - but fails to account for basal lineages and the fact that the entire family cannot be clearly divided at present beyond the superspecies or species-complex level. The resolution provided by the mtDNA 12S rRNA and ATPase subunits 6 and 8 sequence data is not sufficient to properly resolve several groups to satisfaction; in addition, many species remain unsampled, the fossil record has not been integrated in the data, and the effects of hybridization - known in some Pacific species especially - on the DNA sequence data are unstudied.

Species in HBW taxonomic sequence

Cormorant (species unknown) begins its dive



Immature *Phalacrocorax atriceps albivente*

Phalacrocorax niger in Hyderabad, India.

This sequence follows the *Handbook of the Birds of the World*.

- Double-crested Cormorant or White-crested Cormorant, *Phalacrocorax auritus*
- Neotropic Cormorant or Olivaceous Cormorant, *Phalacrocorax brasilianus* (or *Phalacrocorax olivaceus*)
- Little Black Cormorant, *Phalacrocorax sulcirostris*
- Great Cormorant or Black Shag, *Phalacrocorax carbo*
- White-breasted Cormorant, *Phalacrocorax lucidus*
- Indian Cormorant, *Phalacrocorax fuscicollis*
- Cape Cormorant, *Phalacrocorax capensis*
- Socotra Cormorant, *Phalacrocorax nigrogularis*
- Wahlberg's Cormorant or Bank Cormorant, *Phalacrocorax neglectus*
- Temminck's Cormorant or Japanese Cormorant, *Phalacrocorax capillatus*
- Brandt's Cormorant, *Phalacrocorax penicillatus*
- Spectacled Cormorant, *Phalacrocorax perspicillatus* - extinct (c.1850)
- Common Shag, *Phalacrocorax aristotelis*
- Pelagic Cormorant or Baird's Cormorant, *Phalacrocorax pelagicus*
- Red-faced Cormorant, *Phalacrocorax urile*

- Rock Shag, *Phalacrocorax magellanicus*
- Guanay Cormorant, *Phalacrocorax bougainvillii*
- Pied Cormorant or Yellow-faced Cormorant, *Phalacrocorax varius*
- Black-faced Cormorant, *Phalacrocorax fuscescens*
- King Shag or Rough-faced Shag, *Phalacrocorax carunculatus*
- Stewart Island Shag, *Phalacrocorax chalconotus*
- Chatham Shag, *Phalacrocorax onslowi*
- Auckland Shag, *Phalacrocorax colensoi*
- Campbell Shag, *Phalacrocorax campbelli*
- Bounty Shag, *Phalacrocorax ranfurlyi*
- Imperial Shag or Blue-eyed Shag, *Phalacrocorax atriceps*
    - White-bellied Shag, *Phalacrocorax atriceps albiventer*
- Antarctic Shag, *Phalacrocorax bransfieldensis*
- South Georgia Shag, *Phalacrocorax georgianus*
- Heard Shag, *Phalacrocorax nivalis*
- Crozet Shag, *Phalacrocorax melanogenis*
- Kerguelen Shag, *Phalacrocorax verrucosus*
- Macquarie Shag, *Phalacrocorax purpurascens*
- Red-footed Shag, *Phalacrocorax gaimardi*
- Spotted Shag *Phalacrocorax punctatus*
- Pitt Cormorant or Featherstone's Shag *Phalacrocorax featherstoni*
- Little Pied Cormorant, *Phalacrocorax melanoleucos*
- Long-tailed Cormorant, *Phalacrocorax africanus*
- Crowned Cormorant, *Phalacrocorax coronatus*
- Little Cormorant, *Phalacrocorax niger*
- Pygmy Cormorant, *Phalacrocorax pygmaeus*
- Flightless Cormorant, *Phalacrocorax harrisi*

Species in phylogenetic sequence

Little Cormorant, *Phalacrocorax niger*

The peculiar Red-footed Shag (*Phalacrocorax gaimardi*)

This list attempts to follow a phylogenetic order. If the distinction into subfamilies would be upheld, the "blue-eyed" and related species would probably be the Leucocarboninae, and the groups that follow them the Phalacrocoracinae. The first two lineages (and possibly the Flightless Cormorant) are basal and cannot be assigned to either subfamily.

Basal lineage 1: "Microcormorants", proposed genus ***Microcarbo*** or *Halietor* ("Phalacrocoracinae"); the former genus name would be valid.

> Small, short-billed subtropical to tropical marine and freshwater species from the Old World and Australia. They have black feet and almost all lack significant white feathers. They often have a diminutive frontal tuft.

- Little Pied Cormorant, *Phalacrocorax melanoleucos*
- Long-tailed Cormorant, *Phalacrocorax africanus*
- Crowned Cormorant, *Phalacrocorax coronatus*
- Little Cormorant, *Phalacrocorax niger*
- Pygmy Cormorant, *Phalacrocorax pygmaeus*

Basal lineage 2: Red-footed Shag. Included in *Leucocarbo* or *Stictocarbo* ("Leucocarboninae")

Pacific coast of South America. This species apparently has no close living relatives. It has a highly apomorphic color pattern: naked red base of bill, red feet, and a white neck spot, and it is crestless. It seems to be convergent in some aspects with the *punctatus* superspecies. What seems sure by now is that this species must be placed in a distinct monotypic genus ***Poikilocarbo*** in almost any case, if any species are split from *Phalacrocorax* at all.

- Red-footed Shag, *Phalacrocorax gaimardi*

The Double-crested Cormorant's crests are normally not visible

Blue-eyed shags and relatives: variously placed in *Euleucocarbo*, *Hypoleucos*, *Leucocarbo*, *Notocarbo* and *Stictocarbo* ("Leucocarboninae"), and the monotypic *Nannopterum*.

This reasonably well-supported marine clade contains 3 lineages:

1. One containing American species which are mainly black-footed, black-plumaged, and have yellow skin at the base of the bill as well as white display crests behind the eyes in breeding plumage. They occur in marine and freshwater habitats. The Flightless Cormorant of the Galápagos Islands also seems to belong here. Its wings have been reduced by evolution to tiny size, it is extremely apomorphic due to its flightlessness, and its plumage is entirely nondescript. If considered a distinct genus, they would get the name ***Dilophalieus*** or (more probably) ***Nannopterum***, the old genus of the Flightless Cormorant.
2. The Rock Shag from southern South America with red skin at the bill base, pink feet, a frontal crest, and an apomorphic white ear-spot
3. A group of numerous close-knit forms from southern Pacific and subantarctic waters which are white below with pink feet but otherwise quite varying in appearance. It contains the King and Imperial complexes and the Guanay Cormorant. Almost all have some amount of white on the upperwing coverts, frontal crests, and blue eye-rings. The crested shags with yellow warts in front of the eyes belong to this group. The genus name ***Leucocarbo*** would apply to either this group, or the entire clade.

- Double-crested Cormorant or White-crested Cormorant, *Phalacrocorax auritus*
- Neotropic Cormorant or Olivaceous Cormorant, *Phalacrocorax brasilianus*
- Flightless Cormorant, *Phalacrocorax harrisi*
- Rock Shag, *Phalacrocorax magellanicus*

Guanay Cormorant, *Phalacrocorax bougainvillii*

- Imperial Shag or Blue-eyed Shag, *Phalacrocorax atriceps*
  - White-bellied Shag, *Phalacrocorax (atriceps) albiventer*
  - Antarctic Shag, *Phalacrocorax (atriceps) bransfieldensis*
  - South Georgian Shag, *Phalacrocorax (atriceps) georgianus*
  - Heard Shag, *Phalacrocorax (atriceps) nivalis*
  - Crozet Shag, *Phalacrocorax (atriceps) melanogenis*
  - Kerguelen Shag, *Phalacrocorax (atriceps) verrucosus*
  - Macquarie Shag, *Phalacrocorax (atriceps) purpurascens*
- Guanay Cormorant, *Phalacrocorax bougainvillii*
- King Shag or Rough-faced Shag, *Phalacrocorax carunculatus*
- Stewart Island Shag, *Phalacrocorax chalconotus*
- Chatham Shag, *Phalacrocorax onslowi*
- Auckland Shag, *Phalacrocorax colensoi*
- Campbell Shag, *Phalacrocorax campbelli*
- Bounty Shag, *Phalacrocorax ranfurlyi*

Brandt's Cormorant (*Phalacrocorax penicillatus*) - crestless, but with ornamental plumes

North Pacific shags: spread between ***Compsohalieus*** ("Phalacrocoracinae") and *Stictocarbo* ("Leucocarboninae"). If a distinct genus, the former name would apply

> A well-supported marine group ranging from the Bering Strait to California. They are black-footed and have white ornamental plumes strewn about the head and neck in breeding plumage. They tend to have prominent double crests.

- Brandt's Cormorant, *Phalacrocorax penicillatus*
- Spectacled Cormorant, *Phalacrocorax perspicillatus* - extinct (c.1850)
- Pelagic Cormorant or Baird's Cormorant, *Phalacrocorax pelagicus*
- Red-faced Cormorant, *Phalacrocorax urile*

Common Shag lineage: formerly in *Compsohalieus* ("Phalacrocoracinae") and *Stictocarbo* ("Leucocarboninae")

Black-footed smallish marine shags of Europe and southern Africa. Wahlberg's Cormorant is very tentatively placed here; it seems anatomically more similar to the *P. fuscscens*, but the more informative characters - the combination of frontal crest and lack of extensive naked skin at bill base in mid-sized Old World species - seem to place it here. If this is correct, they are probably very distantly related due to biogeography.

- Common Shag, *Phalacrocorax aristotelis*
- Wahlberg's Cormorant or Bank Cormorant, *Phalacrocorax neglectus* - tentatively placed here

Indian Ocean group: spread between *Hypoleucos* and *Leucocarbo* ("Leucocarboninae") and *Compsohalieus* ("Phalacrocoracinae"). ***Hypoleucos*** would be the correct genus name if they were split off.

Little Black Cormorant, *Phalacrocorax sulcirostris*

A group of black-footed species occurring in tropical coastal or inland habitat between the Persian Gulf and Australia. Most species are tentatively assigned here, based on the combination of range, crestlessness, size, general lack of naked skin ornaments and the presence of some amount of white feathering in the ear region at least in breeding plumage. This clade is not too well supported, but this may be because the two presumed members included in recent research are quite dissimilar; the three unstudied ones are very similar to one or the other.

- Little Black Cormorant, *Phalacrocorax sulcirostris*

- Indian Cormorant, *Phalacrocorax fuscicollis* - tentatively placed here
- Socotran Cormorant, *Phalacrocorax nigrogularis* - tentatively placed here
- Pied Cormorant or Yellow-faced Cormorant, *Phalacrocorax varius*
- Black-faced Cormorant, *Phalacrocorax fuscescens* - tentatively placed here

Spotted group: placed in ***Stictocarbo*** ("Leucocarboninae"); indeed, they would be the only members of this possibly distinct genus

> A superspecies of the New Zealand region. Peculiarly apomorphic, with yellowish legs, prominent double crests, white ornamental plumes on the neck, a grey belly and spotted wings.

- Spotted Shag *Phalacrocorax punctatus*
- Pitt Cormorant or Featherstone's Shag *Phalacrocorax featherstoni*

Cape Cormorant: sometimes placed in *Leucocarbo* ("Leucocarboninae")

> Highly plesiomorphic among its relatives; a species from the southern coasts of Africa. It is apparently close to the common ancestor of the next group and, perhaps apart from the all-black plumage, looks almost identical to that long-extinct bird.

- Cape Cormorant, *Phalacrocorax capensis*

Great Cormorant (*Phalacrocorax carbo*) drying its wings

True cormorants: these would be retained in ***Phalacrocorax*** no matter how the cormorants and shags are split up

> They occur from the western Atlantic through the Old World into Australia, usually but not always in marine and temperate to subtropical habitat. They are characteristic, being large, with white cheek and thigh patches, ornamental plumes in the neck, a yellow naked bill base, black feet, and a shaggy nape crest.

- Great Cormorant, *Phalacrocorax carbo*
- White-breasted Cormorant, *Phalacrocorax lucidus*
- Temminck's Cormorant or Japanese Cormorant, *Phalacrocorax capillatus*

Evolution and fossil record

Cormorants seem to be a very ancient group, with similar ancestors reaching all the way back to the time of the dinosaurs. In fact, the very earliest known modern bird, *Gansus yumenensis*, had essentially the same structure, although it was not a cormorant per se. The details of the evolution of the cormorant are mostly unknown. Even the technique of using the distribution and relationships of a species to figure out where it came from, biogeography, usually very informative, does not give very specific data for this probably rather ancient and widespread group. However, the closest living relatives of the cormorants and shags are the other families of the suborder Sulae—darters and gannets and boobies—which have a primarily Gondwanan distribution. Hence, at least the modern diversity of Sulae probably originated in the southern hemisphere.

While the leucocarbonines are almost certainly of southern Pacific origin—possibly even the Antarctic which, at the time when cormorants evolved. was not yet ice-covered—all that can be said about the phalacrocoracines is that they are most diverse in the regions bordering the Indian Ocean, but generally occur over a large area.

Similarly, the origin of the family is shrouded in uncertainties. Some Late Cretaceous fossils have been proposed to belong with the Phalacrocoracidae:
A scapula from the Campanian-Maastrichtian boundary, about 70 mya (million years ago), was found in the Nemegt Formation in Mongolia; it is now in the PIN collection. It is from a bird roughly the size of a Spectacled Cormorant, and quite similar to the corresponding bone in *Phalacrocorax*. A Maastrichtian (Late Cretaceous, c.66 mya) right femur, AMNH FR 25272 from the Lance Formation near Lance Creek, Wyoming, is sometimes suggested to be the second-oldest record of the Phalacrocoracidae; this was from a rather smaller bird, about the size of a Long-tailed Cormorant.

As the Early Oligocene *"Sula" ronzoni* cannot be assigned to any of the suloid families—cormorants and shags, darters, and gannets and boobies—with certainty, the best interpretation is that the Phalacrocoracidae diverged from their closest ancestors in the Early Oligocene, perhaps some 30 million years ago, and that the Cretaceous fossils represent ancestral suloids, "pelecaniforms" or "higher waterbirds"; at least the last lineage is generally believed to have been already distinct and undergoing evolutionary

radiation at the end of the Cretaceous. What *can* be said with near certainty is that AMNH FR 25272 is from a diving bird that used its feet for underwater locomotion; as this is liable to result in some degree of convergent evolution and the bone is missing undisputable neornithine features, it is not entirely certain that the bone is correctly referred to this group.

During the late Paleogene, when the family presumably originated, much of Eurasia was covered by shallow seas, as the Indian Plate finally attached to the mainland. Lacking a detailed study, it may well be that the first "modern" cormorants were small species from eastern, south-eastern or southern Asia, possibly living in freshwater habitat, that dispersed due to tectonic events. Such a scenario would account for the present-day distribution of cormorants and shags and is not contradicted by the fossil record; as remarked above, a thorough review of the problem is not yet available.

Double-crested Cormorant in its natural habitat.

Two distinct genera of prehistoric cormorants are widely accepted today, if *Phalacrocorax* is used for all living species:

- *Limicorallus* (Indricotherium middle Oligocene of Chelkar-Teniz, Kazakhstan)
- *Nectornis* (Late Oligocene?/Early Miocene of C Europe - Middle Miocene of Bes-Konak, Turkey) - includes *Oligocorax miocaenus*

The proposed genus *Oligocorax* appears to be paraphyletic - the European species have been separated in *Nectornis*, and the North American ones are placed in the expanded *Phalacrocorax*. A Late Oligocene fossil cormoran foot from Enspel (Germany),

sometimes placed herein, would then be referable to *Nectornis* if it proves not to be too distinct. All these early European species might belong to the basal group of "microcormorants", as they conform with them in size and seem to have inhabited the same habitat: subtropical coastal or inland waters. *Limicorallus*, meanwhile, was initially believed to be a rail or a dabbling duck by some. There are also undescribed remains of apparent cormorants from the Quercy Phosphorites of Quercy (France), dating to some time between the Late Eocene and the mid-Oligocene.

Some other Paleogene remains are sometimes assigned to the Phalacrocoracidae, but these birds seem quite intermediate between cormorants and darters (and lack clear autapomorphies of either). Thus, they may be quite basal members of the Palacrocoracoidea. The taxa in question are:

- *Piscator* (Late Eocene of England)
- "Pelecaniformes" gen. et sp. indet. (Jebel Qatrani Early Oligocene of Fayum, Egypt) – similar to *Piscator*?
- *Borvocarbo* (Late Oligocene of C Europe)

The supposed Late Pliocene/Early Pleistocene *"Valenticarbo"* is a *nomen dubium* and given its recent age probably not a separate genus.

The remaining species are, in accordance with the scheme used here, all placed in the modern genus *Phalacrocorax*:

- *Phalacrocorax marinavis* (Oligocene ?-? Early Miocene of Oregon, USA) - formerly *Oligocorax*
- *Phalacrocorax littoralis* (Late Oligocene/Early Miocene of St-Gérand-le-Puy, France) - formerly *Oligocorax*, might belong into *Nectornis*
- *Phalacrocorax intermedius* (Early - Middle Miocene of C Europe) - includes *P. praecarbo, Ardea/P. brunhuberi* and *Botaurites avitus*
- *Phalacrocorax macropus* (Early Miocene ?-? Pliocene of NW USA)
- *Phalacrocorax ibericus* (Late Miocene of Valles de Fuentiduena, Spain)
- *Phalacrocorax lautus* (Late Miocene of Golboçica, Moldavia)
- *Phalacrocorax serdicensis* (Late Miocene of Hrabarsko, Bulgaria)
- *Phalacrocorax femoralis* (Modelo Late Miocene/Early Pliocene of WC North America) - formerly *Miocorax*
- *Phalacrocorax* sp. (Late Miocene/Early Pliocene of Lee Creek Mine, USA)
- *Phalacrocorax longipes* (Late Miocene - Early Pliocene of the Ukraine) - formerly *Pliocarbo*
- *Phalacrocorax goletensis* (Early Pliocene ?-? Early Pleistocene of Mexico)
- *Phalacrocorax wetmorei* (Bone Valley Early Pliocene of Florida)
- *Phalacrocorax* sp. (Bone Valley Early Pliocene of Polk County, Florida, USA)
- *Phalacrocorax leptopus* (Juntura Early/Middle Pliocene of Juntura, Malheur County, Oregon, USA)
- *Phalacrocorax idahensis* (Middle Pliocene ?-? Pleistocene of Idaho, USA)
- *Phalacrocorax destefanii* (Late Pliocene of Italy) - formerly *Paracorax*

- *Phalacrocorax filyawi* (Pinecrest Late Pliocene of Florida, USA) - may be *P. idahensis*
- *Phalacrocorax kumeyaay* (San Diego Late Pliocene of California)
- *Phalacrocorax macer* (Late Pliocene of Idaho, USA)
- *Phalacrocorax mongoliensis* (Late Pliocene of W Mongolia)
- *Phalacrocorax rogersi* (Late Pliocene -? Early Pleistocene of California, USA)
- *Phalacrocorax kennelli* (San Diego Pliocene of California)
- *Phalacrocorax* sp. "Wildhalm" (Pliocene) - may be same as *P. longipes*
- *Phalacrocorax chapalensis* (Late Pliocene/Early Pleistocene of Jalisco, Mexico
- *Phalacrocorax gregorii* (Late Pleistocene of Australia) - possibly not a valid species
- *Phalacrocorax vetustus* (Late Pleistocene of Australia) - formerly *Australocorax*, possibly not a valid species
- *Phalacrocorax reliquus*
- *Phalacrocorax* sp. (Sarasota County, Florida) - may be *P. filawyi/idahensis*

The former *"Phalacrocorax"* (or *"Oligocorax"*) *mediterraneus* is now considered to belong to the bathornithid *Paracrax antiqua*. *"P." subvolans* was actually a darter (*Anhinga*).

Cormorant fishing

A Chinese fisherman with his two cormorants

Japanese man performing the ancient cormorant night fishing technique.

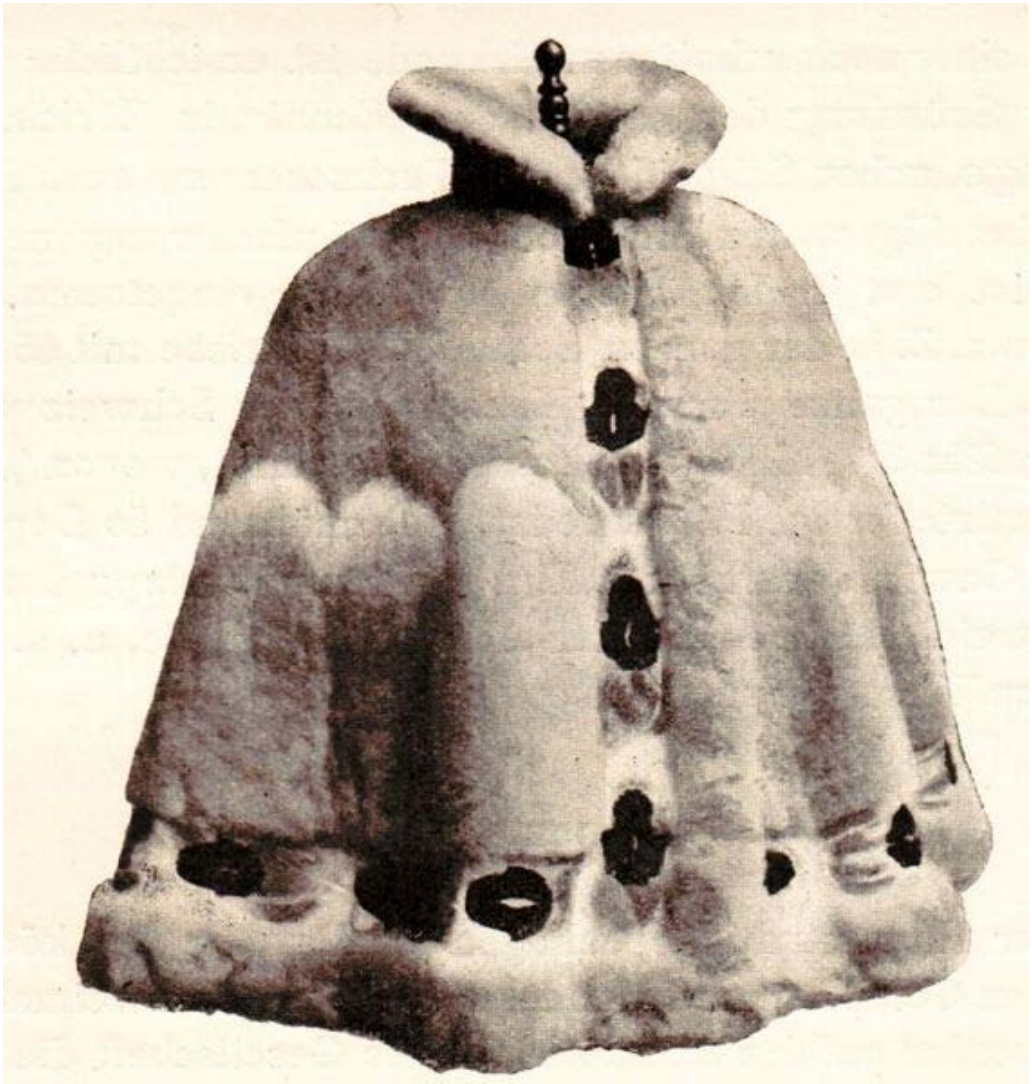
Humans have used cormorants' fishing skills, in China, Japan, and Macedonia, where they have been trained by fishermen. A snare is tied near the base of the bird's throat, which allows the bird only to swallow small fish. When the bird captures and tries to swallow a large fish, the fish is caught in the bird's throat. When the bird returns to the fisherman's raft, the fisherman helps the bird to remove the fish from its throat. The method is not as common today, since more efficient methods of catching fish have been developed.

In Japan, cormorant fishing is called *ukai* (鵜飼). Traditional forms of *ukai* can be seen on the Nagara River in the city of Gifu, Gifu Prefecture, where cormorant fishing has continued uninterrupted for 1300 years, or in the city of Inuyama, Aichi. In Guilin, China, cormorant birds are famous for fishing on the shallow Lijiang River.

In Gifu, the Japanese Cormorant (*P. capillatus*) is used; Chinese fishermen often employ Great Cormorants (*P. carbo*).

Cormorants in human culture

Moche Cormorant. Larco Museum Collection Lima, Peru.



Cormorant fur coat

- Cormorants feature quite commonly in heraldry and medieval ornamentation, usually in their "wing-drying" pose, which was seen as representing the Christian cross. For example, the Norwegian municipalities of Røst, Loppa and Skjervøy have cormorants in their coat-of-arms. The species depicted in heraldry is most likely to be the Great Cormorant, the most familiar species in Europe.
- In the first speech of Love's Labour's Lost, King Ferdinand of Navarre says: "When, spite of cormorant devouring Time,/The endeavor of this present breath may buy/That honour which shall bate his scythe's keen edge/And make us heirs of all eternity."
- In 1853, a woman wearing a dress made of cormorant feathers was found on San Nicolas Island, off the southern coast of California. She had sewn the feather dress together using whale sinews. She is known as the Lone Woman of San Nicolas and was later baptized "Juana Maria" (her original name is lost). The woman had lived alone on the island for 18 years before being rescued.
- In addition to those mentioned above, the bird has inspired numerous writers, including Amy Clampitt, who wrote a poem called "The Cormorant in its Element". Which species she was referring to is not obvious, since all members of the family share the characteristic behavioural and morphological features that the poem celebrates. The combination of "slim head [...] vermilion-strapped" and "big black feet" perhaps points at the Pelagic Cormorant, which is the only species occurring in the temperate U.S. with these features.
- The cormorant was the disguise used by Satan in Milton's Paradise Lost. The cormorant was significant as a symbol of "true Life/ Thereby regain'd," and was ironically used by Satan. Satan sat on top of the Tree of Life as a cormorant in his first attempt to deceive and tempt Eve.
- There is a cormorant portrayed in the first of the fictional paintings by Jane Eyre in Charlotte Bronte's novel, representing Blanche Ingram.
- The mythical Liver Bird symbol of Liverpool is commonly thought to be a cross between an eagle and a cormorant.