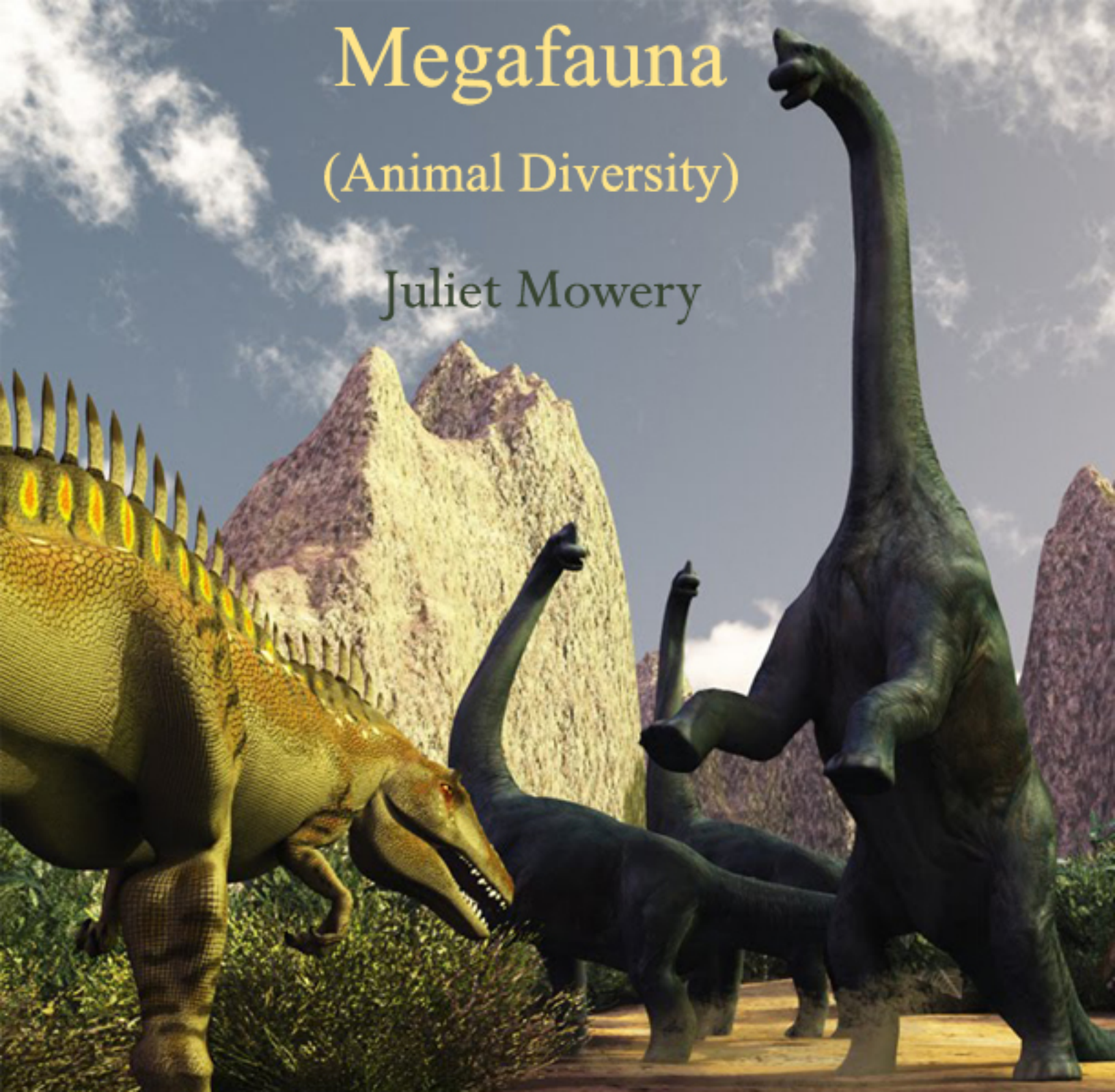
Megafauna

(Animal Diversity)

Juliet Mowery



First Edition, 2012

ISBN 978-81-323-4185-7

Published by:
White Word Publications
4735/22 Prakashdeep Bldg,
Ansari Road, Darya Ganj,
Delhi - 110002
Email: info@wtbooks.com

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Chapter 1

Megafauna

The African bush elephant, Earth's largest living land animal

In terrestrial zoology, **megafauna** are "giant", "very large" or "large" animals. Their original and most common definition is 100 lb, often rounded in the metric system to 40

or 45 kg. This thus includes many species not popularly thought of as overly large, such as white-tailed deer and red kangaroo, as well as humans.

In practice the most common usage encountered in academic and popular writing describes land animals roughly larger than a human which are not (solely) domesticated. The term is especially associated with the Pleistocene megafauna — the giant and very large land animals considered archetypical of the last ice age such as mammoths. It is also commonly used for the largest extant wild land animals, especially elephants, giraffes, hippopotamuses, rhinoceroses, elk, condors, etc. Megafauna may be subcategorized by their trophic position into megaherbivores (e.g. elk), megacarnivores (e.g. lions), and more rarely, megaomnivores (e.g. bears).

Other common uses are for giant aquatic species, especially whales, any larger wild or domesticated land animals such as larger antelope and cattle, and dinosaurs and other extinct giant reptilians.

The term is also sometimes applied to animals (usually extinct) of great size *relative to* a more common or surviving type of the animal, for example the 1 m (3 ft) dragonflies of the Carboniferous period.

Ecological strategy

Megafauna — in the sense of the largest mammals and birds — are generally K-strategists, with great longevity, slow population growth rates, low death rates, and few or no natural predators capable of killing adults. These characteristics, although not exclusive to such megafauna, make them highly vulnerable to human over-exploitation.

Mass extinctions

A well-known mass extinction of megafauna, the Holocene extinction occurred at the end of the last ice age glacial period (a.k.a. the Würm glaciation) and wiped out many giant ice age animals, such as woolly mammoths, in the Americas and northern Eurasia. Various theories have attributed the wave of extinctions to human hunting, climate change, disease, a putative extraterrestrial impact, or other causes. However, this extinction pulse near the end of the Pleistocene was just one of a series of megafaunal extinction pulses that have occurred during the last 50,000 years over much of the Earth's surface, with Africa and southern Asia being largely spared. (The latter areas did suffer a gradual attrition of megafauna, particularly of the slower-moving species, over the last several million years.) Outside of Eurasia, these megafaunal extinctions followed a distinctive landmass-by-landmass pattern that closely parallels the spread of humans into previously uninhabited regions of the world, and which shows no correlation with climate. Australia was struck first around 50,000 years ago, followed by the Solomon Islands 30,000 years ago, the Americas 13,000 years ago, Cyprus 9000 years ago, the Antilles 6000 years ago, New Caledonia 3000 years ago, Madagascar 2000 years ago, New Zealand 800 years ago, the Mascarenes 400 years ago, and the Commander Islands 250 years ago. Nearly all of the world's isolated islands could furnish examples of

extinctions occurring shortly after the arrival of *Homo sapiens*, though most of these islands, such as the Hawaiian Islands, never had terrestrial megafauna, so their extinct fauna were smaller.

Continuing human hunting and environmental disturbance has led to additional megafaunal extinctions in the recent past, and has created a serious danger of further extinctions in the near future.

A number of other mass extinctions occurred earlier in Earth's geologic history, in which some or all of the megafauna of the time also died out. Famously, in the Cretaceous–Tertiary extinction event the dinosaurs and most other giant reptilians were eliminated. However, the earlier mass extinctions were more global and not so selective for megafauna; i.e., many species of other types, including plants, marine invertebrates and plankton, went extinct as well. Thus, the earlier events must have been caused by more generalized types of disturbances to the biosphere.

Effect of megafaunal extinctions on methane emissions

Many herbivores produce methane as a byproduct of foregut fermentation in digestion, and release it through belching. Large populations of herbivore megafauna have the potential to contribute greatly to the atmospheric concentration of methane, which is an important greenhouse gas. Today, around 20% of annual methane emissions come from livestock methane release. Recent studies have indicated that the extinction of megafaunal herbivores may have caused a reduction in atmospheric methane. This hypothesis is relatively new.

Several studies have examined the effect of elimination of megaherbivorous mammals on methane emissions. One study examined the methane emissions from the bison that occupied the Great Plains of North America before contact with European settlers. The study estimated that the removal of the bison caused a decrease of 2.2 Tg/yr. This is a proportionally large change for the time period.

Another study examined the change of methane concentration in the atmosphere at the end of the Pleistocene epoch after the extinction of megafauna in the Americas. After early humans migrated to the Americas ~13,000 BP, their hunting and other associated ecological impacts led to the extinction of many megafaunal species in the region. Calculations suggest that this extinction decreased methane production by ~9.6 Tg/yr. Ice core records support this hypothesis of rapid methane decrease during the time period. This suggests that the absence of megafaunal methane emissions may have contributed to the abrupt climatic cooling at the onset of the Younger Dryas.

Examples

The following are some notable examples of animals often considered as megafauna (in the sense of the "large animal" definition). This list is not intended to be exhaustive:

class Mammalia

- infraclass Metatheria
  - order Diprotodontia
    - The red kangaroo (*Macropus rufus*) is the largest living Australian mammal and marsupial at a weight of up to 85 kg (187 lb). However, its extinct relative, the giant short-faced kangaroo *Procoptodon goliah* reached 230 kg (510 lb), while extinct diprotodonts attained the largest size of any marsupial in history, up to an estimated 2,750 kg (6,060 lb). The extinct marsupial lion (*Thylacleo carnifex*), at up to 160 kg (350 lb) was much larger than any extant carnivorous marsupial.
- infraclass Eutheria
  - superorder Afrotheria
    - order Proboscidea
      - Elephants are the largest living land animals. They and their relatives arose in Africa, but until recently had a nearly worldwide distribution. The African bush elephant (*Loxodonta africana*) has a shoulder height of up to 4.3 m (14 ft) and weighs up to 13 tons. Among recently extinct proboscideans, mammoths (*Mammuthus*) were close relatives of elephants, while mastodons (*Mammut*) were much more distantly related. The Songhua River mammoth (*M. sungari*) is estimated to have weighed 17 tonnes, making it the largest proboscid and second largest land mammal after indricotherines.

order Sirenia

- The largest sirenian at up to 1500 kg is the West Indian manatee (*Trichechus manatus*). Steller's sea cow (*Hydrodamalis gigas*) was probably around five times as massive, but unfortunately was exterminated by humans within 27 years of its discovery off the remote Commander Islands in 1741. In prehistoric times this sea cow also lived along the coasts of northeastern Asia and northwestern North America; it was apparently eliminated from these more accessible locations by aboriginal hunters.

superorder Xenarthra

- order Cingulata
  - The glyptodonts were a group of large, heavily armored ankylosaur-like xenarthrans related to living armadillos. They originated in South America, invaded North America during the Great American Interchange, and went extinct at the end of the Pleistocene epoch.
- order Pilosa

- Ground sloths were another group of slow, terrestrial xenarthrans, related to modern tree sloths. They had a similar history, although they reached North America earlier, and spread farther north. The largest genera, *Megatherium* and *Eremotherium*, reached sizes comparable to elephants.
    - superorder Euarchontoglires
        - order Primates
        - The largest living primate, at up to 266 kg (586 lb), is the gorilla (*Gorilla beringei* and *Gorilla gorilla*, with three of four subspecies being critically endangered). The extinct Malagasy sloth lemur *Archaeoindris* reached a similar size, while the extinct *Gigantopithecus blacki* of Southeast Asia is believed to have been several times larger. Some populations of archaic *Homo* were significantly larger than recent *Homo sapiens*; for example, *Homo heidelbergensis* in southern Africa may have commonly reached 7 feet in height, while Neanderthals were about 30% more massive.

order Rodentia

- The extant capybara (*Hydrochoerus hydrochaeris*) of South America, the largest living rodent, weighs up to 65 kg (140 lb). Several recently extinct North American forms were larger: the capybara *Neochoerus pinckneyi* (another neotropic migrant) was about 40% heavier; the giant beaver (*Castoroides ohioensis*) was similar. The extinct blunt-toothed giant hutia (*Amblyrhiza inundata*) of several Caribbean islands may have been larger still. However, several million years ago South America harbored much more massive rodents. *Phoberomys pattersoni*, known from a nearly full skeleton, probably reached 700 kg (1,543 lb). Fragmentary remains suggest that *Josephoartigasia monesi* grew to upwards of 1,000 kg (2,200 lb).

superorder Laurasiatheria

- order Carnivora
    - Big cats include the tiger (*Panthera tigris*) and lion (*Panthera leo*). The largest subspecies, at up to 306 kg, is the Siberian tiger (*P. tigris altaica*), in accord with Bergmann's rule. Members of *Panthera* are distinguished by morphological features which enable them to roar. Larger extinct felids include the American lion (*Panthera leo atrox*) and the South American saber-toothed cat *Smilodon populator*.

- Bears are large carnivorans of the caniform suborder. The largest living forms are the polar bear (*Ursus maritimus*), with a body weight of up to 680 kg (1,500 lb), and the similarly sized Kodiak bear (*Ursus arctos middendorffi*), again consistent with Bergmann's rule. The extinct giant short-faced bear of North America (*Arctodus simus*) was the largest fully terrestrial mammalian carnivore of the late Pleistocene, reaching

1,136 kg (2,504 lb). *Ursus maritimus tyrannus*, a very large extinct subspecies of polar bear, may have attained comparable average body weights (1200 kg or more).

- Seals, sea lions, and walruses are amphibious marine carnivorans that evolved from bearlike ancestors. The southern elephant seal (*Mirounga leonina*) of Antarctic and subantarctic waters is the largest carnivoran of all time, with bull males reaching a maximum length of 6–7 m (20–23 ft) and maximum weight of 5,000 kilograms.

- order Perissodactyla
  - Tapirs are browsing animals, with a short prehensile snout and pig-like form that appears to have changed little in 20 million years. They inhabit tropical forests of Southeast Asia and South and Central America, and include the largest surviving land animals of the latter two regions. There are four species.
  - Rhinoceroses are odd-toed ungulates with horns made of keratin, the same type of protein composing hair. They are among the largest living land mammals after elephants (hippos attain a similar size). Three of five extant species are critically endangered. Their extinct central Asian relatives the indricotherines were the largest terrestrial mammals of all time.

- order Artiodactyla (or cladistically, Cetartiodactyla)
  - Giraffes (*Giraffa camelopardalis*) are the tallest living land animals, reaching heights of up to nearly 6 m (20 ft).

- Bovine ungulates include the largest surviving land animals of Europe and North America. The water buffalo (*Bubalis arnee*), bison (*Bison bison* and *B. bonasus*), and gaur (*Bos gaurus*) can all grow to weights of over 900 kg (1,984 lb).

- The semiaquatic hippopotamus (*Hippopotamus amphibius*) is the heaviest living even-toed ungulate; it and the critically endangered pygmy hippo (*Choeropsis liberiensis*) are believed to be the closest extant relatives of cetaceans.

order Cetacea (or cladistically, Cetartiodactyla)

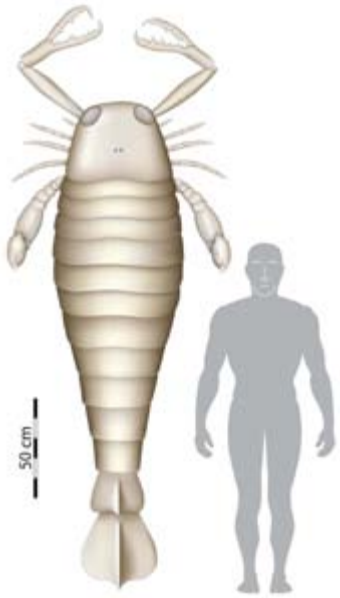
- Whales, dolphins, and porpoises are marine mammals. The blue whale (*Balaenoptera musculus*) is the largest baleen whale and the largest animal that has ever lived. The sperm whale (*Physeter macrocephalus*) is the largest toothed whale, as well as the planet's loudest and brainiest animal (with a brain about five times as massive as a human's). The killer whale (*Orcinus orca*) is the largest dolphin.

- class Aves (phylogenetically, a clade within Coelurosauria, a taxon within the order Saurischia of the clade Sauropsida; see below)
    - order Struthioniformes
        - The ratites are an ancient and diverse group of flightless birds that are found on fragments of the former supercontinent Gondwana. The largest living bird, the Ostrich (*Struthio camelus*) was surpassed by the extinct *Aepyornis* of Madagascar, the heaviest of the group, and the extinct giant moa (*Dinornis*) of New Zealand, the tallest, growing to heights of 3.4 m (11 ft). The latter two are examples of island gigantism.
    - order Anseriformes
        - Extinct dromornithids of Australia such as *Dromornis* may have exceeded the largest ratites in size. (Due to its small size for a continent and its isolation, Australia is sometimes viewed as the world's largest island; thus, these species could also be considered insular giants.)
- class Reptilia (or cladistically, Sauropsida)
    - order Crocodilia
        - Alligators and crocodiles are large semiaquatic reptiles, the largest of which, the saltwater crocodile (*Crocodylus porosus*), can grow to a weight of 1,360 kg (3,000 lb). Crocodilians' distant ancestors and their kin, the crurotarsans, dominated the world in the late Triassic, until the Triassic–Jurassic extinction event allowed dinosaurs to overtake them. They remained diverse during the later Mesozoic, when crocodyliforms such as *Deinosuchus* and *Sarcosuchus* reached lengths of 12 m. Similarly large crocodilians, such as *Mourasuchus* and *Purussaurus*, were present as recently as the Miocene in South America.
    - order Saurischia
        - Saurischian dinosaurs of the Jurassic and Cretaceous include sauropods, the longest (at up to 40 m or 130 ft) and most massive terrestrial animals known (*Argentinosaurus* reached 80–100 metric tonnes, or 90–110 tons), as well as theropods, the largest terrestrial carnivores (*Spinosaurus* grew to 7–9 tonnes).
    - order Squamata
        - While the largest extant lizard, the Komodo dragon (*Varanus komodoensis*), another island giant, can reach 3 m (10 ft) in length, its extinct Australian relative *Megalania* may have reached more than twice that size. These monitor lizards' marine relatives, the mosasaurs, were apex predators in late Cretaceous seas.
        - The heaviest extant snake is considered to be the green anaconda (*Eunectes murinus*), while the reticulated python (*Python reticulatus*), at up to 8.7 m or more, is considered the longest. An extinct Australian Pliocene species of *Liasis*, the Bluff Downs giant python, reached 10 m, while the Paleocene *Titanoboa* of

South America reached lengths of 12–15 m and an estimated weight of about 1135 kilograms (2500 lb).
    - order Testudines
        - The largest turtle is the critically endangered marine leatherback turtle (*Dermochelys coriacea*), weighing up to 900 kg (2,000 lb). It is distinguished from other sea turtles by its lack of a bony shell. The most massive terrestrial chelonians are the giant tortoises of the Galápagos Islands (*Chelonoidis nigra*) and Aldabra Atoll (*Aldabrachelys gigantea*), at up to 300 kg (660 lb). These tortoises are the biggest survivors of an assortment of giant tortoise species that were widely present on continental landmasses and additional islands during the Pleistocene.
- class Amphibia
    - order Temnospondyli
        - The Permian temnospondyl *Prionosuchus*, the largest amphibian known, reached 9 m in length and was an aquatic predator resembling a crocodilian. After the appearance of real crocodilians, temnospondyls such as *Koolasuchus* (5 m long) had retreated to the Antarctic region by the Cretaceous, before going extinct.
- class Actinopterygii
    - order Tetraodontiformes
        - The largest extant bony fish is the ocean sunfish (*Mola mola*), whose average adult weight is 1,000 kg (2,200 lb). While phylogenetically a "bony fish", its skeleton is primarily cartilage (which is lighter than bone). It has a disk-shaped body, and propels itself with its long, thin dorsal and anal fins; it feeds primarily on jellyfish. In these three respects (as well as in its size and diving habits), it resembles a leatherback turtle.
    - order Acipenseriformes
        - The critically endangered beluga (European sturgeon, *Huso huso*) at up to 1476 kg (3250 lb) is the largest sturgeon (which are also mostly cartilaginous) and is considered the largest anadromous fish.
    - order Siluriformes
        - The critically endangered Mekong giant catfish (*Pangasianodon gigas*), at up to 293 kg (646 lb), is often viewed as the largest freshwater fish.
- class Chondrichthyes
    - order Lamniformes
        - The largest living predatory fish, the great white shark (*Carcharodon carcharias*), reaches weights up to 2,240 kg (4,940 lb). Its extinct relative *C. megalodon* (the disputed genus being either *Carcharodon* or *Carcharocles*) was more than an order of magnitude larger, and is the largest predatory shark or fish of all time; it preyed on whales and other marine mammals.
    - order Orectolobiformes

        - The largest extant shark, cartilaginous fish, and fish overall is the whale shark (*Rhincodon typus*), which reaches weights in excess of 21.5 tonnes (47,000 lb). Like baleen whales, it is a filter feeder and primarily consumes plankton.
    - order Rajiformes
        - The manta ray (*Manta birostris*) is another filter feeder and the largest ray, growing to up to 2300 kg.
- class Cephalopoda
    - order Teuthida
        - A number of deep ocean creatures exhibit abyssal gigantism. These include the giant squid (*Architeuthis*) and colossal squid (*Mesonychoteuthis hamiltoni*); both (although rarely seen) are believed to attain lengths of 12 m (39 ft) or more. The latter is the world's largest invertebrate, and has the largest eyes of any animal. Both are preyed upon by sperm whales.

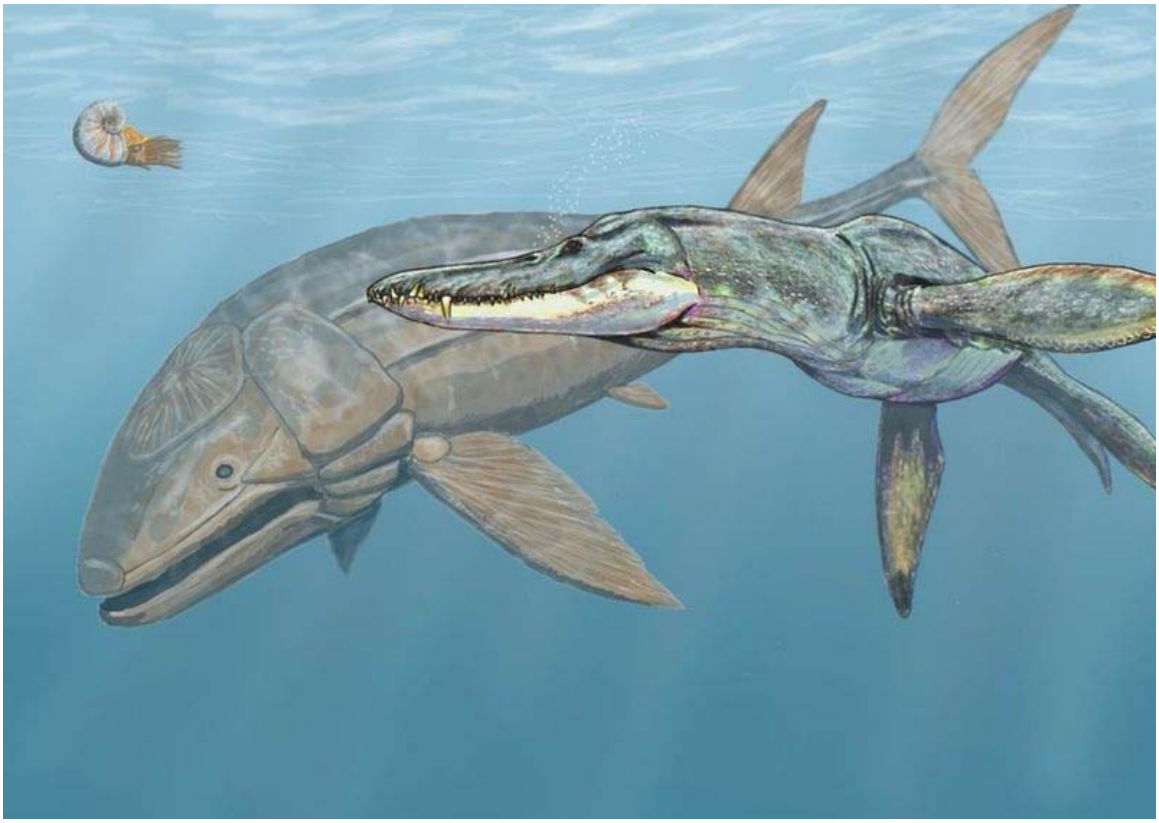
Extinct



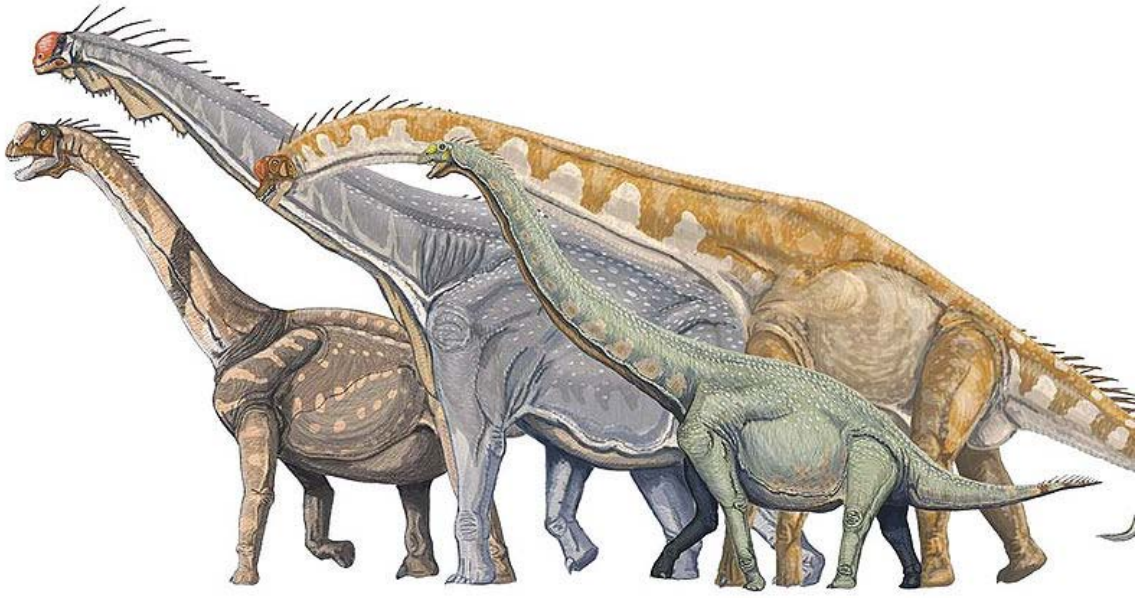
Jaekelopterus was a Devonian sea scorpion and likely an ambush predator.

Dunkleosteus was a gigantic, 10 m (33 ft) long predatory Devonian placoderm fish.

Sail-backed pelycosaur *Dimetrodon* and temnospondyl *Eryops* from North America's Permian.



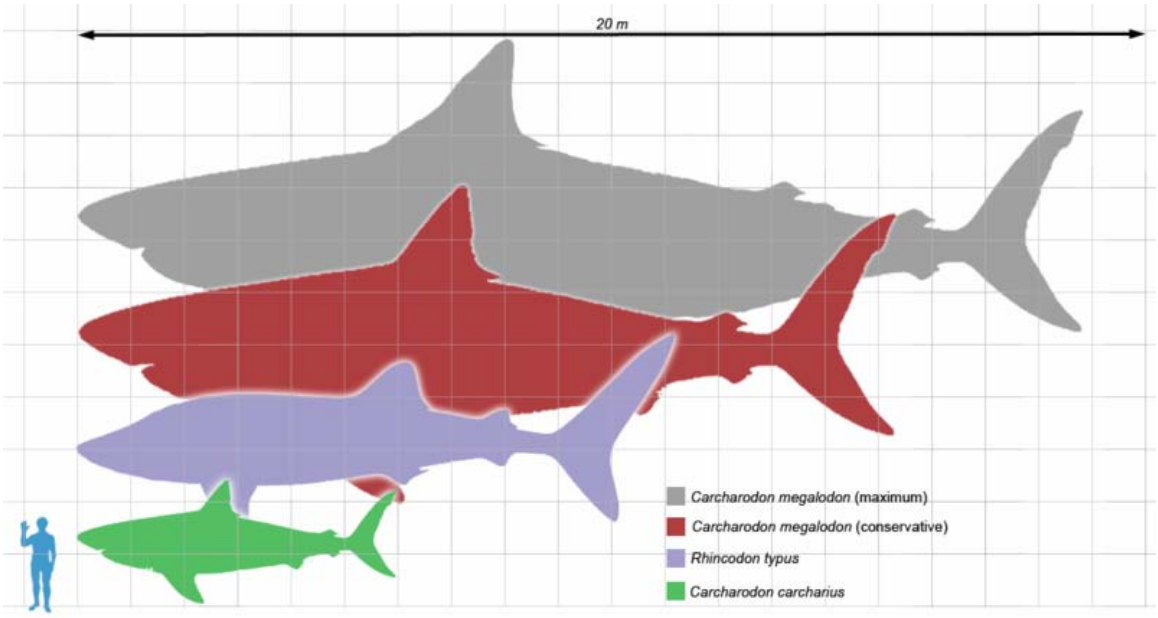
Pliosaur *Liopleurodon* (right) harassing the filter feeder fish *Leedsichthys* during the Jurassic.



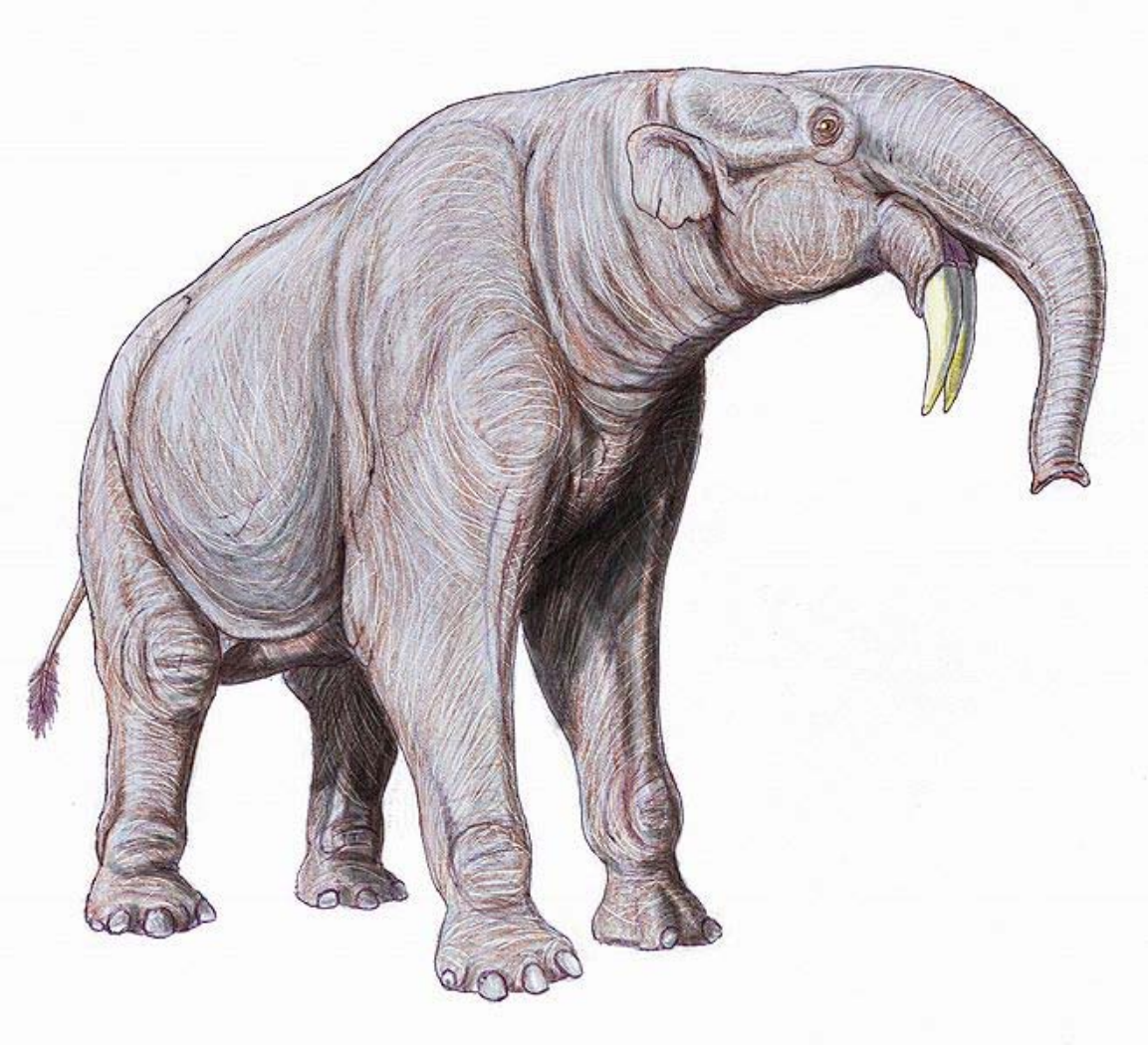
Macronarian sauropods; from left, *Camarasaurus*, *Brachiosaurus*, *Giraffatitan*, *Euhelopus*.

Indricotheres, the land mammals closest to sauropods in size and lifestyle, were rhinos.

The Late Miocene teratorn *Argentavis* of South America had an 8 m (26 ft) wingspan.

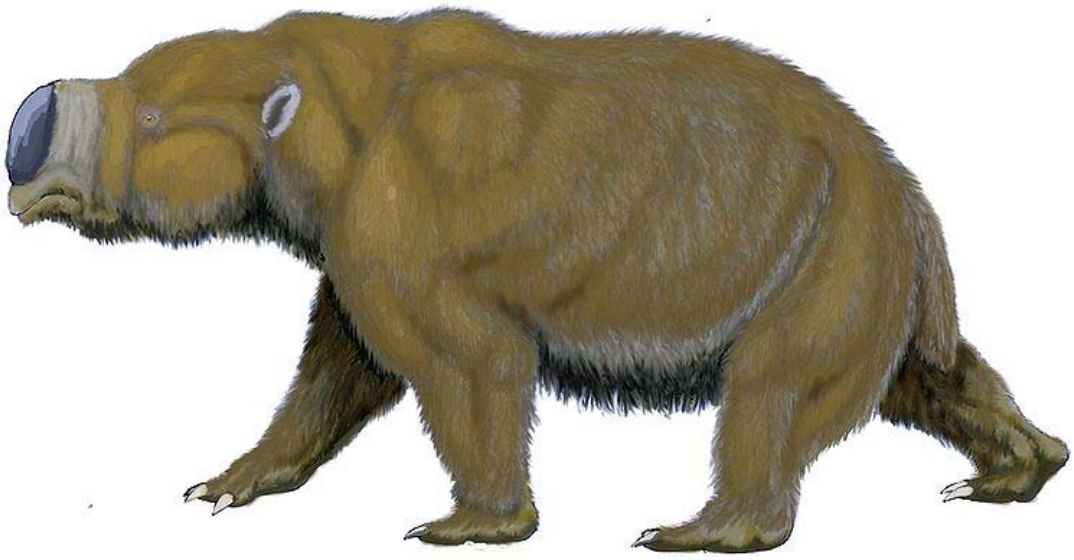


C. megalodon with a whale shark, great white shark and a human for scale.



Deinotherium had downward-curving tusks and ranged widely over Afro-Eurasia.

Titanis walleri, the most recent terror bird and the only one known to have invaded North America.



Hippo-sized *Diprotodon* of Australia, the largest marsupial of all time, went extinct 40,000 years ago.

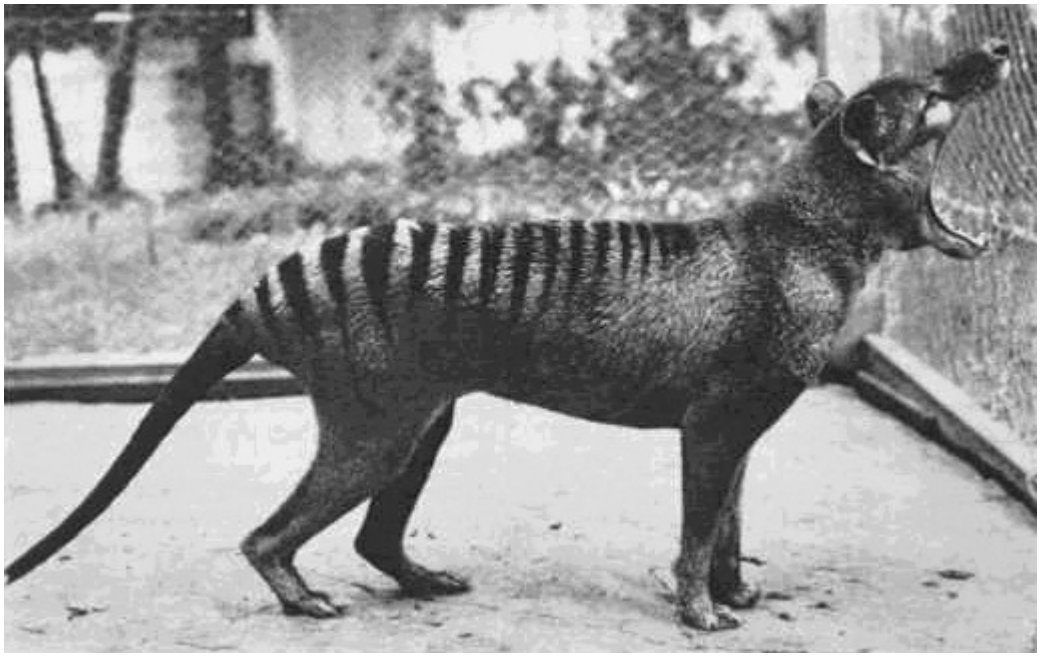
Elephant-sized *Megatherium*, from South America's Pleistocene, was the largest sloth.

Toxodon, one of South America's largest and last notoungulates. It had a relative in Mexico.

American lions exceeded extant lions in size and ranged over two continents until 10,000 BP.

Woolly mammoths vanished shortly after *Homo sapiens* invaded their habitat.

Haast's Eagle, the largest eagle known, attacking moa (which included the tallest bird known).

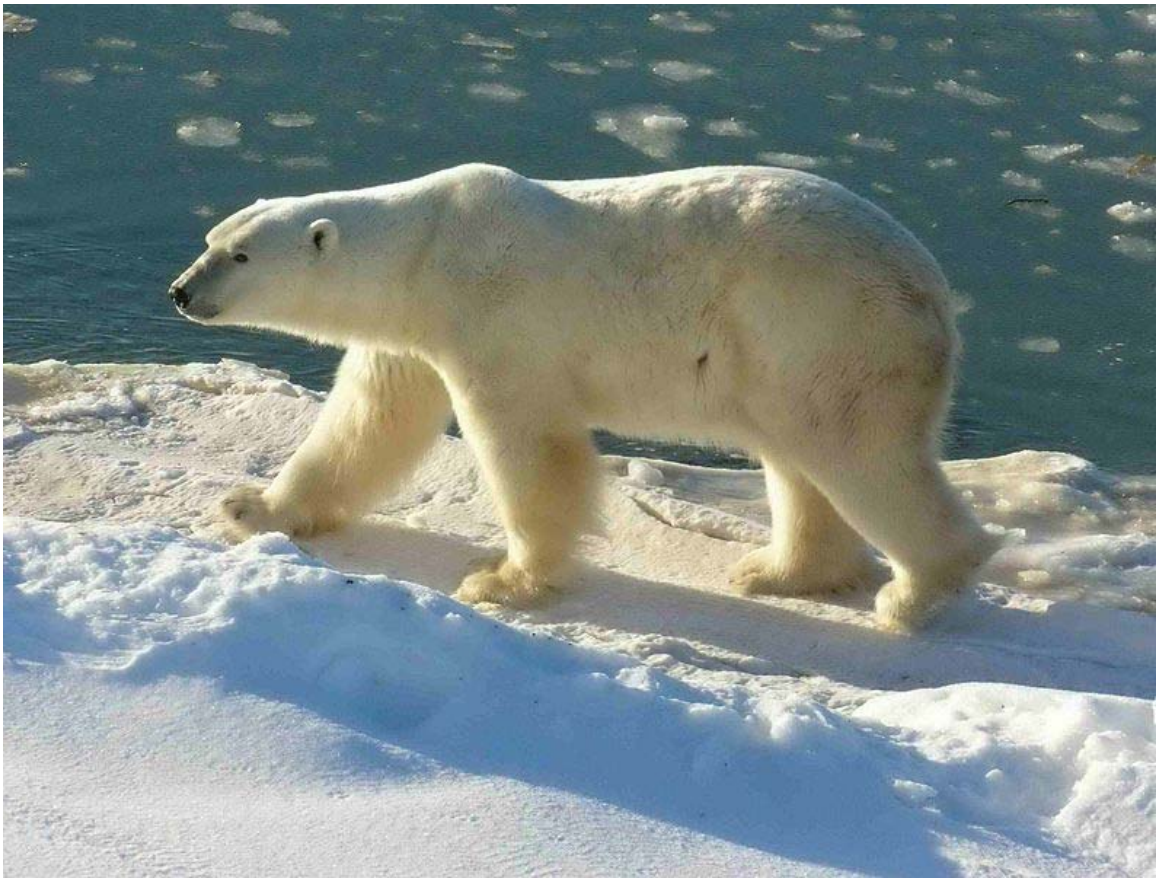


The Tasmanian thylacine was the largest carnivorous marsupial of modern times.

Living

The gorilla is the largest and one of the most endangered primates on the planet.

Siberian tigers are the biggest living cats, exemplifying Bergmann's rule.



Polar bears, the largest bears and semi-aquatic carnivores, are vulnerable to global warming.

The critically endangered black rhinoceros, up to 14 feet long, is threatened by poaching.

Wild Bactrian camels are critically endangered. Their ancestors originated in North America.

Unlike woolly rhinos and mammoths, muskoxen narrowly survived the Holocene extinction.

Hippos, the heaviest and most aquatic even-toed ungulates, are whales' closest living relatives.

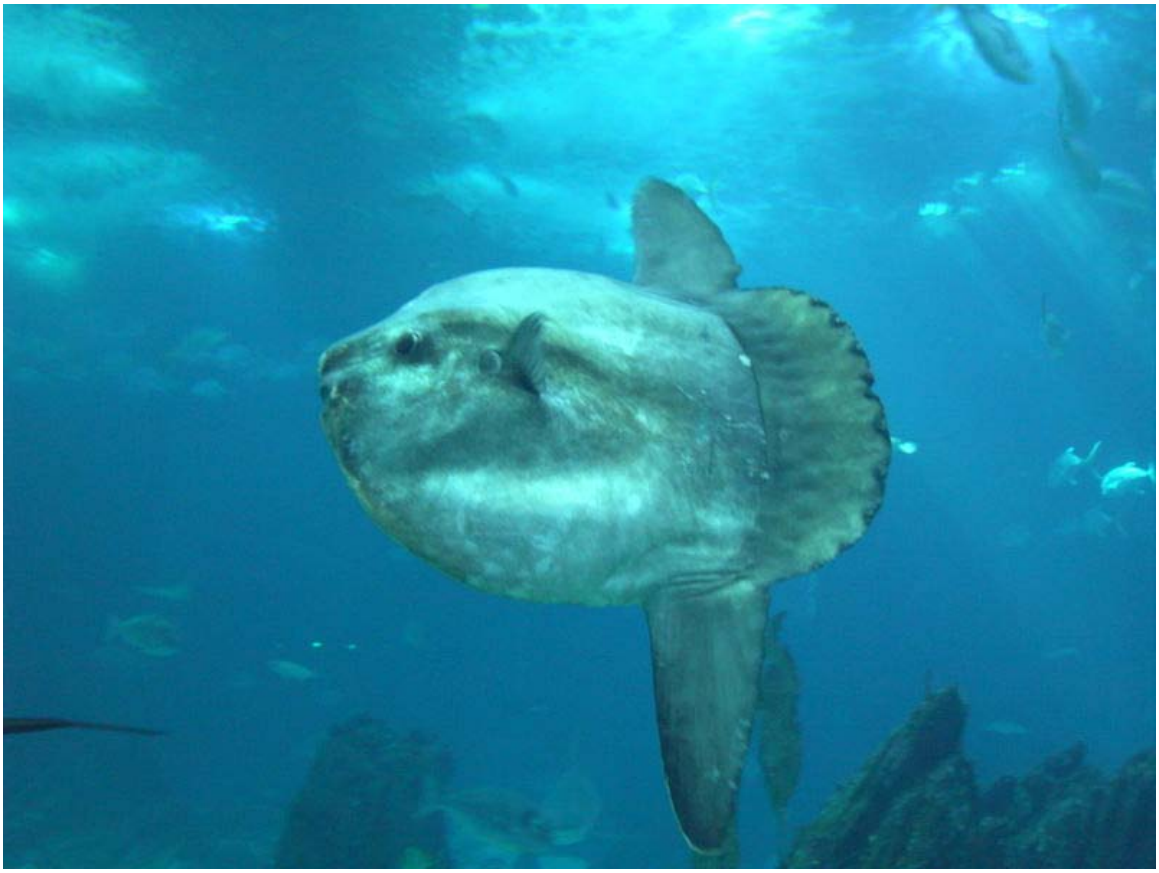
The orca, the largest dolphin and pack predator, is highly intelligent and lives in complex societies.

The Ostrich is the largest ratite, the heaviest living bird, and, at 70 km/h, the fastest running bird.

The saltwater crocodile is the largest living reptile and a dangerous predator of humans.

The Komodo dragon, an insular giant, is the largest lizard and has infectious and venomous saliva.

The green anaconda, an aquatic constrictor, is the heaviest snake, weighing up to 97.5 kg (215 lb).



The deep-diving ocean sunfish is the largest bony fish, but its skeleton is mostly cartilaginous.

The manta ray, a filter feeder, is the largest ray at up to 7.6 m across, yet can breach clear of the water.

The Nile perch is one of the largest freshwater fish, as well as a damaging invasive species.

The giant squid is an abyssal giant and the second largest cephalopod.

Chapter 2

Basking Shark

Basking shark
Temporal range: Early Oligocene–Present

Conservation status

Vulnerable (IUCN 3.1)

Scientific classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Chondrichthyes
Subclass:	Elasmobranchii
Order:	Lamniformes
Family:	**Cetorhinidae** Gill, 1862

Genus: ***Cetorhinus*** Blainville, 1816

Species: ***C. maximus***

Binomial name

Cetorhinus maximus
(Gunnerus, 1765)

Range of the basking shark

Synonyms

Cetorhinus blainvillei Capello, 1869
Cetorhinus maximus infanuncula Deinse & Adriani, 1953
Cetorhinus normani Siccardi, 1961
Hannovera aurata van Beneden, 1871
*Halsydrus pontoppidiani** Neill, 1809
Polyprosopus macer Couch, 1862
*Scoliophis atlanticus** Anonymous, 1817
Selachus pennantii Cornish, 1885
*Squalis gunneri** Blainville, 1816
*Squalis shavianus** Blainville, 1816
Squalus cetaceus Gronow, 1854
Squalus elephas Lesueur, 1822
Squalus gunnerianus Blainville, 1810
Squalus homianus Blainville, 1810
Squalus isodus Macri, 1819
Squalus maximus Gunnerus, 1765
Squalus pelegrinus Blainville, 1810
Squalus rashleighanus Couch, 1838
*Squalus rhinoceros** DeKay, 1842
Squalus rostratus Macri, 1819
*Tetraoras angiova** Rafinesque, 1810
*Tetroras angiova** Rafinesque, 1810
Tetroras maccoyi Barrett, 1933

* ambiguous synonym

The **basking shark** (*Cetorhinus maximus*) is the second largest living shark, after the whale shark. It is a cosmopolitan species, found in all the world's temperate oceans. It is a slow moving and generally harmless filter feeder.

Taxonomy

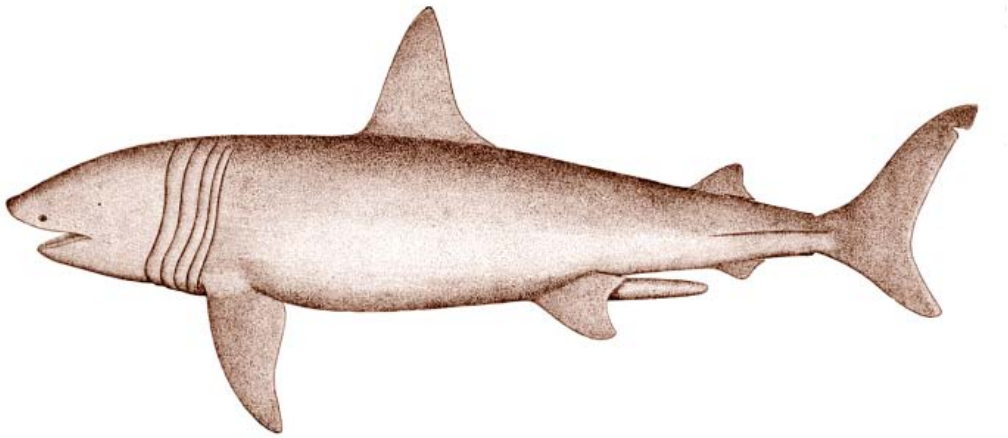
This shark is called the *basking* shark because it is most often observed when feeding at the surface and appears to be basking in the warmer water there. It is the only member of the family Cetorhinidae, part of the mackerel shark order Lamniformes. Gunnerus was the first to describe and name the species *Cetorhinus maximus* from a specimen found in Norway. The genus name *Cetorhinus* comes from the Greek, *ketos* which means marine monster or whale and *rhinos* meaning nose, the species name *maximus* is from Latin and means "greatest". The following centuries featured more attempts at naming: *Squalus isodus*, in 1819 by Macri; *Squalus elephas*, by Lesueur in 1822; *Squalus rashleighanus*, by Couch in 1838; *Squalus cetaceus*, by Gronow in 1854; *Cetorhinus blainvillei* by Capello in 1869; *Selachus pennantii*, by Cornish in 1885; *Cetorhinus maximus infanuncula*, by Deinse & Adriani 1953; and finally *Cetorhinus maximus normani*, by Siccardi 1961.

Range and habitat

The basking shark is a coastal-pelagic shark found worldwide in boreal to warm-temperate waters around the continental shelves. It prefers 8 to 14.5 °C (46 to 58 °F) temperatures, but recently has been confirmed to cross the much-warmer waters at the equator. It is often seen close to land, including bays with narrow openings. The shark follows plankton concentrations in the water column and is therefore often visible at the surface. They characteristically migrate with the seasons. The basking shark is found from the surface down to at least 910 metres (2,990 ft).

Anatomy and appearance

The largest accurately-measured specimen was trapped in a herring net in the Bay of Fundy, Canada in 1851. Its total length was 12.27 metres (40.3 ft), and it weighed an estimated 19 short tons (17 t). There are dubious reports from Norway of three basking sharks over 12 metres (39 ft), the largest at 13.7 metres (45 ft), dubious because few anywhere near that size have been caught in the area since. Normally the basking shark reaches a length of between 6 metres (20 ft) and a little over 8 metres (26 ft). Some specimens surpass 9–10 metres (30–33 ft), but after years of large-scale fishing, specimens of this size have become rare.



Male basking shark

They possess the typical shark lamniform body plan and have been mistaken for great white sharks. The two species can be easily distinguished, however, by the basking shark's cavernous jaw, up to 1 metre (3 ft 3 in) in width, longer and more obvious gill slits that nearly encircle the head and are accompanied by well-developed gill rakers, smaller eyes, and smaller average girth. Great whites possess large, dagger-like teeth, basking shark teeth are much smaller 5–6 millimetres (0.20–0.24 in) and hooked; only the first 3 or 4 rows of the upper jaw and 6 or 7 rows of the lower jaw function. There are also several behavioral differences between the two.

Other distinctive characteristics include a strongly keeled caudal peduncle, highly textured skin covered in placoid scales and a mucus layer, a pointed snout—distinctly hooked in younger specimens—and a lunate caudal fin. In large individuals the dorsal fin may flop to one side when above the surface. Coloration is highly variable (and likely dependent on observation conditions and the individual's condition: commonly, the coloring is dark brown to black or blue dorsally fading to a dull white ventrally. The sharks are often noticeably scarred, possibly through encounters with lampreys or cookiecutter sharks. The basking shark's liver, which may account for 25% of its body weight, runs the entire length of the abdominal cavity and is thought to play a role in buoyancy regulation and long-term energy storage.

Life history

Head of a basking shark

Studies in 2003 proved that basking sharks do not hibernate, showing that they are active year-round. In winter, basking sharks move to depths of up to 900 metres (3,000 ft) to feed on deep water plankton.

Migration

Satellite tagging confirms that basking sharks move thousands of kilometres during the winter months, seeking plankton blooms. It also found that basking sharks shed and renew their gill rakers in an ongoing process, rather than over one short period.

A 2009 study tagged 25 sharks off the coast of Cape Cod, Massachusetts, and indicated that at least some individuals migrate south in the winter. Remaining at depths between 200 metres (660 ft) and 1,000 metres (3,300 ft) for many weeks, the tagged sharks crossed the equator to reach Brazil. One individual spent a month near the mouth of the Amazon River. It is unknown why they undertake this journey. Lead author Gregory Skomal of the Massachusetts Division of Marine Fisheries, suspects it may be related to reproduction.

They are slow-moving sharks (feeding at about 2 knots (3.7 km/h; 2.3 mph) and do not evade approaching boats (unlike great white sharks). They are harmless to humans if left alone and are not attracted to chum.

Even though the basking shark is large and slow, it can breach, jumping entirely out of the water. This behavior could be an attempt to dislodge parasites or commensals.

Interactions

A basking shark filter feeding.

Basking sharks are social animals and form sex-segregated schools, usually in small numbers (3 or 4) but reportedly up to 100 individuals. Their social behavior is thought to follow visual cues. Although the basking shark's eyes are small, they are fully developed. They may visually inspect boats, possibly mistaking them for conspecifics. Females are thought to seek shallow water to give birth.

Predators

While basking sharks have few if any predators, white sharks have been reported to scavenge on the remains of these sharks. Observers have long suspected that killer

whales, also known as orcas, actively pursue and feed on basking sharks; yet, this is based upon the account of only one person, a West Cornwall fisherman who claims to have witnessed a frenzied attack by a killer whale on a large basking shark off Porthcurno more than 50 years ago.

Lampreys are often seen attached to them, although it is unlikely that they are able to cut through the shark's thick skin.

Diet

Basking Shark filter feeding at Dursey Sound

The basking shark is a passive filter feeder, filtering zooplankton, small fish and invertebrates from up to 2,000 short tons (1,800 t) of water per hour. They feed at or close to the surface with their mouths wide open and gill rakers erect. Unlike the megamouth shark and whale shark, the basking shark does not appear to actively seek quarry, but it does possess large olfactory bulbs that may guide it. It relies only on the water that it pushes through its gills by swimming; the megamouth shark and whale shark can suck or pump water through their gills.

Reproduction

Basking sharks are ovoviviparous: the developing embryos first rely on a yolk sac, and there is no placental connection. Their seemingly useless teeth may play a role before

birth in helping them feed on the mother's unfertilized ova (a behaviour known as oophagy).

In females, only the right ovary appears to function.

Gestation is thought to span over a year (perhaps 2 or 3 years), with a small though unknown number of young born fully developed at 1.5–2 metres (4 ft 10 in–6 ft 7 in). Only one pregnant female is known to have been caught; she was carrying 6 unborn young. Mating is thought to occur in early summer and birthing in late summer, following the female's movement into shallow waters.

The age of maturity is not known but is thought to be between the ages of 6 and 13 and at a length of 4.6–6 metres (15–20 ft). Breeding frequency is also unknown, but is thought to be 2 to 4 years.

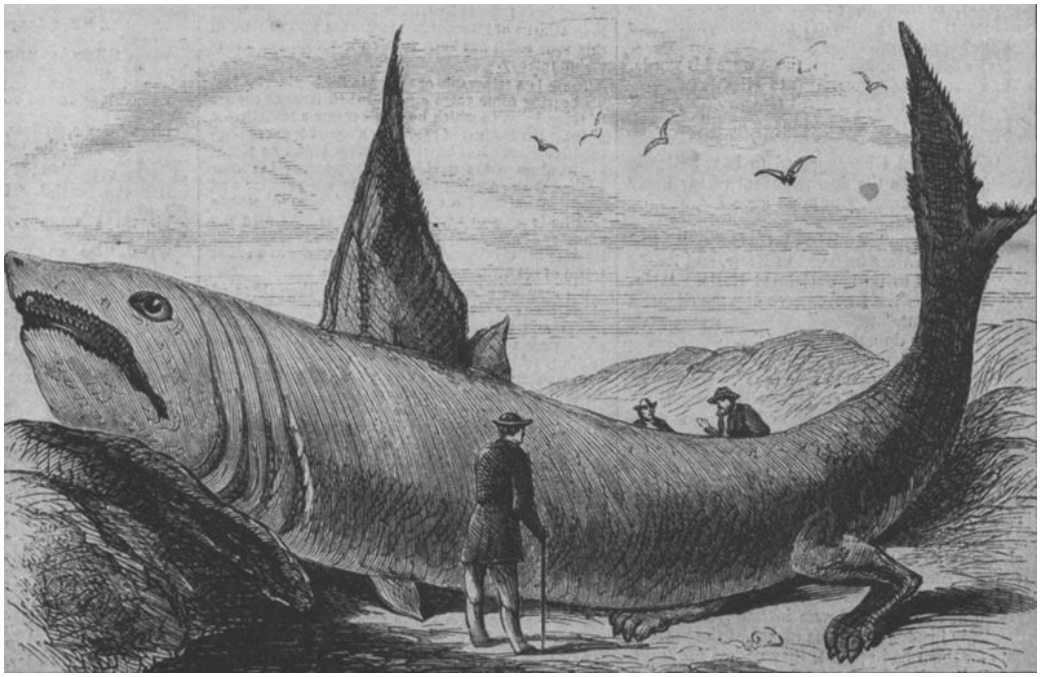
Importance to humans

Historically, the basking shark has been a staple of fisheries because of its slow swimming speed, unaggressive nature and previously abundant numbers. Commercially it was put to many uses: the flesh for food and fishmeal, the hide for leather, and its large liver (which has a high squalene content) for oil. It is currently fished mainly for its fins (for shark fin soup). Parts (such as cartilage) are also used in traditional Chinese medicine and as an aphrodisiac in Japan, further adding to demand.

As a result of rapidly declining numbers, the basking shark has been protected and trade in its products restricted in many countries. It is fully protected in the UK, Ireland, Malta, Florida and US Gulf and Atlantic waters. Targeted fishing for basking sharks is illegal in New Zealand. Once considered a nuisance along the Canadian Pacific coast, basking sharks were the target of a government eradication program there from 1945 to 1970. As of 2008, efforts are underway to determine if any sharks still live in the area and monitor their potential recovery.

It is tolerant of boats and divers approaching it and may even circle divers, making it an important draw for dive tourism in areas where it is common.

Basking sharks and cryptozoology



The "wonderful fish" described in *Harper's Weekly* on October 24, 1868, was likely the remains of a basking shark.

On several occasions, "globster" corpses initially thought to be sea serpents or plesiosaurs have later been identified as likely to be the decomposing carcasses of basking sharks, as in the Stronsay beast and the *Zuiyo Maru* cases.

Chapter 3

Beluga Whale

Beluga

Size compared to an average human

Conservation status

Near Threatened (IUCN 3.1)

Scientific classification [e]

Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Order:	Cetacea
Family:	Monodontidae
Genus:	***Delphinapterus***
Species:	***D. leucas***

Binomial name

Delphinapterus leucas
(Pallas, 1776)

Beluga range

The **beluga** or **white whale**, ***Delphinapterus leucas***, is an Arctic and sub-Arctic species of cetacean. It is one of two members of the family Monodontidae, along with the narwhal. This marine mammal is commonly referred to simply as the **beluga** or **sea canary** due to its high-pitched twitter. It is up to 5 m (16 ft) in length and an unmistakable all-white color with a distinctive protuberance on the head. From a conservation perspective, the beluga is considered "near threatened" by the International Union for Conservation of Nature; however the subpopulation from the Cook Inlet in Alaska is considered critically endangered and is under the protection of the United States' Endangered Species Act. Of seven Canadian beluga populations, two are listed as endangered, inhabiting eastern Hudson Bay, and Ungava Bay.

Taxonomy

In 1776 Peter Simon Pallas first described the beluga. It is a member of the Monodontidae family, which is in turn part of the toothed whale suborder. The Irrawaddy dolphin was once placed in the same family; however, recent genetic evidence suggests otherwise. The narwhal is the only other species within the Monodontidae family besides the beluga.

The Red List of Threatened Species gives both beluga and white whale as common names, though the former is now more popular. The English name comes from the Russian белуга (*beluga*) or белуха (*belukha*), which derives from the word белый (*belyy*), meaning "white". It is sometimes referred to by scientists as the belukha whale in order to avoid confusion with the beluga sturgeon.

The whale is also colloquially known as the Sea Canary on account of its high-pitched squeaks, squeals, clucks and whistles. A Japanese researcher says he taught a beluga to "talk" by using these sounds to identify three different objects, offering hope that humans may one day be able to communicate effectively with sea mammals.

Description

A beluga in the shallow waters of the Vancouver Aquarium

Male belugas are larger than females. Males can reach 5.5 metres (18 ft) long, while females grow to 4.1 metres (13 ft). Males weigh between 1,100 and 1,600 kilograms (2,400 and 3,500 lb) while females weigh between 700 and 1,200 kilograms (1,500 and 2,600 lb). This is larger than most dolphins, but is smaller than most other toothed whales.

The adult beluga is rarely mistaken for another species, because it is completely white or whitish-gray in color. Calves, however, are usually gray. Its head is unlike that of any other cetacean. Like most toothed whales it has a melon—an oily, fatty tissue lump found at the center of the forehead. The beluga's melon is extremely bulbous and even malleable. The beluga is able to change the shape of its head by blowing air around its sinuses. Unlike many dolphins and whales, the vertebrae in the neck are not fused together, allowing the animal to turn its head laterally. The rostrum has about 8 to 10 teeth on each side of the jaw and a total of 34 to 40 teeth.

Belugas have a dorsal ridge, rather than a dorsal fin. The absence of the dorsal fin is reflected in the genus name of the species—*apterus* the Greek word for "wingless." The evolutionary preference for a dorsal ridge rather than a fin is believed to be an adaptation to under-ice conditions, or possibly as a way of preserving heat. As in other cetaceans,

the thyroid gland is relatively large compared to terrestrial mammals (proportionally three times as large as a horse's thyroid) and may help to sustain higher metabolism during the summer estuarine occupations.

Its body is round, particularly when well-fed, and tapers less smoothly to the head than the tail. The sudden tapering to the base of its neck gives it the appearance of shoulders, unique among cetaceans. The tail fin grows and becomes increasingly and ornately curved as the animal ages. The flippers are broad and short—making them almost square-shaped.

Range and habitat

Beluga at the mouth of Churchill River into Hudson Bay, Canada

The beluga inhabits a discontinuous circumpolar distribution in Arctic and sub-Arctic waters ranging from 50° N to 80° N, particularly along the coasts of Alaska, Canada, Greenland, and Russia. The southernmost extent of their range includes isolated populations in the St. Lawrence River estuary and the Saguenay fjord, around the village of Tadoussac, Quebec, in the Atlantic and the Amur River delta, the Shantar Islands and the waters surrounding Sakhalin Island in the Sea of Okhotsk.

In the spring, the beluga moves to its summer grounds: bays, estuaries and other shallow inlets. These summer sites are discontinuous. A mother usually returns to the same site

year after year. As its summer homes clog with ice during autumn, the beluga moves away for winter. Most travel in the direction of the advancing icepack and stay close its edge for the winter months. Others stay under the icepack—surviving by finding ice leads and polynyas (patches of open water in the ice) in which they can surface to breathe. Beluga may also find air pockets trapped under the ice. The beluga's ability to find the thin slivers of open water within a dense ice pack that may cover more than 96% of the surface mystifies scientists. Its echo-location capabilities are highly adapted to the sub-ice sea's peculiar acoustics and it has been suggested that belugas can sense open water through echo-location.

In 1849, while constructing the first railroad between Rutland and Burlington in Vermont, workers unearthed the bones of a mysterious animal in the town of Charlotte. Buried nearly 10 feet (3.0 m) below the surface in a thick blue clay, these bones were unlike those of any animal previously discovered in Vermont. Experts identified the bones as those of a beluga. Because Charlotte is over 150 miles (241 km) from the nearest ocean, early naturalists were at a loss to explain the bones of a marine mammal buried beneath the fields of rural Vermont. Today, the Charlotte whale aids in the study of the geology and the history of the Champlain Basin, and this fossil is now the official Vermont State Fossil (making Vermont the only state whose official fossil is that of a still extant animal).

On June 9, 2006, a young beluga carcass was found in the Tanana River near Fairbanks in central Alaska, nearly 1,700 kilometers (1,056 mi) from the nearest ocean habitat. Belugas sometimes follow migrating fish, leading Alaska state biologist Tom Seaton to speculate that it had followed migrating salmon up the river at some point in the prior fall.

Life history

Pod of belugas swimming

Belugas are highly sociable. Groups of males may number in the hundreds, while mothers with calves generally mix in slightly smaller groups. When pods aggregate in

estuaries, they may number in the thousands. This can represent a significant proportion of the entire population and is when they are most vulnerable to hunting.

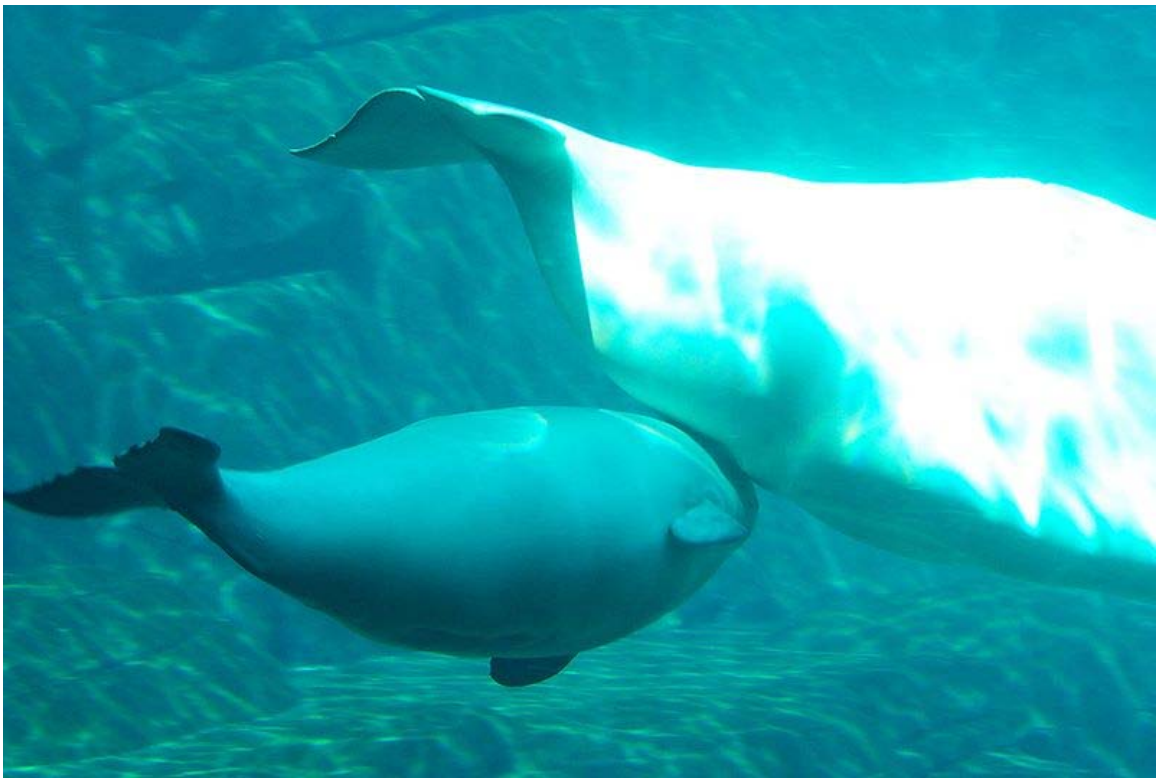
Pods tend to be unstable, meaning that they tend to move from pod to pod. Radio tracking has shown that belugas can start out in a pod and within a few days be hundreds of miles away from that pod. Mothers and calves form the beluga's closest social relationship. Nursing times of two years have been observed and lactational anestrus may not occur. Calves often return to the same estuary as their mother in the summer, meeting her sometimes even after becoming fully mature.

Belugas can be playful—they may spit at humans or other whales. It is not unusual for an aquarium handler to be drenched by one of his charges. Some researchers believe that spitting originated with blowing sand away from crustaceans at the sea bottom.

Unlike most whales, it is capable of swimming backwards.

Males reach sexual maturity between four and seven years, while females mature at between six and nine years. The beluga can live more than 50 years.

Reproduction



Female and calf

Female belugas typically give birth to one calf every three years. Most mating occurs between February and May, but some mating occurs at other times of year. It is questionable whether the beluga has delayed implantation. Gestation last 12 to 14.5 months.

Calves are born over a protracted period that varies by location. In the Canadian Arctic, calves are born between March and September, while in Hudson Bay the peak calving period is in late June and in Cumberland Sound most calves are born from late July to early August.

Newborns are about 1.5 metres (4.9 ft) long, weigh about 80 kilograms (180 lb), and are grey in color. The calves remain dependent on their mothers for at least two years.

Ecology

Feeding

The beluga is a slow swimmer that feeds mainly on fish. It also eats cephalopods (squid and octopus) and crustaceans (crab and shrimp). Foraging on the seabed typically takes place at depths of up to 1,000 feet (300 m) but they can dive at least twice this depth. A typical feeding dive lasts 3–5 minutes, but belugas submerge for up to 20 minutes at a time.

Predation

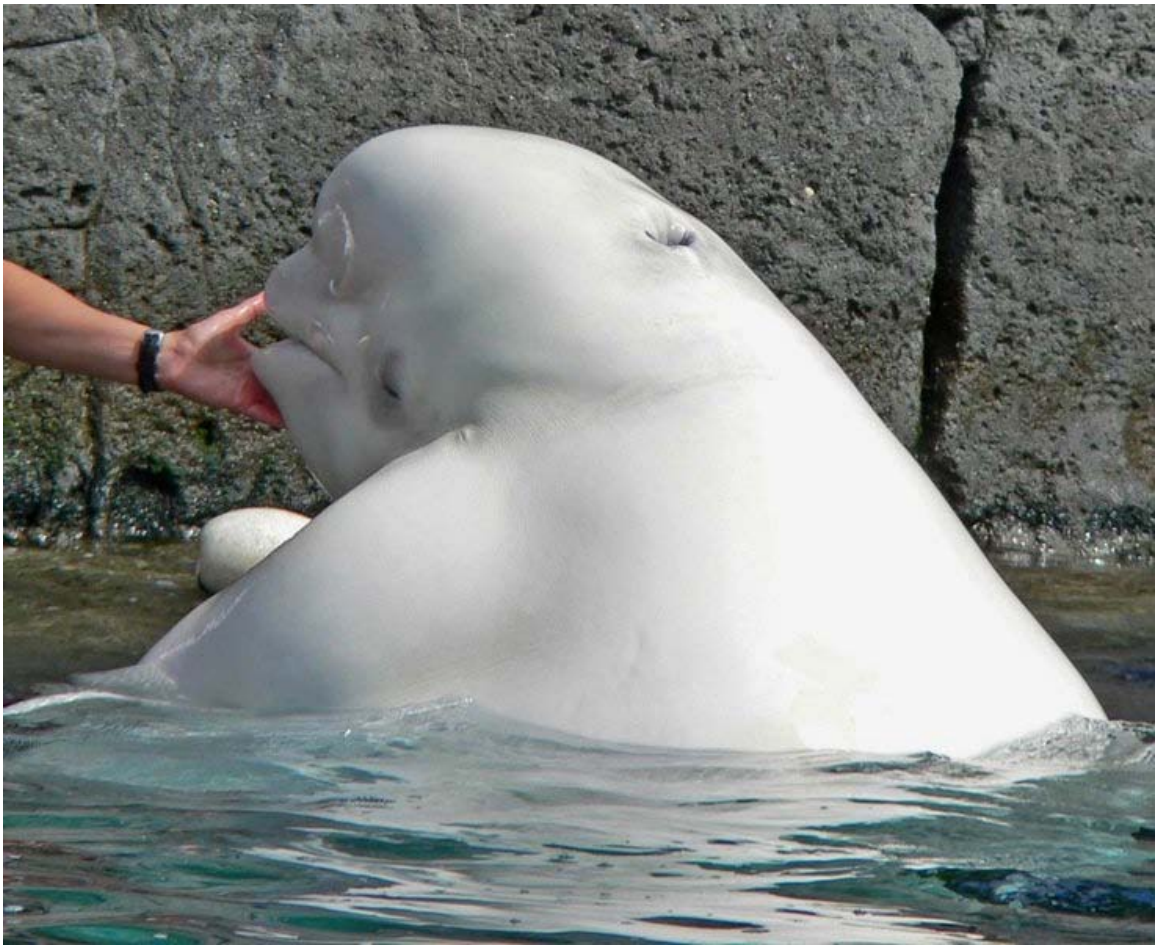
Polar bears take particular advantage of situations when belugas become trapped by ice and are thus unable to reach the ocean. The bears swipe at the belugas and drag them onto the ice. The orca is its other significant natural predator.

Relation to humans

Belugas were among the first whale species in captivity. The first beluga was shown at Barnum's Museum in New York City in 1861. Today it remains one of the few whale species kept at aquaria and sea life parks across North America, Europe, and Asia. Its popularity there with visitors reflects its attractive color, and its range of facial expressions. While most cetacean "smiles" are fixed, the extra movement afforded by the beluga's unfused cervical vertebrae allows a greater range of apparent expression. Most belugas found in aquariums are caught in the wild, though captive breeding programs enjoy some success.

Both the United States Navy and the Russian Navy have used belugas in anti-mining operations in Arctic waters. In one instance, a captive beluga helped bring a distressed diver who was performing a stunt in his pool up to the surface, possibly saving the diver's life. Another time, a captive beluga brought a cramp-paralized diver from the bottom of the pool up to the surface by holding her foot in its mouth, certainly saving the female diver's life.

Population and threats



A beluga whale in an aquarium with a trainer

The global population of belugas today stands at about 100,000. Although this number is much greater than that of many other cetaceans, it is much smaller than pre-hunting populations. There are estimated to be 40,000 individuals in the Beaufort Sea, 25,045 in Hudson Bay, 18,500 in the Bering Sea, and 28,008 in the Canadian Low Arctic. The population in the St. Lawrence estuary is estimated to be around 1,000. It is considered an excellent sentinel species (indicator of environment health and changes). This is because it is long-lived, on top of the food web, bearing large amounts of fat and blubber, relatively well-studied for a cetacean, and still somewhat common.

Because the beluga congregates in river estuaries, pollution is proving to be a significant health danger. Incidents of cancer have been reported to be rising as a result of St. Lawrence River pollution. Local beluga carcasses contain so many contaminants that they are treated as toxic waste. Reproductive pathology has been discovered here, possibly caused by organochlorines. Levels between 240 ppm and 800 ppm of PCBs have been found, with males typically having higher levels. The long-term effects of this pollution on the affected populations is not known.

A beluga resurfaces

Indirect human disturbance may also be a threat. While some populations tolerate small boats, others actively try to avoid ships. Whale-watching has become a booming activity in the St. Lawrence and Churchill River areas.

Because of its predictable migration pattern and high concentrations, the beluga has been hunted by indigenous Arctic peoples for centuries. In many areas, hunting continues, and is believed to be sustainable. However, in other areas, such as the Cook Inlet, Ungava Bay, and off western Greenland, previous commercial operations left the populations in great peril. Indigenous whaling continues in these areas, and some populations continue to decline. These areas are the subject of intensive dialogue between Inuit communities and national governments aiming to create a sustainable hunt.

Pathogens

Papillomaviruses have been found in the gastric compartments of belugas in the St. Lawerence River. Herpesvirus as well has been detected on occasion in belugas. Encephalitis has sometimes been observed and the protozoa *Sarcocystis* can infect the animals. Ciliates have been observed to colonize the blowhole yet may not be pathogenic or especially harmful.

Erysipelothrix rhusiopathiae bacilli, likely from contaminated fish in the diet, can endanger captive belugas, causing anorexia, dermal plaques, and lesions. This may lead to death if not diagnosed early and treated with antibiotics.

Conservation status

Pictured on Faroe Islands stamp

As of 2008, the beluga is listed as "near threatened" by the IUCN. This is due to uncertainty about the number of belugas over parts of its range (especially the Russian Arctic) and the expectation that if current conservation efforts cease, especially hunting management, the beluga population is likely to qualify for "threatened" status within five years. Prior to 2008, the beluga was listed as "vulnerable", a higher level of concern. IUCN cited the stability of the largest subpopulations and improved census methods that indicate a larger population than previously estimated.

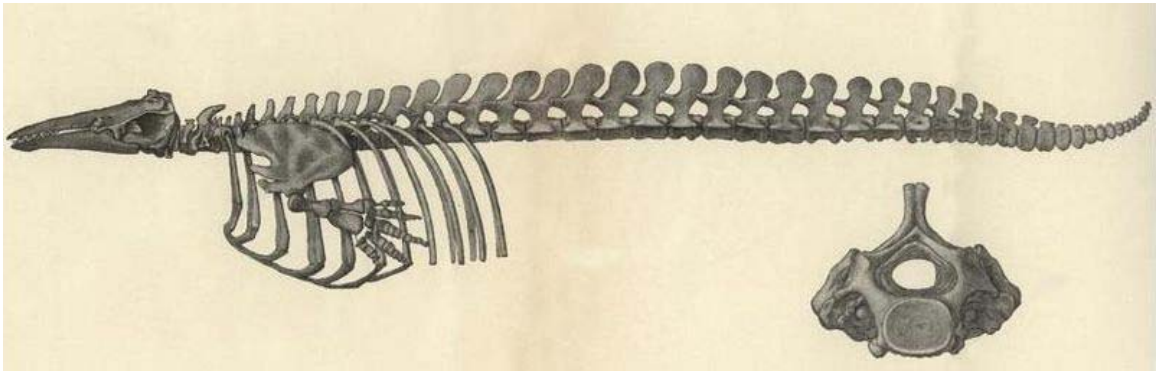
To prevent hunting, belugas are protected under the International Moratorium on Commercial Whaling; however, small amounts of beluga whaling are still allowed. Since it is very difficult to know the exact population of belugas because their habitats include inland waters away from the ocean, it is easy for them to come in contact with oil and gas development centers. To prevent whales from coming in contact with industrial waste, the Alaskan and Canadian governments are relocating sites where whales and waste come in contact.

To prevent captive whales from dying, researchers from the Vancouver Aquarium Marine Science Centre are finding ways to prevent fungi from entering the habitats and to constantly check their health. Healthy captive belugas are important because they are one of the only whales found in many marine aquariums. The high numbers of captives adds to the threat to the beluga population, while their carcasses contribute to scientific research.

Subpopulations are subject to differing levels of threat and warrant individual assessment. The Cook Inlet subpopulation is listed as "Critically Endangered" by the IUCN as of 2006. The Cook Inlet beluga population is listed as Endangered under the Endangered Species Act as of October 2008. This was due to overharvesting of belugas prior to 1998. The population has failed to recover even though the reported harvest has been small. The most recent published estimate as of May 2008 was 302 (CV=0.16) in 2006. In

addition, the National Marine Fisheries Service indicated that the 2007 aerial survey's point estimate was 375.

Evolution



Skeleton of D. leucas

The beluga's earliest known ancestor is the prehistoric *Denebola brachycephala* from the late Miocene period. A single fossil from the Baja California peninsula, indicates that the family once inhabited warmer waters. The fossil record also indicates that in comparatively recent times the beluga's range varied with that of the polar ice packs—expanding during ice ages and contracting when the ice retreats.

Chapter 4

Blue Whale

Blue whale

Adult blue whale from the eastern Pacific Ocean

Size compared to an average human

Conservation status

Endangered (IUCN 3.1)

Scientific classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Order:	Cetacea
Suborder:	Mysticeti
Family:	Balaenopteridae
Genus:	*Balaenoptera*

Species: ***B. musculus***

Binomial name

Balaenoptera musculus
(Linnaeus, 1758)

Subspecies

- *B. m. brevicauda* Ichihara, 1966
- ?*B. m. indica* Blyth, 1859
- *B. m. intermedia* Burmeister, 1871
- *B. m. musculus* Linnaeus, 1758

Blue whale range (in blue)

The **blue whale** (***Balaenoptera musculus***) is a marine mammal belonging to the suborder of baleen whales (called Mysticeti). At perhaps over 33 metres (108 ft) in length and 180 metric tons (200 short tons) or more in weight, it is the largest animal ever known to have existed.

Long and slender, the blue whale's body can be various shades of bluish-grey dorsally and somewhat lighter underneath. There are at least three distinct subspecies: *B. m. musculus* of the North Atlantic and North Pacific, *B. m. intermedia* of the Southern Ocean and *B. m. brevicauda* (also known as the pygmy blue whale) found in the Indian Ocean and South Pacific Ocean. *B. m. indica*, found in the Indian Ocean, may be another subspecies. As with other baleen whales, its diet consists almost exclusively of small crustaceans known as krill.

Blue whales were abundant in nearly all the oceans on Earth until the beginning of the twentieth century. For over a century, they were hunted almost to extinction by whalers until protected by the international community in 1966. A 2002 report estimated there were 5,000 to 12,000 blue whales worldwide, located in at least five groups. More recent research into the Pygmy subspecies suggests this may be an underestimate. Before whaling, the largest population was in the Antarctic, numbering approximately 239,000 (range 202,000 to 311,000). There remain only much smaller (around 2,000) concentrations in each of the North-East Pacific, Antarctic, and Indian Ocean groups. There are two more groups in the North Atlantic, and at least two in the Southern Hemisphere.

Taxonomy

Blue whales are rorquals (family Balaenopteridae), a family that includes the humpback whale, the fin whale, Bryde's whale, the sei whale and the minke whale. The family Balaenopteridae is believed to have diverged from the other families of the suborder Mysticeti as long ago as the middle Oligocene. However, it is not known when the members of those families diverged from each other.

The blue whale is usually classified as one of eight species in the genus *Balaenoptera*; one authority places it in a separate monotypic genus, *Sibbaldus*, but this is not accepted elsewhere. DNA sequencing analysis indicates that the blue whale is phylogenetically closer to the sei whale (*Balaenoptera borealis*) and Bryde's whale (*Balaenoptera brydei*) than to other *Balaenoptera* species, and closer to the humpback whale (*Megaptera*) and the gray whale (*Eschrichtius*) than to the minke whales (*Balaenoptera acutorostrata* and *Balaenoptera bonaerensis*). If further research confirms these relationships, it will be necessary to reclassify the rorquals.

There have been at least 11 documented cases of blue/fin hybrid adults in the wild. Arnason and Gullberg describe the genetic distance between a blue and a fin as about the same as that between a human and a gorilla. Researchers working off of Fiji believe they photographed a hybrid humpback/blue whale.

The first published description of the blue whale comes from Robert Sibbald's *Phalainologia Nova* (1694). In September 1692, Sibbald found a blue whale that had stranded in the Firth of Forth—a male 78-feet-long—which had "black, horny plates" and "two large apertures approaching a pyramid in shape".

The specific name *musculus* is Latin and could mean "muscle", but it can also be interpreted as "little mouse". Linnaeus, who named the species in his seminal *Systema Naturae* of 1758, would have known this and may have intended the ironic double meaning. Herman Melville called this species **sulphur-bottom** in his novel *Moby-Dick* due to an orange-brown or yellow tinge on the underparts from diatom films on the skin. Other common names for the blue whale have included **Sibbald's rorqual** (after Sibbald, who first described the species), the **great blue whale** and the **great northern rorqual**. These names have now fallen into disuse. The first known usage of the term **blue whale** was in Melville's *Moby-Dick*, which only mentions it in passing and doesn't specifically attribute it to the species in question. The name was really derived from the Norwegian **blåhval**, coined by Svend Foyn shortly after he had perfected the harpoon gun; the Norwegian scientist G.O. Sars adopted it as the Norwegian common name in 1874.

Authorities classify the species into three or four subspecies: *B. m. musculus*, the northern blue whale consisting of the North Atlantic and North Pacific populations, *B. m. intermedia*, the southern blue whale of the Southern Ocean, *B. m. brevicauda*, the pygmy blue whale found in the Indian Ocean and South Pacific, and the more problematic *B. m. indica*, the great Indian rorqual, which is also found in the Indian Ocean and, although described earlier, may be the same subspecies as *B. m. brevicauda*.

Description and behaviour

A blue whale lifting its tail flukes.

Adult blue whale

Aerial view of a blue whale showing both pectoral fins

The blow of a blue whale

The small dorsal fin of this blue whale is just visible on the far left.

The blue whale has a long tapering body that appears stretched in comparison with the stockier build of other whales. The head is flat and *U*-shaped and has a prominent ridge running from the blowhole to the top of the upper lip. The front part of the mouth is thick with baleen plates; around 300 plates (each around one metre (3.2 ft) long) hang from the upper jaw, running 0.5 m (1.6 ft) back into the mouth. Between 60 and 90 grooves (called ventral pleats) run along the throat parallel to the body length. These pleats assist with evacuating water from the mouth after lunge feeding.

The dorsal fin is small, visible only briefly during the dive sequence. Located around three-quarters of the way along the length of the body, it varies in shape from one individual to another; some only have a barely perceptible lump, but others may have prominent and falcate (sickle-shaped) dorsals. When surfacing to breathe, the blue whale raises its shoulder and blowhole out of the water to a greater extent than other large whales, such as the fin or sei whales. Observers can use this trait to differentiate between species at sea. Some blue whales in the North Atlantic and North Pacific raise their tail fluke when diving. When breathing, the whale emits a spectacular vertical single-column spout up to 12 metres (39 ft), typically 9 metres (30 ft). Its lung capacity is 5,000 litres (1320 U.S. gallons). Blue whales have twin blowholes shielded by a large splashguard.

The flippers are 3–4 metres (9.8–13 ft) long. The upper sides are grey with a thin white border; the lower sides are white. The head and tail fluke are generally uniformly grey. The whale's upper parts, and sometimes the flippers, are usually mottled. The degree of mottling varies substantially from individual to individual. Some may have a uniform slate-grey color, but others demonstrate a considerable variation of dark blues, greys and blacks, all tightly mottled.

Blue whales can reach speeds of 50 kilometres per hour (31 mph) over short bursts, usually when interacting with other whales, but 20 kilometres per hour (12 mph) is a more typical traveling speed. When feeding, they slow down to 5 kilometres per hour (3.1 mph).

Blue whales most commonly live alone or with one other individual. It is not known how long traveling pairs stay together. In locations where there is a high concentration of food, as many as 50 blue whales have been seen scattered over a small area. However, they do not form the large, close-knit groups seen in other baleen species.

Size

A 19-foot-long blue whale skull in the collections of the Smithsonian Museum of Natural History.

Blue whales are difficult to weigh because of their size. Most blue whales killed by whalers were not weighed whole, but cut up into manageable pieces first. This caused an underestimate of the total weight of the whale, due to the loss of blood and other fluids.

Nevertheless, measurements between 150–170 metric tons (170–190 short tons) were recorded of animals up to 27 metres (89 ft) in length. The weight of an individual 30 metres (98 ft) long is believed by the American National Marine Mammal Laboratory (NMML) to be in excess of 180 metric tons (200 short tons). The largest blue whale accurately weighed by NMML scientists to date was a female that weighed 177 metric tons (195 short tons).

The blue whale is the largest animal ever known to have lived. The largest known dinosaur of the Mesozoic Era was the *Argentinosaurus*, which is estimated to have weighed up to 90 metric tons (99 short tons), though a controversial vertebra of *Amphicoelias fragillimus* may indicate an animal of up to 122 metric tons (134 short tons) and 40–60 metres (130–200 ft). Furthermore, there are weight estimates for the very poorly known *Bruhathkayosaurus* ranging from 140–220 metric tons (150–240 short tons), besides length estimates up to about 45 metres (148 ft). The extinct fish *Leedsichthys* may have approached its size. However, complete fossils are difficult to come by, making size comparisons difficult. All these animals are considered to be smaller than the blue whale.

There is some uncertainty about the biggest blue whale ever found, as most data come from blue whales killed in Antarctic waters during the first half of the twentieth century, and was collected by whalers not well-versed in standard zoological measurement techniques. The longest whales ever recorded were two females measuring 33.6–33.3 metres (110–109 ft) respectively. The longest whale measured by scientists at the NMML was 29.9 metres (98 ft).

A blue whale's tongue weighs around 2.7 metric tons (3.0 short tons) and, when fully expanded, its mouth is large enough to hold up to 90 metric tons (99 short tons) of food and water. Despite the size of its mouth, the dimensions of its throat are such that a blue whale cannot swallow an object wider than a beach ball. Its heart weighs 600 kilograms (1,300 lb) and is the largest known in any animal. A blue whale's aorta is about 23 centimetres (9.1 in) in diameter. During the first seven months of its life, a blue whale calf drinks approximately 400 litres (100 U.S. gallons) of milk every day. Blue whale calves gain weight quickly, as much as 90 kilograms (200 lb) every 24 hours. Even at birth, they weigh up to 2,700 kilograms (6,000 lb)—the same as a fully grown hippopotamus.

Feeding

Blue whales feed almost exclusively on krill, though they also take small numbers of copepods. The species of this zooplankton eaten by blue whales varies from ocean to ocean. In the North Atlantic, *Meganyctiphanes norvegica*, *Thysanoessa raschii*, *Thysanoessa inermis* and *Thysanoessa longicaudata* are the usual food; in the North Pacific, *Euphausia pacifica*, *Thysanoessa inermis*, *Thysanoessa longipes*, *Thysanoessa spinifera*, *Nyctiphanes symplex* and *Nematoscelis megalops*; and in the Antarctic, *Euphausia superba*, *Euphausia crystallorophias* and *Euphausia valentin*.

An adult blue whale can eat up to 40 million krill in a day. The whales always feed in the areas with the highest concentration of krill, sometimes eating up to 3,600 kilograms (7,900 lb) of krill in a single day. This daily requirement of an adult blue whale is in the region of 1.5 million kilocalories.

Because krill move, blue whales typically feed at depths of more than 100 metres (330 ft) during the day and only surface-feed at night. Dive times are typically 10 minutes when feeding, though dives of up to 20 minutes are common. The longest recorded dive is 36 minutes. The whale feeds by lunging forward at groups of krill, taking the animals and a large quantity of water into its mouth. The water is then squeezed out through the baleen plates by pressure from the ventral pouch and tongue. Once the mouth is clear of water, the remaining krill, unable to pass through the plates, are swallowed. The blue whale also incidentally consumes small fish, crustaceans and squid caught up with krill.

Life history

A juvenile blue whale with its mother

Mating starts in late autumn and continues to the end of winter. Little is known about mating behaviour or breeding grounds. Females typically give birth once every two to three years at the start of the winter after a gestation period of ten to twelve months. The calf weighs about 2.5 metric tons (2.8 short tons) and is around 7 metres (23 ft) in length. Blue whale calves drink 380–570 litres (100–150 U.S. gallons) of milk a day. Weaning takes place for about six months, by which time the calf has doubled in length. Sexual

maturity is typically reached at eight to ten years, by which time males are at least 20 metres (66 ft) long (or more in the Southern Hemisphere). Females are larger still, reaching sexual maturity at around the age of five, by which they are about 21 metres (69 ft) long.

Scientists estimate that blue whales can live for at least 80 years; however, since individual records do not date back into the whaling era, this will not be known with certainty for many years. The longest recorded study of a single individual is 34 years, in the northeast Pacific. The whales' only natural predator is the orca. Studies report that as many as 25% of mature blue whales have scars resulting from orca attacks. The mortality rate of such attacks is unknown.

Blue whale strandings are extremely uncommon, and, because of the species' social structure, mass strandings are unheard of. However, when strandings do occur, they can become the focus of public interest. In 1920, a blue whale washed up near Bragar on the Isle of Lewis in the Outer Hebrides of Scotland. It had been shot by whalers, but the harpoon had failed to explode. As with other mammals, the fundamental instinct of the whale was to try to carry on breathing at all costs, even though this meant beaching to prevent itself from drowning. Two of the whale's bones were erected just off a main road on Lewis and remain a tourist attraction.

Vocalizations

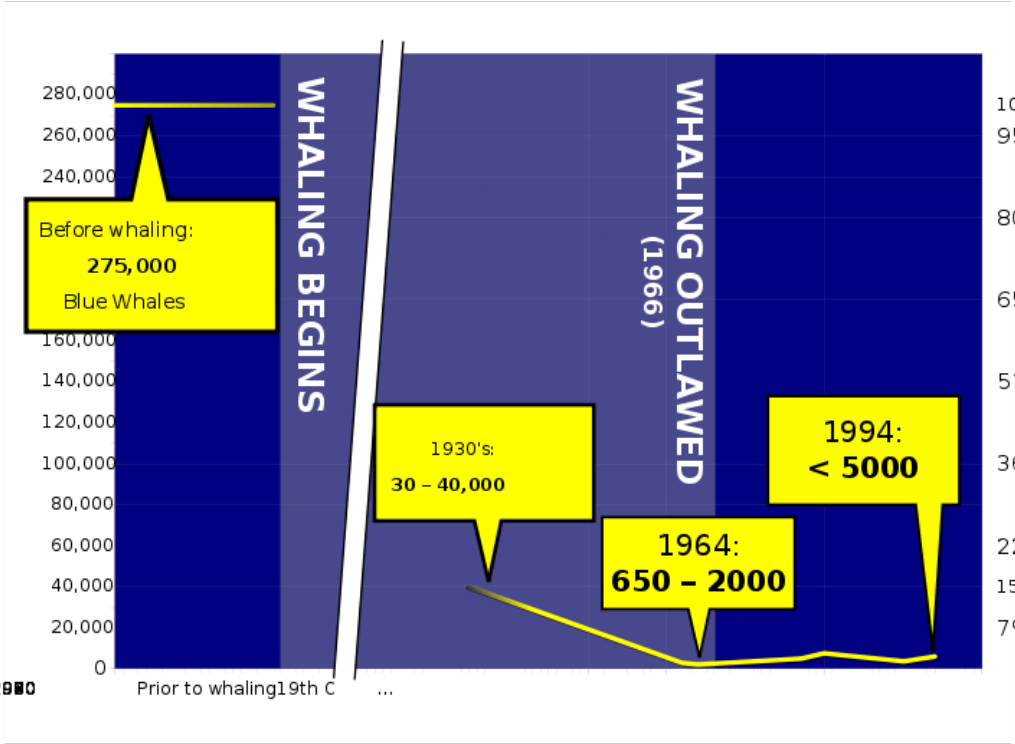
Estimates made by Cummings and Thompson (1971) suggest the source level of sounds made by blue whales are between 155 and 188 decibels when measured relative to a reference pressure of one micropascal at one metre. All blue whale groups make calls at a fundamental frequency between 10 and 40 Hz; the lowest frequency sound a human can typically perceive is 20 Hz. Blue whale calls last between ten and thirty seconds. Blue whales off the coast of Sri Lanka have been repeatedly recorded making "songs" of four notes, lasting about two minutes each, reminiscent of the well-known humpback whale songs. As this phenomenon has not been seen in any other populations, researchers believe it may be unique to the *B. m. brevicauda* (pygmy) subspecies.

The reason for vocalization is unknown. Richardson *et al.* (1995) discuss six possible reasons:

1. Maintenance of inter-individual distance
2. Species and individual recognition
3. Contextual information transmission (e.g., feeding, alarm, courtship)
4. Maintenance of social organization (e.g., contact calls between females and males)
5. Location of topographic features
6. Location of prey resources

Population and whaling

Hunting era



Blue whale populations have declined dramatically due to commercial whaling.

Blue whales are not easy to catch or kill. Their speed and power meant that they were rarely pursued by early whalers, who instead targeted sperm and right whales. In 1864, the Norwegian Svend Foyn equipped a steamboat with harpoons specifically designed for catching large whales. Although initially cumbersome and with a low success rate, Foyn perfected the harpoon gun, and soon several whaling stations were established on the coast of Finnmark in northern Norway. Because of disputes with the local fishermen, the last whaling station in Finnmark was closed down in 1904.

Soon, blue whales were being hunted in Iceland (1883), the Faroe Islands (1894), Newfoundland (1898), and Spitsbergen (1903). In 1904-05 the first blue whales were taken off South Georgia. By 1925, with the advent of the stern slipway in factory ships and the use of steam-driven whale catchers, the catch of blue whales, and baleen whales as a whole, in the Antarctic and sub-Antarctic began to increase dramatically. In the 1930-31 season, these ships caught 29,400 blue whales in the Antarctic alone. By the end of World War II, populations had been significantly depleted, and, in 1946, the first quotas restricting international trade in whales were introduced, but they were ineffective because of the lack of differentiation between species. Rare species could be hunted on an equal footing with those found in relative abundance.

Arthur C. Clarke, in his 1962 book *Profiles of the Future*, was the first prominent intellectual to call attention to the plight of the blue whale. He mentioned its large brain and said, "we do not know the true nature of the entity we are destroying."

Blue whale hunting was banned in 1966 by the International Whaling Commission, and illegal whaling by the USSR finally halted in the 1970s, by which time 330,000 blue whales had been caught in the Antarctic, 33,000 in the rest of the Southern Hemisphere, 8,200 in the North Pacific, and 7,000 in the North Atlantic. The largest original population, in the Antarctic, had been reduced to 0.15% of their initial numbers.

Population and distribution today

A blue whale set against the backdrop of the Azores

Image of a blue whale's tail fluke with the Santa Barbara Channel Islands in the background, August 2007

Since the introduction of the whaling ban, studies have failed to ascertain whether the conservation reliant global blue whale population is increasing or remaining stable. In the Antarctic, best estimates show a significant increase at 7.3% per year since the end of illegal Soviet whaling, but numbers remain at under 1% of their original levels. It has also been suggested that Icelandic and Californian populations are increasing but these increases are not statistically significant. The total world population was estimated to be between 5,000 and 12,000 in 2002, although there are high levels of uncertainty in available estimates for many areas.

The IUCN Red List counts the blue whale as "endangered" as it has since the list's inception. In the United States, the National Marine Fisheries Service lists them as endangered under the Endangered Species Act. The largest known concentration, consisting of about 2,800 individuals, is the northeast Pacific population of the northern blue whale (*B. m. musculus*) subspecies that ranges from Alaska to Costa Rica, but is most commonly seen from California in summer. Infrequently, this population visits the northwest Pacific between Kamchatka and the northern tip of Japan.

In the North Atlantic, two stocks of *B. m. musculus* are recognised. The first is found off Greenland, Newfoundland, Nova Scotia and the Gulf of Saint Lawrence. This group is

estimated to total about 500. The second, more easterly group is spotted from the Azores in spring to Iceland in July and August; it is presumed the whales follow the Mid-Atlantic Ridge between the two volcanic islands. Beyond Iceland, blue whales have been spotted as far north as Spitsbergen and Jan Mayen, though such sightings are rare. Scientists do not know where these whales spend their winters. The total North Atlantic population is estimated to be between 600 and 1,500.

In the Southern Hemisphere, there appear to be two distinct subspecies, *B. m. intermedia*, the Antarctic blue whale, and the little-studied pygmy blue whale, *B. m. brevicauda*, found in Indian Ocean waters. The most recent surveys (midpoint 1998) provided an estimate of 2,280 blue whales in the Antarctic., of which fewer than 1% are likely to be pygmy blue whales Estimates from a 1996 survey were that 424 pygmy blue whales were in a small area south of Madagascar alone, thus it is likely that numbers in the entire Indian Ocean are in the thousands. If this is true, the global numbers would be much higher than estimates predict.

A fourth subspecies, *B. m. indica*, was identified by Blyth in 1859 in the northern Indian Ocean, but difficulties in identifying distinguishing features for this subspecies led to it being used a synonym for *B. m. brevicauda*, the pygmy blue whale. Records for Soviet catches seem to indicate that the female adult size is closer to that of the Pygmy Blue than *B. m. musculus*, although the populations of *B. m. indica* and *B. m. brevicauda* appear to be discrete, and the breeding seasons differ by almost six months.

Migratory patterns of these subspecies are not well known. For example, pygmy blue whales have been recorded in the northern Indian Ocean (Oman, Maldives and Sri Lanka), where they may form a distinct resident population. In addition, the population of blue whales occurring off Chile and Peru may also be a distinct population. Some Antarctic blue whales approach the eastern South Atlantic coast in winter, and occasionally, their vocalizations are heard off Peru, Western Australia, and in the northern Indian Ocean. In Chile, the Cetacean Conservation Center, with support from the Chilean Navy, is undertaking extensive research and conservation work on a recently discovered feeding aggregation of the species off the coast of Chiloe Island in the Gulf of Corcovado, where 326 blue whales were spotted in the summer of 2007.

Efforts to calculate the blue whale population more accurately are supported by marine mammologists at Duke University, who maintain the Ocean Biogeographic Information System—Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP), a collation of marine mammal sighting data from around 130 sources.

Threats other than hunting

A blue whale surfaces off Santa Cruz Island in the Channel Islands, near Santa Barbara, CA

Due to their enormous size, power and speed, adult blue whales have virtually no natural predators. There is, however, one documented case in *National Geographic Magazine* of a blue whale being attacked by orcas off the Baja California Peninsula; although the orcas were unable to kill the animal outright during their attack, the blue whale sustained massive wounds and probably died as a result of them shortly after the attack. Up to a quarter of the blue whales identified in Baja bear scars from orca attacks.

Blue whales may be wounded, sometimes fatally, after colliding with ocean vessels, as well as becoming trapped or entangled in fishing gear. The ever-increasing amount of ocean noise, including sonar, drowns out the vocalizations produced by whales, which may make it harder for them to communicate. Human threats to the potential recovery of blue whale populations also include accumulation of polychlorinated biphenyl (PCB) chemicals within the whale's body.

With global warming causing glaciers and permafrost to melt rapidly and allowing a large amount of fresh water to flow into the oceans, there are concerns that if the amount of fresh water in the oceans reaches a critical point, there will be a disruption in the

thermohaline circulation. Considering the blue whale's migratory patterns are based on ocean temperature, a disruption in this circulation, which moves warm and cold water around the world, would be likely to have an effect on their migration. The whales summer in the cool, high latitudes, where they feed in krill-abundant waters; they winter in warmer, low latitudes, where they mate and give birth.

The change in ocean temperature would also affect the blue whale's food supply. The warming trend and decreased salinity levels would cause a significant shift in krill location and abundance.

Museums

Blue whale skeleton, outside the Long Marine Laboratory at the University of California, Santa Cruz

The Natural History Museum in London contains a famous mounted skeleton and life-size model of a blue whale, which were both the first of their kind in the world, but have since been replicated at the University of California, Santa Cruz. Similarly, the American Museum of Natural History in New York City has a full-size model in its Milstein Family Hall of Ocean Life. A juvenile blue whale skeleton is installed at the New Bedford Whaling Museum in New Bedford, Massachusetts.

The Aquarium of the Pacific in Long Beach, California features a life-size model of a mother blue whale with her calf suspended from the ceiling of its main hall. The Beaty Biodiversity Museum at the University of British Columbia, Canada, houses a display of a blue whale skeleton directly on the main campus boulevard. A real skeleton of a blue whale at the Canadian Museum of Nature in Ottawa, Canada was also unveiled in May 2010

The Museum of Natural History in Gothenburg, Sweden contains the only stuffed blue whale in the world. There one can also find the skeleton of the whale mounted beside the whale.

The Melbourne Museum features a skeleton of the pygmy blue whale.

Whale-watching

Living blue whales may be encountered on whale-watching cruises in the Gulf of Maine and are the main attractions along the north shore of the Gulf of Saint Lawrence and in the Saint Lawrence estuary.

Chapter 5

Colossal Squid

Colossal Squid

Scientific classification	
Kingdom:	Animalia
Phylum:	Mollusca
Class:	Cephalopoda
Order:	Teuthida
Family:	Cranchiidae
Subfamily:	Taoniinae
Genus:	***Mesonychoteuthis*** Robson, 1925
Species:	***M. hamiltoni***
Binomial name	

Mesonychoteuthis hamiltoni
Robson, 1925

Global range of *M. hamiltoni*

The **Colossal Squid** (*Mesonychoteuthis hamiltoni*, from Greek *mesos* (middle), *nychus* (claw), and *teuthis* (squid)), sometimes called the **Antarctic** or **Giant Cranch Squid**, is believed to be the largest squid species in terms of mass. It is the only known member of the genus ***Mesonychoteuthis***. Though it is known from only a few specimens, current estimates put its maximum size at 12–14 metres (39–46 feet) long, based on analysis of smaller and immature specimens, making it the largest known invertebrate.

Morphology

Unlike the giant squid, whose arms and tentacles only have suckers lined with small teeth, the Colossal Squid's limbs are also equipped with sharp hooks: some swiveling, others three-pointed. Its body is wider and stouter, and therefore heavier, than that of the giant squid. Colossal Squids are believed to have a longer mantle than giant squids, although their tentacles are shorter.

The squid exhibits abyssal gigantism. The beak of *Mesonychoteuthis hamiltoni* is the largest known of any squid, exceeding that of *Architeuthis* (giant squid) in size and in robustness. The Colossal Squid also has the largest eyes documented in the animal kingdom.

Distribution

The squid's known range extends thousands of miles northward from Antarctica to southern South America, southern South Africa, and the southern tip of New Zealand, making it primarily an inhabitant of the entire circumantarctic Southern Ocean.

Ecology and life history

While little is known about the life of this creature, it is believed to feed on prey such as chaetognatha, large fish like the Patagonian toothfish and other squid in the deep ocean using bioluminescence. The Colossal Squid is thought to have a slow metabolic rate, requiring only around 30 g of prey daily. Estimates of its energetic demands suggest that it is a slow-moving ambush predator, using its large eyes primarily for predator detection rather than active hunting.

Based on capture depths of a few specimens, as well as beaks found in sperm whale stomachs, the adult squid ranges at least to a depth of 2200 metres, while juveniles can go as deep as 1000 metres. It is believed to be sexually dimorphic, with mature females generally being much larger than mature males, as is common in many species of invertebrates.

The squid's method of reproduction has not been observed, although some data on their reproduction can be inferred from anatomy. Since males lack an organ called a hectocotylus (a tentacle used in other cephalopods to transfer a spermatophore to the female), they probably use a penis instead, which would be used to directly implant sperm into females.

Many sperm whales carry scars on their backs believed to be caused by the hooks of Colossal Squid. Colossal Squid are a major prey item for Antarctic sperm whales feeding in the Southern Ocean; 14% of the squid beaks found in the stomachs of these sperm whales are those of the Colossal Squid, which indicates that Colossal Squid make up 77% of the biomass consumed by these whales. Many other animals also feed on this squid, including beaked whales (such as the bottlenose whales), pilot whales, southern elephant seals, Patagonian toothfish, sleeper sharks (*Somniosus* cf. *microcephalus*), and albatrosses (e.g., the Wandering and Sooty albatrosses). However, beaks from mature adults have only been recovered from those animals large enough to take such prey (i.e., sperm whales and sleeper sharks), while the remaining predators are limited to eating juveniles or young adults.

Timeline

- 1925 – Species was first discovered in the form of two tentacles found in the stomach of a sperm whale.
- 1981 – A Russian trawler in the Ross Sea, off the coast of Antarctica, caught a large squid with a total length of 4 metres (13 ft), which was later identified as an immature female of *Mesonychoteuthis hamiltoni*.
- 2003 – A complete specimen of a subadult female was found near the surface with a total length of 6 m (20 ft) and a mantle length of 2.5 m (8 ft).
- 2005 – A specimen was captured at a depth of 1625 m while taking a toothfish from a longline off South Georgia Island. Although the mantle was not brought aboard, the mantle length was estimated at over 2.5 m, and the tentacles measured 230 cm. The animal is thought to have weighed between 150 and 200 kg.
- 2007 – The largest recorded specimen was captured by a New Zealand fishing boat off Antarctica. It was initially estimated to measure 10 m (33 ft) in length and weigh 450 kg (992 lb). The squid was taken back to New Zealand for scientific study. A study on the specimen later showed that its actual weight was 495 kg (1,091 lb), but that it only measured 4.2 m (14 ft) in total length as a result of the tentacles shrinking *post mortem*.

Largest known specimen

This specimen, caught in early 2007, is the largest cephalopod ever recorded. Here it is shown in its live state during capture, with the delicate red skin still intact and the mantle characteristically inflated.

On February 22, 2007, it was announced by authorities in New Zealand that the largest known Colossal Squid had been captured. The specimen weighed 495 kg (1,091 lb) and was initially estimated to measure 10 m (33 ft) in total length. Fishermen on the vessel *San Aspiring*, owned by the Sanford seafood company, caught the animal in the freezing Antarctic waters of the Ross Sea. It was brought to the surface as it fed on an Antarctic toothfish that had been caught off a long line. It would not let go of its prey and could not be removed from the line by the fishermen, so they decided to catch it instead. They managed to envelop it in a net, hauled it aboard and froze it. The specimen eclipsed the previous largest find in 2003 by about 195 kilograms (430 lb), although it is still considerably smaller than some estimates have predicted. The specimen was frozen in a cubic metre of water and transported to the Museum of New Zealand Te Papa Tongarewa, New Zealand's national museum. Media reports suggested that scientists at the museum were considering using a giant microwave to defrost the squid because defrosting the squid at room temperatures would take days and it would be likely for the outside to rot while the core remained frozen. However, they later opted for the more conventional approach of thawing the specimen in a bath of salt water. After thawing, the squid measured only 4.2 m (14 ft) in total length, with the tentacles having shrunk significantly. Although initially thought to be a male, closer inspection of the specimen showed it to be a female.

Defrosting and dissection, April-May 2008

Thawing and dissection of the specimen took place at the Museum of New Zealand Te Papa Tongarewa under the direction of senior biologist Chris Paulin, with technician Mark Fenwick, Dutch marine biologist and toxicologist Olaf Blaauw, AUT biologist Dr Steve O'Shea, Dr Tsunemi Kubodera, and AUT biologist Kat Bolstad.

Parts of the specimen have been examined:

- The beak is considerably smaller than some found in the stomachs of sperm whales, suggesting there are Colossal Squid much larger than this one.
- The eye is 27 cm (10.63 in) wide, with a lens 12 cm across. This is the largest eye of any known animal. These measurements are of the partly collapsed specimen: when living the eye was probably 30 to 40 cm (12 to 16 in) across.
- Inspection of the specimen with an endoscope revealed ovaries containing thousands of eggs.

Exhibition

The specimen on display at the Museum of New Zealand Te Papa Tongarewa

The Museum of New Zealand Te Papa Tongarewa is displaying this specimen in an exhibition which opened on December 13, 2008. A website on the squid specimen is also available.

Chapter 6

Giant Clam

Giant Clam

Conservation status

Vulnerable (IUCN 2.3)

Scientific classification

Kingdom:	Animalia
Phylum:	Mollusca
Class:	Bivalvia
Subclass:	Heterodonta
Infraclass:	Euheterodonta
Order:	Euheterodonta *incertae sedis*
Superfamily:	Cardioidea
Subfamily:	Tridacninae
Genus:	*Tridacna*
Subgenus:	*Tridacna (Tridacna)*
Species:	***T. gigas***

Binomial name

Tridacna (Tridacna) gigas

(Linnaeus, 1758)

Synonyms

Chama gigantea Perry, 1811

The **giant clam**, *Tridacna gigas* (known as *pā'ua* in Cook Islands Māori), is the largest living bivalve mollusc. *T. gigas* is one of the most endangered clam species. It was mentioned as early as 1825 in scientific reports. One of a number of large clam species native to the shallow coral reefs of the South Pacific and Indian oceans, they can weigh more than 200 kilograms (441 lb) measure as much as 120 cm (47.2 in) across, and have an average lifespan in the wild of 100 years or more. They are also found off the shores of the Philippines, where they are called **taklobo**. *T. gigas* lives in flat coral sand or broken coral and can be found at depth of as much as 20 m (66 ft). Its range covers the Indo-Pacific, but populations are diminishing quickly and the giant clam has become extinct in many areas where it was once common. *T. maxima* has the largest geographical distribution among giant clam species; it can be found in high- or low-islands, lagoons, or fringeing reefs. Its rapid growth rate is likely due to its ability to cultivate plants in its body tissue.

Although larval clams are planktonic, they become sessile in adulthood. The creature's mantle tissues act as a habitat for the symbiotic single-celled dinoflagellate algae (zooxanthellae) from which it gets nutrition. By day, the clam opens its shell and extends its mantle tissue so that the algae receive the sunlight they need to photosynthesize.

Anatomy

Young *T. gigas* are difficult to distinguish from other species of Tridacnidae. Adult *T. gigas* are the only giant clams unable to close their shells completely. Even when closed, part of the mantle is visible, unlike the very similar *T. derasa*. However, this can only be recognized with increasing age and growth. Small gaps always remain between shells through which retracted brownish-yellow mantle can be seen.

T. gigas has four or five vertical folds in its shell; this is the main characteristic that separates it from the very similar shell of *T. derasa*, which has six or seven vertical folds. As with massive deposition of coral matrices composed of calcium carbonate, the bivalves containing zooxanthellae have a tendency to grow massive calcium carbonate shells. The mantle's edges are packed with symbiotic zooxanthellae that presumably utilize carbon dioxide, phosphates, and nitrates supplied by the clam.

Largest Specimens

The largest known *T. gigas* specimen measured 137 cm. It was discovered around 1817 on north western coast of Sumatra. The weight of the two shells was 230 kilograms (507 lb). This suggests that the live weight of the animal would have been roughly 250 kilograms (551 lb). Today these shells are on display in a museum in Northern Ireland.

Another unusually large giant clam was found in 1956 off the Japanese island of Ishigaki. However, it was not examined scientifically before 1984. The shell's length was 115 cm and the weight of the shells and soft parts was 333 kilograms (734 lb). Scientists estimated the live weight to be around 340 kilograms (750 lb).

Ecology

Feeding

Algae provide giant clams with a supplementary source of nutrition. These plants consist of unicellular algae, whose metabolic products add to the clam's filter food. As a result, they are able to grow as large as100 cm length even in nutrient-poor coral-reef waters. The clams cultivate algae in a special circulatory system which enables them to keep a substantially higher number of symbionts per unit of volume.

In small clams—10 milligrams (0.010 g) dry tissue weight—filter feeding provides about 65% of total carbon needed for respiration and growth; large clams (10 g) acquire only 34% of carbon from this source. A single species of zooxenthellae may be symbionts of both giant clams and nearby reef–building (hermatypic) corals.

Reproduction

T. gigas reproduce sexually, and are hermaphrodites (producing both eggs and sperm). Self-fertilization is not possible but, this characteristic does allow them to reproduce with any other member of the species. This reduces the burden of finding a compatible mate, while simultaneously doubling the number of offspring produced by the process. As with all other forms of sexual reproduction, hermaphroditism ensures that new gene combinations are passed to further generations.

Since giant clams cannot move themselves, they adopt broadcast spawning. They release sperm and eggs into the water. A transmitter substance called Spawning Induced Substance (SIS) helps synchronize the release of sperm and eggs to ensure fertilization. The substance is released through a syphonal outlet. Other clams can detect SIS immediately. Incoming water passes chemoreceptors situated close to the inccurent syphon, which transmit the information directly to the cerebral ganglia, a simple form of brain.

Detection of SIS stimulates the giant clam to swell its mantle in the central region and to contract its adductor muscle. Each clam then fills its water chambers and closes the incurrent syphon. The shell contracts vigorously with the adductor's help, so the excurrent chamber's contents flows through the excurrent syphon. After a few contractions containing only water, eggs and sperm appear in the excurrent chamber and then pass through the excurrent syphon into the water. Female eggs have a diameter of 100 micrometres (0.0039 in). Egg release initiates the reproductive process. An adult *T. gigas* can release more than 500 million eggs at a time.

Richard D. Braley of the University of New South Wales School of Zoology observed that spawning seems to coincide with incoming tides near the second (full), third, and fourth (new) quarters of the moon phase. Spawning contractions occurred every 2–3 minutes, with intense spawning ranging from thirty minutes to two and a half hours. Braley also hypothesized that clams that do not respond to the spawning of neighbor clams may be reproductively inactive.

Development

The fertilized egg floats in the sea for about 12 hours until eventually a larva (trocophore) hatches. It then starts to produce a chalk shell. Two days after fertilization it measures 160 micrometres (0.0063 in). Soon it develops a "foot," which is used to move on the ground; it can also swim to search for appropriate habitat.

At roughly one week of age, the clam settles on the ground, although it changes location frequently within the first few weeks. The larva does not yet have symbiotic algae, so it depends completely on plankton. Free floating zooxanthellae are also captured while filtering food. Eventually the front adductor muscle disappears and the rear muscle moves into the clam's center. Many small clams die at this stage. The clam is considered a juvenile when it reaches a length of 20 cm . It is difficult to observe the growth rate of *T. gigas* in the wild, but laboratory-reared giant clams have been observed to grow 12 cm a year.

Relation to People

The main reason that giant clams are becoming endangered is likely to be intensive exploitation by mussel-catching vessels. Mainly large adults are killed since they are the most profitable.

The giant clam is considered a delicacy in Japan (known as *Himejako*), France, South East Asia and many Pacific Islands. Some Asian foods include the meat from the muscles of clam. On the black market, giant clam shells are sold as decorative accouterments. At times large amounts of money were paid for the adductor muscle, which Chinese people believed have aphrodisiac powers.

Legend

As is often the case with uncharacteristically large species, the giant clam has been historically misunderstood. It was known in times past as the *killer clam* or *man-eating clam*, and reputable scientific and technical manuals once claimed that the great mollusc had caused deaths; versions of the *U.S. Navy Diving Manual* even gave detailed instructions for releasing oneself from its grasp by severing the adductor muscles used to close its shell.

In a colorful account of the discovery of the Pearl of Lao Tzu, Wilburn Cobb said he was told that a Dyak diver was drowned when the *Tridacna* closed its shell on his arm.

Today the giant clam is considered neither aggressive nor particularly dangerous. While it is certainly capable of gripping a person, the shell's closing action is defensive, not aggressive and the shell valves close too slowly to pose a serious threat. Furthermore, many large individuals are unable to completely close their shells.

Aquaculture

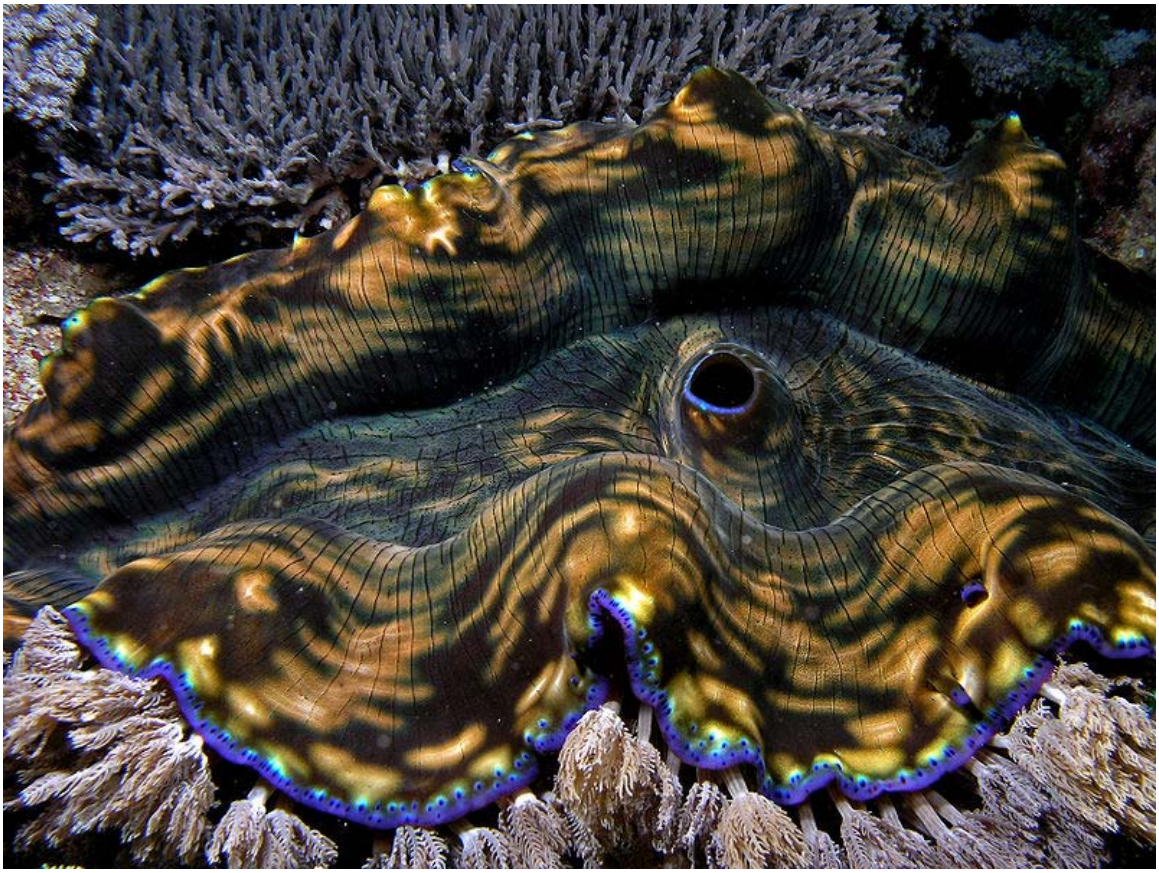
Mass culture of giant clams began at the Micronesian Mariculture Demonstration Center in Palau (belau). A large Australian government-funded project from 1985-1992 mass cultured giant clams, particularly T. gigas at James Cook University's Orpheus Island Research Station, and supported the development of hatcheries in the Pacific Islands and the Philippines. Recent developments in aquaculture, specifically at Harbor Branch Oceanographic Institute in Ft. Pierce, Florida, and in the Marshall Islands, have succeeded in tank-raising *T. gigas* both for use in home aquariums and for release into the wild.

Conservation status

The IUCN lists the giant clams as vulnerable. There is concern among conservationists about whether those who use the species as a source of livelihood are overexploiting it. The numbers in the wild have been greatly reduced by extensive harvesting for food and the aquarium trade.

Green and blue giant clam from East Timor

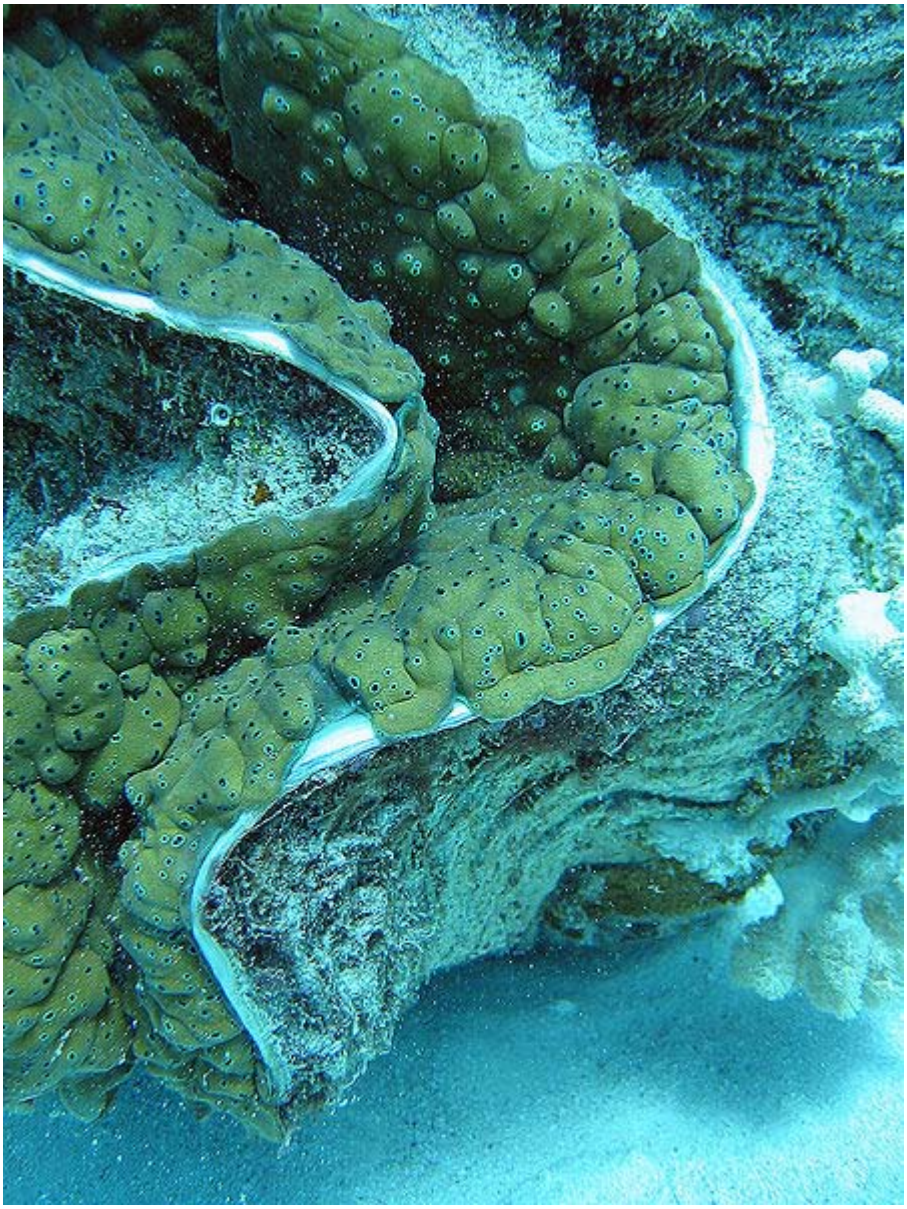
Camouflaged giant clam



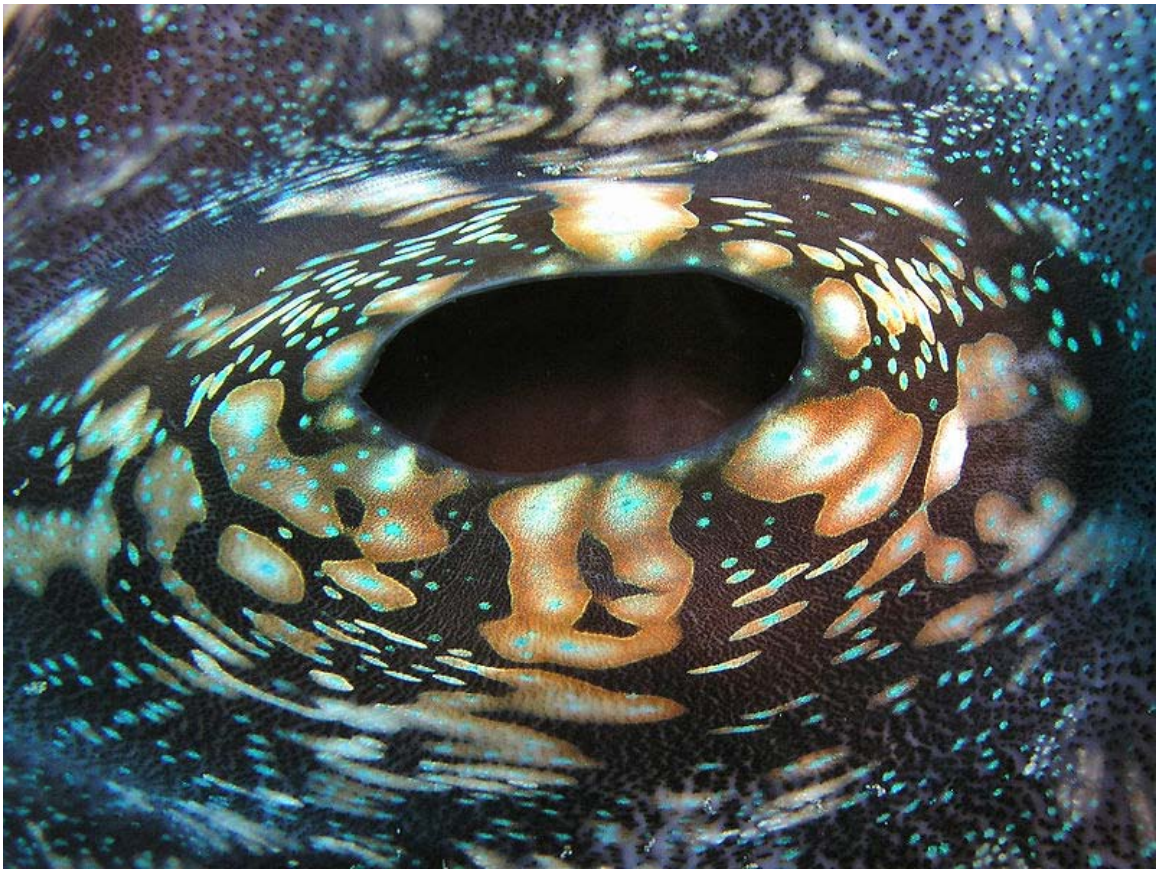
Colorful giant clam from Komodo National Park

Fully opened giant clam from Komodo National Park

The largest of all clam species

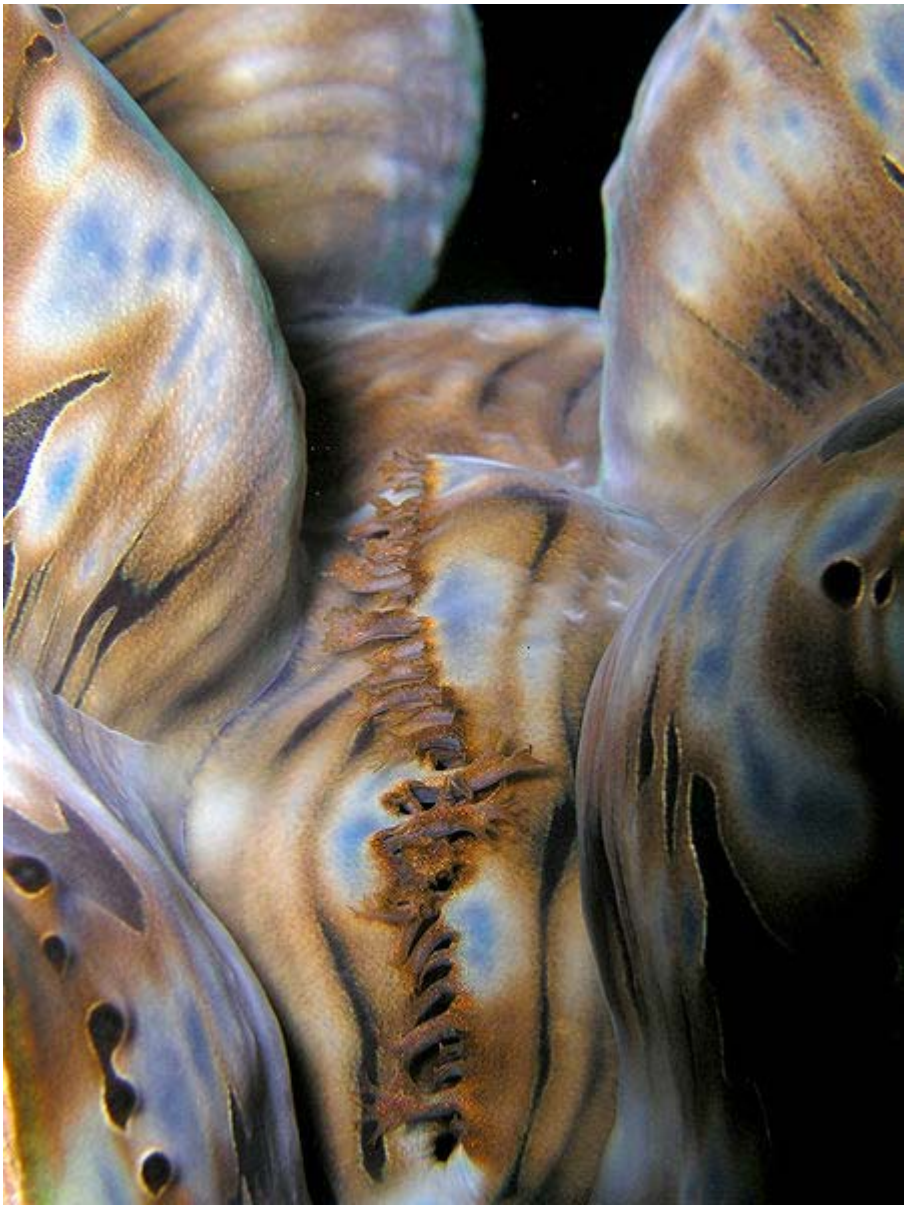


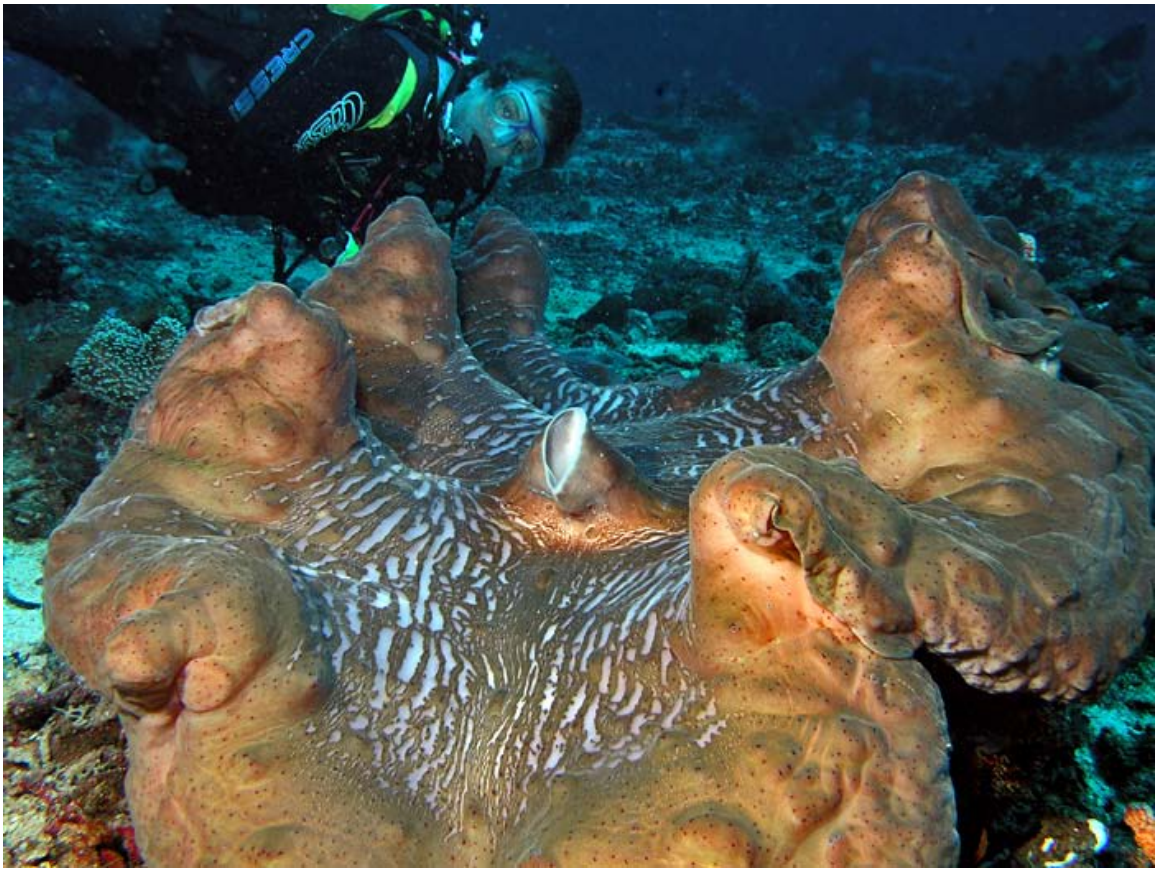
Mantle detail 1



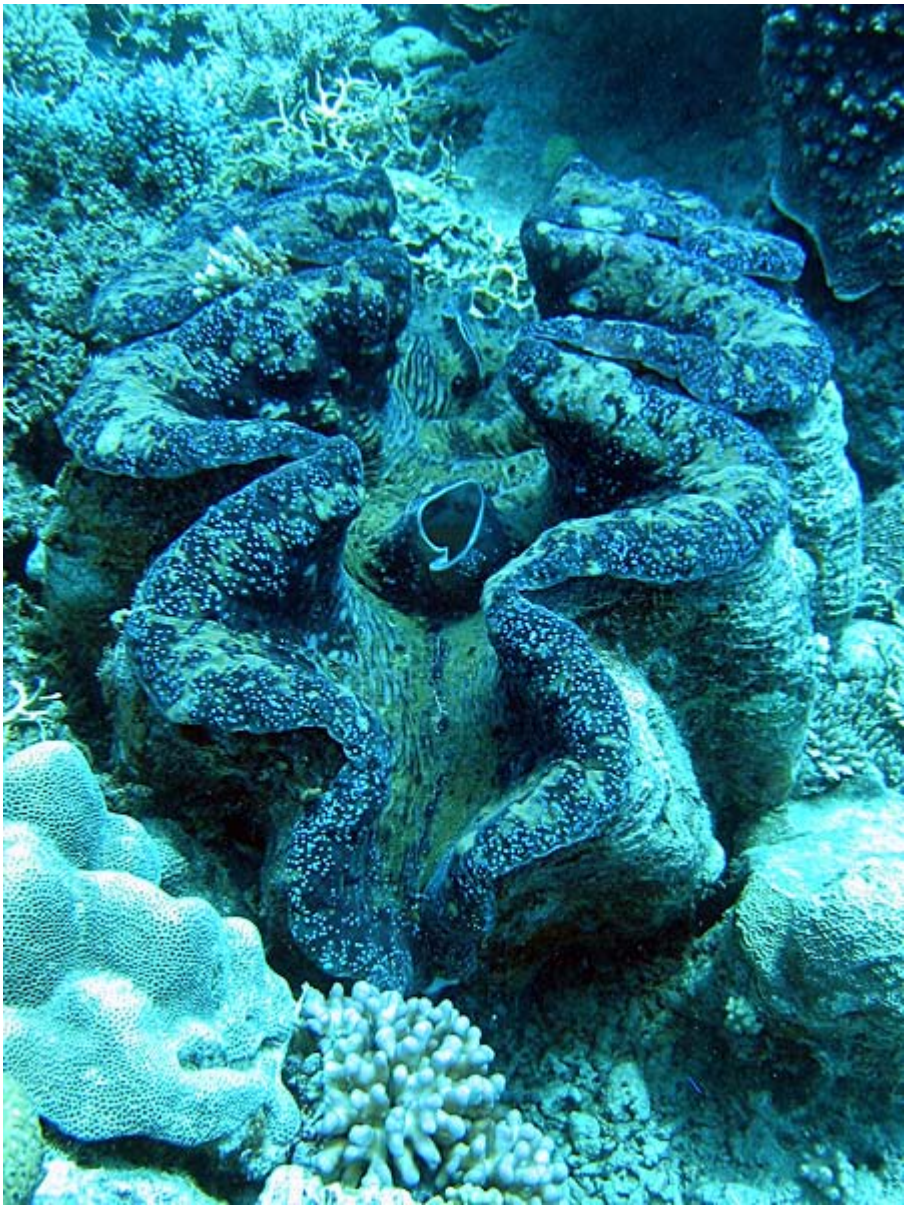
Giant clam siphon

Crocus giant clam





A giant clam from East Timor of over 1 meter in length.



Chapter 7

Humpback Whale

Humpback whale

Size comparison against an average human

Conservation status

Least Concern (IUCN 3.1)

Scientific classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Subclass:	Eutheria
Order:	Cetacea
Suborder:	Mysticeti
Family:	Balaenopteridae
Genus:	***Megaptera*** Gray, 1846

Species: ***M. novaeangliae***

Binomial name

Megaptera novaeangliae
Borowski, 1781

Humpback whale range

The **humpback whale** (*Megaptera novaeangliae*) is a species of baleen whale. One of the larger rorqual species, adults range in length from 12–16 metres (39–52 ft) and weigh approximately 36,000 kilograms (79,000 lb). The humpback has a distinctive body shape, with unusually long pectoral fins and a knobbly head. It is an acrobatic animal, often breaching and slapping the water. Males produce a complex whale song, which lasts for 10 to 20 minutes and is repeated for hours at a time. The purpose of the song is not yet clear, although it appears to have a role in mating.

Found in oceans and seas around the world, humpback whales typically migrate up to 25,000 kilometres (16,000 mi) each year. Humpbacks feed only in summer, in polar waters, and migrate to tropical or sub-tropical waters to breed and give birth in the winter. During the winter, humpbacks fast and live off their fat reserves. The species' diet consists mostly of krill and small fish. Humpbacks have a diverse repertoire of feeding methods, including the bubble net feeding technique.

Like other large whales, the humpback was and is a target for the whaling industry. Due to over-hunting, its population fell by an estimated 90% before a whaling moratorium was introduced in 1966. Stocks have since partially recovered; however, entanglement in fishing gear, collisions with ships, and noise pollution also remain concerns. There are at least 80,000 humpback whales worldwide. Once hunted to the brink of extinction, humpbacks are now sought by whale-watchers, particularly off parts of Australia, New Zealand, South America, Canada, and the United States.

Taxonomy

Young whale with blowholes clearly visible

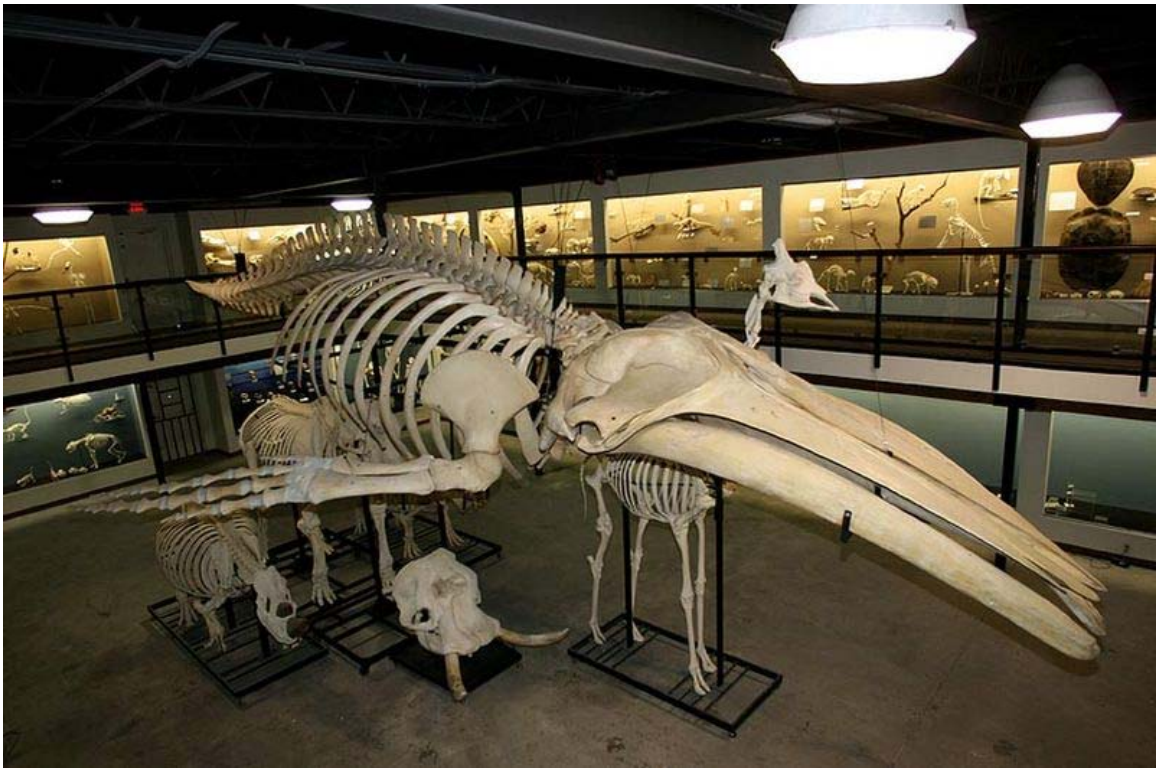
Humpback whales are rorquals (family Balaenopteridae), a family that includes the blue whale, the fin whale, the Bryde's whale, the sei whale and the minke whale. The rorquals are believed to have diverged from the other families of the suborder Mysticeti as long ago as the middle Miocene. However, it is not known when the members of these families diverged from each other.

Though clearly related to the giant whales of the genus *Balaenoptera*, the humpback has been the sole member of its genus since Gray's work in 1846. More recently though, DNA sequencing analysis has indicated the Humpback is more closely related to the gray whale (*Eschrichtius robustus*) and to certain rorquals, such as the fin whale (*Balaenoptera physalus*) than it is to other rorquals such as the minke whales. If further research confirms these relationships, it will be necessary to reclassify the rorquals.

The humpback whale was first identified as "*baleine de la Nouvelle Angleterre*" by Mathurin Jacques Brisson in his *Regnum Animale* of 1756. In 1781, Georg Heinrich Borowski described the species, converting Brisson's name to its Latin equivalent, *Balaena novaeangliae*. Early in the 19th century Lacépède shifted the humpback from the Balaenidae family, renaming it *Balaenoptera jubartes*. In 1846, John Edward Gray created the genus *Megaptera*, classifying the humpback as *Megaptera longpinna*, but in 1932, Remington Kellogg reverted the species names to use Borowski's *novaeangliae*. The common name is derived from the curving of their back when diving. The generic

name *Megaptera* from the Greek *mega*-/μεγα- "giant" and *ptera*/πτερα "wing", refers to their large front flippers. The specific name means "New Englander" and was probably given by Brisson due the regular sightings of humpbacks off the coast of New England.

Description



Humpback Whale Skeleton on Display at The Museum of Osteology, Oklahoma City, Oklahoma

A diving humpback whale, showing hump and tail fins

Humpback whales can easily be identified by their stocky bodies with obvious humps and black dorsal coloring. The head and lower jaw are covered with knobs called tubercles, which are actually hair follicles and are characteristic of the species. The fluked tail, which it lifts above the surface in some dive sequences, has wavy trailing edges. There are four global populations, all under study. North Pacific, Atlantic, and Southern Ocean humpbacks have distinct populations which complete a migratory round-

trip each year. The Indian Ocean population does not migrate, prevented by that ocean's northern coastline.

The long black and white tail fin, which can be up to a third of body length, and the pectoral fins have unique patterns, which make individual whales identifiable. Several hypotheses attempt to explain the humpback's pectoral fins, which are proportionally the longest fins of any cetacean. The two most enduring mention the higher maneuverability afforded by long fins, and the usefulness of the increased surface area for temperature control when migrating between warm and cold climates. Humpbacks also have 'rete mirable', a heat exchanging system, which works similarly in humpbacks, sharks and other fish.

A humpback whale tail displaying wavy rear edges

A tail from a different individual - the tail of each humpback whale is visibly unique.

Humpbacks have 270 to 400 darkly coloured baleen plates on each side of the mouth. The plates measure from a mere 18 inches (46 cm) in the front to approximately 3 feet (0.91 m) long in the back, behind the hinge. Ventral grooves run from the lower jaw to the umbilicus about halfway along the underside of the whale. These grooves are less numerous (usually 16–20) and consequently more prominent than in other rorquals.

The stubby dorsal fin is visible soon after the blow when the whale surfaces, but disappears by the time the flukes emerge. Humpbacks have a 3 metres (9.8 ft) heart-shaped to bushy blow, or exhalation of water through the blowholes. Because Humpback Whales breathe voluntarily, researchers have said that it is possible that the whales shut off only half of the brain when sleeping. Early whalers also noted blows from humpback adults to be 10–20 feet (3.0–6.1 m) high.

Newborn calves are roughly the length of their mother's head. At birth, calves measure 20-foot (6.1 m) at 2 short tons (1.8 t) The mother, by comparison, is about 50-foot (15 m). They nurse for approximately six months, then mix nursing and independent feeding for possibly six months more. Humpback milk is 50% fat and pink in color. Some calves have been observed alone after arrival in Alaskan waters.

Females reach sexual maturity at the age of five, achieving full adult size a little later. Males reach sexual maturity at approximately 7 years of age. The humpback whale lifespan ranges from 45-100 years.

Fully grown, the males average 15–16 metres (49–52 ft). Females are slightly larger at 16–17 metres (52–56 ft), and 40,000 kilograms (44 short tons); the largest recorded specimen was 19 metres (62 ft) long and had pectoral fins measuring 6 metres (20 ft) each.

Females have a *hemispherical lobe* about 15 centimetres (5.9 in) in diameter in their genital region. This visually distinguishes males and females. The male's penis usually remains hidden in the genital slit. Male whales have distinctive scars on heads and bodies, some resulting from battles over females.

Identifying individuals

The varying patterns on the tail flukes are sufficient to identify individuals. Unique visual identification is not currently possible in most cetacean species (other exceptions include orcas and right whales), making the humpback a popular study species. A study using data from 1973 to 1998 on whales in the North Atlantic gave researchers detailed information on gestation times, growth rates, and calving periods, as well as allowing more accurate population predictions by simulating the mark-release-recapture technique (Katona and Beard 1982). A photographic catalogue of all known North Atlantic whales was developed over this period and is currently maintained by College of the Atlantic. Similar photographic identification projects have begun in the North Pacific by SPLASH (Structure of Populations, Levels of Abundance and Status of Humpbacks), and around the world.

Life history

Reproduction

Females typically breed every two or three years. The gestation period is 11.5 months, yet some individuals have been known to breed in two consecutive years. The peak months for birth are January, February, July, and August. There is usually a 1-2 year period between humpback births. Humpback whales were thought to live 50–60 years, but new studies using the changes in amino acids behind eye lenses proved another baleen whale, the bowhead, to be 211 years old. This animal was taken by the Inuit off Alaska.

Recent research on humpback mitochondrial DNA reveals that groups that live in proximity to each other may represent distinct breeding pools.

Social structure

Humpbacks frequently breach, throwing two thirds or more of their bodies out of the water and splashing down on their backs.

The humpback social structure is loose-knit. Typically, individuals live alone or in small, transient groups that disband after a few hours. These whales are not excessively social in most cases. Groups may stay together a little longer in summer to forage and feed cooperatively. Longer-term relationships between pairs or small groups, lasting months or even years, have rarely been observed. It is possible that some females retain bonds created via cooperative feeding for a lifetime. The humpback's range overlaps considerably with other whale and dolphin species — for instance, the minke whale. However, humpbacks rarely interact socially with them, though humpback calves in Hawaiian waters sometimes play with bottlenose dolphin calves.

Courtship

Courtship rituals take place during the winter months, following migration toward the equator from summer feeding grounds closer to the poles. Competition is usually fierce, and unrelated males dubbed *escorts* by researcher Louis Herman frequently trail females as well as mother-calf dyads. Groups of two to twenty males gather around a single female and exhibit a variety of behaviors over several hours to establish dominance of what is known as a *competitive group*. Group size ebbs and flows as unsuccessful males retreat and others arrive to try their luck. Behaviors include breaching, spy-hopping, lob-tailing, tail-slapping, fin-slapping, peduncle throws, charging and parrying. Less common "super pods" may number more than 40 males, all vying for the same female. (M. Ferrari et al.)

Whale song is assumed to have an important role in mate selection; however, scientists remain unsure whether song is used between males to establish identity and dominance, between a male and a female as a mating call, or both.

Ecology

Humpback swimming on its back in Antarctica

Feeding

A group of 15 whales bubble net fishing near Juneau, Alaska

Aerial view of a bubble net off Cape Fanshaw, Alaska

A whale off Australia on the spring migration, feeding on krill by turning on its side and propelling through the krill.

Humpbacks feed primarily in summer and live off fat reserves during winter. They feed only rarely and opportunistically in their wintering waters. The humpback is an energetic hunter, taking krill and small schooling fish, such as herring *(Clupea harengus)*, salmon *(Salmo salar)*, capelin *(Mallotus villosus)* and sand lance *(Ammodytes americanus)* as well as mackerel *(Scomber scombrus)*, pollock *(Pollachius virens)* and haddock *(Melanogrammus aeglefinus)* in the North Atlantic. Krill and copepods have been recorded from Australian and Antarctic waters. Humpbacks hunt by direct attack or by stunning prey by hitting the water with pectoral fins or flukes.

A pair of humpback whales feeding by lunging

The humpback has the most diverse feeding repertoire of all baleen whales. Its most inventive technique is known as *bubble net feeding*: a group of whales swims in a shrinking circle blowing bubbles below a school of prey. The shrinking ring of bubbles encircles the school and confines it in an ever-smaller cylinder. The whales then suddenly swim upward through the 'net', mouths agape, swallowing thousands of fish in one gulp. The plated grooves in the whales mouth allow the creature to easily drain all the water that was initially taken in.This ring can begin at up to 30 metres (98 ft) in diameter via the cooperation of a dozen animals. Using a crittercam attached to a whale's back it was discovered that some whales blow the bubbles, some dive deeper to drive fish toward the surface, and others herd prey into the net by vocalizing. Humpbacks have been observed bubble net feeding alone as well.

Predation

Given scarring records, killer whales are thought to prey upon juvenile humpbacks, though this has never been witnessed. The result of these attacks is generally nothing more serious than some scarring of the skin, but it is likely that young calves are sometimes killed.

Range and habitat

Humpbacks inhabit all major oceans, in a wide band running from the Antarctic ice edge to 65° N latitude, though not in the eastern Mediterranean or the Baltic Sea.

Humpbacks are migratory, spending summers in cooler, high-latitude waters and mating and calving in tropical and subtropical waters. An exception to this rule is a population in the Arabian Sea, which remains in these tropical waters year-round. Annual migrations of up to 25,000 kilometres (16,000 mi) are typical, making it one of the mammal's best-traveled species.

A large population spreads across the Hawaiian islands every winter, ranging from the island of Hawaii in the south to Kure Atoll in the north. A 2007 study identified seven individuals wintering off the Pacific coast of Costa Rica as having traveled from the Antarctic—around 8,300 kilometres (5,200 mi). Identified by their unique tail patterns, these animals made the longest documented mammalian migration.

In Australia, two main migratory populations have been identified, off the west and east coast respectively. These two populations are distinct, with only a few females in each generation crossing between the two groups.

Whaling

One of the first attempts to hunt humpbacks was made by John Smith in 1614 off the coast of Maine. Opportunistic hunting is likely to have occurred long before. By the 18th century, they had become a common target for whalers.

By the 19th century, many nations (the United States in particular), were hunting the animal heavily in the Atlantic Ocean, and to a lesser extent in the Indian and Pacific Oceans. It was, however, the late 19th century introduction of the explosive harpoon that allowed whalers to accelerate their take. This, along with hunting in the Antarctic Ocean beginning in 1904, sharply reduced whale populations.

It is estimated that during the 20th century, at least 200,000 humpbacks were taken, reducing the global population by over 90%, with North Atlantic populations estimated to have dropped to as low as 700 individuals. In 1946, the International Whaling Commission was founded to oversee the whaling industry. They imposed rules and regulations for hunting whales and set open and closed hunting seasons. To prevent extinction, the International Whaling Commission banned commercial humpback whaling in 1966. By that time the population had been reduced to around 5,000. That ban is still in force.

Prior to commercial whaling, populations could have reached 125,000. North Pacific kills alone are estimated at 28,000. The full toll is much higher. It is now known that the Soviet Union was deliberately under-recording its kills; the Soviet kill was reported at 2,820 whereas the true number is now believed to be over 48,000.

As of 2004, hunting of humpback whales is restricted to a few animals each year off the Caribbean island Bequia in the nation of St. Vincent and the Grenadines. The take is not believed to threaten the local population.

Japan had planned to kill 50 humpbacks in the 2007/08 season under its JARPA II research program, starting in November 2007. The announcement sparked global protests. After a visit to Tokyo by the chairman of the IWC, asking the Japanese for their co-operation in sorting out the differences between pro- and anti-whaling nations on the Commission, the Japanese whaling fleet agreed that no humpback whales would be caught for the two years it would take for the IWC to reach a formal agreement.

Conservation

A dead humpback washed up near Big Sur, California

There are at least 80,000 humpback whales worldwide, with 18,000-20,000 in the North Pacific, about 12,000 in the North Atlantic, and over 50,000 in the Southern Hemisphere, down from a pre-whaling population of 125,000.

This species is considered "least concern" from a conservation standpoint, as of 2008. This is an improvement from vulnerable in the prior assessment. Most monitored stocks of humpback whales have rebounded well since the end of commercial whaling. such as the North Atlantic where stocks are now believed to be approaching pre-hunting levels. However, the species is considered endangered in some countries, including the United States. The United States initiated a status review of the species on August 12, 2009, and is seeking public comment on potential changes to the species listing under the U.S. Endangered Species Act. Areas where population data is limited and the species may be

at higher risk include the Arabian Sea, the western North Pacific Ocean, the west coast of Africa and parts of Oceania.

Today, individuals are vulnerable to collisions with ships, entanglement in fishing gear, and noise pollution. Like other cetaceans, humpbacks can be injured by excessive noise. In the 19th century, two humpback whales were found dead near sites of repeated oceanic sub-bottom blasting, with traumatic injuries and fractures in the ears.

Once hunted to the brink of extinction, the humpback has made a dramatic comeback in the North Pacific. A 2008 study estimates that the humpback population that hit a low of 1,500 whales before hunting was banned worldwide, has made a comeback to a population of between 18,000 and 20,000.

Saxitoxin, a paralytic shellfish poisoning (PSP) from contaminated mackerel has been implicated in humpback whale deaths.

The United Kingdom, among other countries, designated the humpback as a priority species under the national Biodiversity Action Plan.

The sanctuary provided by U.S. National Parks such as Glacier Bay National Park and Preserve and Cape Hatteras National Seashore, among others, have also become major factors in sustaining populations.

Although much was learned about humpbacks from whaling, migratory patterns and social interactions were not well understood until two studies by R. Chittleborough and W. H. Dawbin in the 1960s. Roger Payne and Scott McVay made further studies of the species in 1971. Their analysis of whale song led to worldwide media interest and convinced the public mind that whales were highly intelligent, aiding the anti-whaling advocates.

In August 2008, the IUCN changed humpback's status from Vulnerable to Least Concern, although two subpopulations remain endangered.

The United States is considering listing separate humpback populations, so that smaller groups, such as North Pacific humpbacks, which are estimated to number 18,000-20,000 animals, might be delisted. This is made difficult by humpback's extraordinary migrations, which can extend the 5,157 miles (8,299 km) from Antarctica to Costa Rica.

Whale-watching

Humpback near Maui, HI

Humpback whales are generally curious about objects in their environment. Some individuals, referred to as "friendlies", approach whale-watching boats closely, often staying under or near the boat for many minutes. Because humpbacks are often easily approachable, curious, easily identifiable as individuals, and display many behaviors, they have become the mainstay of whale-watching tourism in many locations around the world. Hawaii has used the concept of "eco tourism" to use the species without killing them. This whale watching business attracts 1 million visitors a year, which results in a profit of $80 million.
There are many commercial whale-watching operations on both the humpback's summer and winter ranges:

	North Atlantic	**North Pacific**	**Southern Hemisphere**
Summer	New England, Nova Scotia and Newfoundland, the northern St. Lawrence River, the Snaefellsnes peninsula in the west of Iceland	California, Alaska, Oregon, Washington, British Columbia	Antarctica, Bahía Solano and Nuquí in Colombia
Winter	Samaná Province of the Dominican Republic, the Bay of Biscay France,	Hawaii, Baja, the Bahía de Banderas off Puerto Vallarta	Sydney, Byron Bay north of Sydney, Hervey Bay north of Brisbane, North and East of Cape Town, New Zealand,

the Tongan islands,

As with other cetacean species, however, a mother whale is generally extremely protective of her infant, and places herself between any boat and her calf before moving quickly away from the vessel. Skilled tour operators avoid stressing the mother.

Famous humpbacks

Migaloo

A presumably albino humpback whale that travels up and down the east coast of Australia has become famous in the local media, on account of its extremely rare all-white appearance. Migaloo is the only known all-white humpback whale in the world. First sighted in 1991 and believed to be 3–5 years old at that time, Migaloo is a word for "white fella" from one of the languages of the Aboriginals, the Indigenous Australians. Speculation about Migaloo's sex was resolved in October 2004 when researchers from Southern Cross University collected sloughed skin samples from Migaloo as he migrated past Lennox Head, and subsequent genetic analysis of the samples proved he is a male. Because of the intense interest, environmentalists feared that he was becoming distressed by the number of boats following him each day. In response, the Queensland and New South Wales governments introduce legislation each year to create a 500 m (1600 ft) exclusion zone around the whale. Recent close up pictures have shown Migaloo to have skin cancer and/or skin cysts as a result of his lack of protection from the sun.

In 2006, a white calf was spotted with a normal humpback mother in Byron Bay, New South Wales.

This current whale watching season, NSW Parks and Wildlife Services has been monitoring the movement of whales up and down its coastline and while Migaloo is yet to be spotted in warmer waters, an official sighting off Fraser Island has been recorded.

Humphrey

One of the most notable humpback whales is Humphrey the Whale, twice-rescued by The Marine Mammal Center and other concerned groups in California. In 1985, Humphrey swam into San Francisco Bay and then up the Sacramento River towards Rio Vista. Five years later, Humphrey returned and became stuck on a mudflat in San Francisco Bay immediately north of Sierra Point below the view of onlookers from the upper floors of the Dakin Building. He was pulled off the mudflat with a large cargo net and the help of the Coast Guard. Both times he was successfully guided back to the Pacific Ocean using a "sound net" in which people in a flotilla of boats made unpleasant noises behind the whale by banging on steel pipes, a Japanese fishing technique known as "oikami." At the same time, the attractive sounds of humpback whales preparing to feed were broadcast from a boat headed towards the open ocean. Since leaving the San Francisco Bay in 1990 Humphrey has been seen only once, at the Farallon Islands in 1991.

Delta and Dawn

A humpback whale mother and calf captivated the San Francisco Bay Area in May 2007. This pair appeared to have gotten lost on their Northern migration, swam into the bay and up the Sacramento River as far as the Port of Sacramento. First spotted on 13 May, the whales inspired intense news coverage and were named Delta and Dawn. Whale fans became worried as the whales, both injured with what were possibly cuts caused by boat propellers, continued their stay in the brackish waters, despite efforts to get them to return to the sea. Unexpectedly, on 20 May they headed back towards the bay, but they tarried near the Rio Vista bridge for 10 days. Finally, on Memorial Day weekend, they left Rio Vista, California; passing Tuesday night, 29 May, through the Golden Gate out to the Pacific Ocean.

Mister Splashy Pants

Mister Splashy Pants is a humpback in the south Pacific Ocean. It's being tracked with a satellite tag by Greenpeace as a part of its Great Whale Trail Expedition. The whale's name was chosen in an online poll that garnered attention from several websites, including Boing Boing and Reddit. The name "Mister Splashy Pants" received over 78% of the votes.

Colin

Colin was the name given to a presumably abandoned starving humpback calf that was discovered in August 2008 at Pittwater, north of Sydney, Australia. It attempted to suckle from moored boats to obtain food. Despite attempts to reunite the calf with whale pods by luring it out to sea, it returned to Pittwater. Opinion was divided on how best to handle the situation, with some advocating feeding artificial milk formula to the calf, and others advocating euthanasia.

Colin was euthanised on 22 August 2008 due to his deteriorating condition. The calf's plight gained media attention as far afield as the United States, United Kingdom, Italy, Netherlands, Russia, Canada and New Zealand.

A subsequent autopsy found that Colin was terminally ill with an emaciated pancreas, ulcers of the stomach and oesophagus, intestinal erosion and infected shark bites. The calf was estimated to be only 7 to 10 days old and must have been separated from its mother shortly after birth.

Thames beaching

On 12 September 2009, a humpback was seen in the London Thames for the first time ever. The 9.5m young male was found beached and dead near Dartford bridge two days later on 14 September. Initial examination of the body suggested death had been by starvation, without any explanation of why this had occurred. Experts suggested that such events as these indicated the expansion of the areas colonised by humpbacks.

"George & Gracie"

George and Gracie were a pair of fictional humpbacks which featured prominently in *Star Trek IV: The Voyage Home*. In the film, Earth is threatened by large object that transmits a signal disabling the global power system and causing extreme weather patterns to develop. Spock determines the alien signal matches the song of humpback whales, extinct on Earth since the mid-21st century (at least 200 years). The crew devises a plan to go back in time, before the extinction, and return with a whale. Arriving in the late 20th century, Kirk and Spock are able to quickly discover a pair of humpback whales, "George" and "Gracie", at the Cetacean Institute, an aquarium devoted exclusively to whales, and are told by the Institute's whale expert, Dr. Gillian Taylor, that the whales are shortly going to be released into the wild, making the pair ideal for their needs. Despite some upsets and the threat of whalers, the crew is able to return to the future, splashing down into San Francisco Bay, where Kirk releases the whales from the cargo hold. The whales respond to the alien signal, causing the object to restore Earth to its normal condition and to return to the depths of outer space.

Industrial Light & Magic created the visual effects. Most shots of the humpback whales were scale models shot at their studio or life-size animatronics shot at Paramount However, some of the shots, including a scene of a whale breaching are stock footage of actual animals.

Chapter 8

Haast's Eagle

Haast's Eagle

Artist's rendition of a Haast's Eagle attacking moa
Conservation status

Extinct (IUCN 3.1)
Scientific classification
Kingdom: Animalia
Phylum: Chordata
Class: Aves
Order: Accipitriformes
Family: Accipitridae
Genus: †***Harpagornis***
Species: †***H. moorei***
Binomial name
Harpagornis moorei Haast, 1872

Haast's Eagle (*Harpagornis moorei*) was a species of massive eagles that once lived on the South Island of New Zealand. The species was the largest eagle known to have existed. Its prey consisted mainly of gigantic flightless birds that were unable to defend themselves from the striking force and speed of these eagles, which at times reached 80 km/h (50 mph). The Haast's Eagle became extinct about 1400 CE, when its major food sources, the moa, were hunted to extinction by humans living on the island and much of its dense-forest habitat was cleared.

Name

A model on display at Te Papa of a Haast's Eagle attacking a moa with its large talons

It is believed that these birds are described in many legends of the Māori, under the names *Pouakai*, *Hokioi*, or *Hakawai*. However, it has been ascertained that the "Hakawai" and "Hokioi" legends refer to the *Coenocorypha* snipe – in particular the extinct South Island subspecies. According to an account given to Sir George Gray, an early governor of New Zealand, Hokioi were huge black-and-white predators with a red crest and yellow-green tinged wingtips. In some Māori legends, Pouakai kill humans, which scientists believe could have been possible if the name relates to the eagle, given the massive size and strength of the bird.

Size and habits

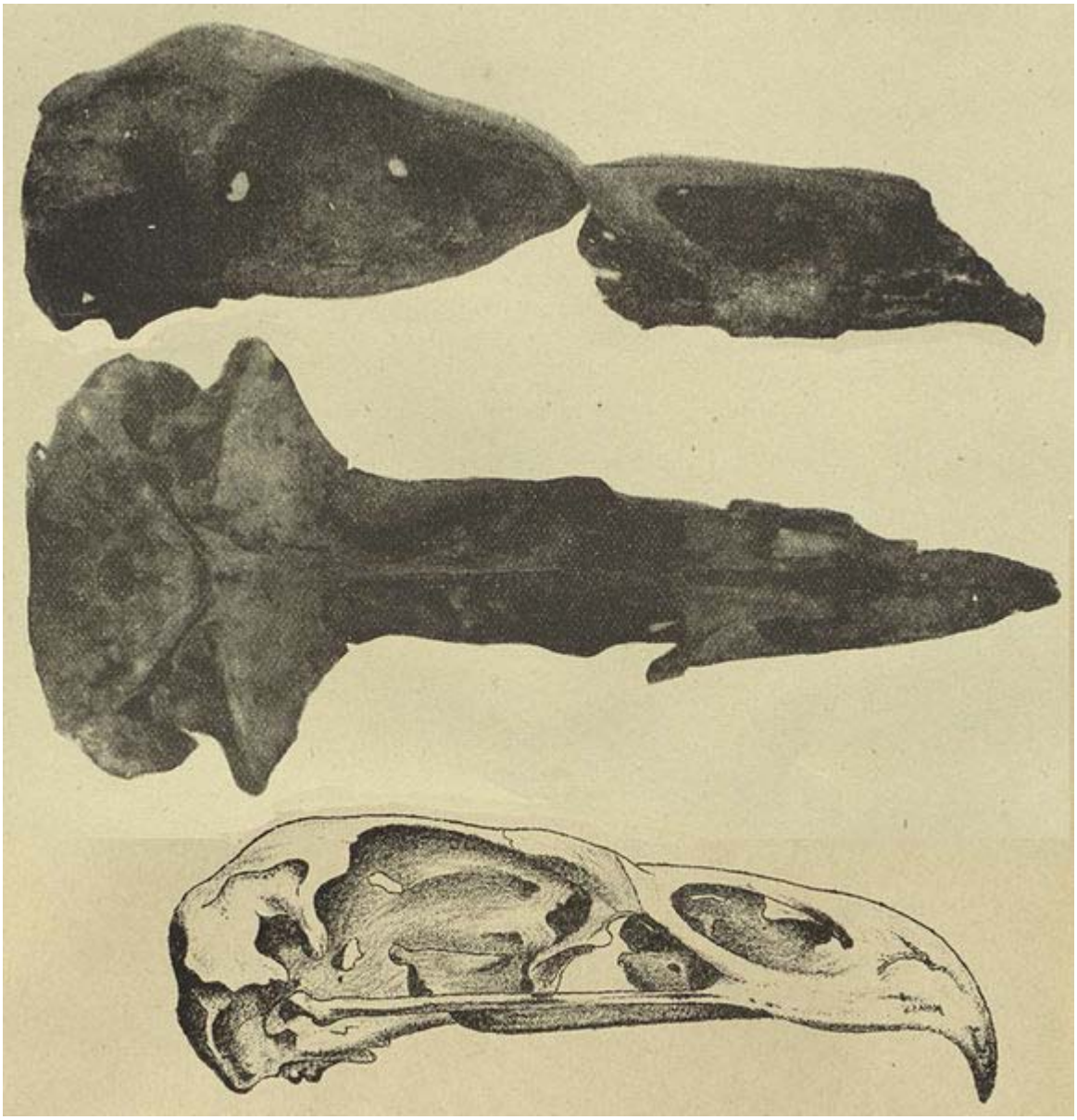
Haast's Eagles were the largest known true raptors, slightly larger even than the largest living vultures. Female eagles are significantly larger than males. Females of the Haast species are believed to have weighed 10–15 kg (22–33 lb) and males 9–12 kg (20–26 lb). They had a relatively short wingspan, measuring roughly 2.6–3 m (8 ft 6 in–9 ft 10 in). This wingspan is similar to that of some extant eagles (the wingspan now reported in large specimens of Golden Eagles and Steller's Sea Eagles). Even the largest extant eagles, however, are about forty percent smaller in body size than the size of Haast's Eagles.

Short wings may have aided Haast's Eagles when hunting in the dense scrubland and forests of New Zealand. Haast's Eagle sometimes is portrayed incorrectly as having evolved toward flightlessness, but this is not so; rather it represents a departure from the mode of its ancestors' soaring flight, toward higher wing loading.

The strong legs and massive flight muscles of these eagles would have enabled the birds to take off with a jumping start from the ground, despite their great weight. The tail was almost certainly long, up to 50 cm (20 inches) in female specimens, and very broad. This characteristic would compensate for the reduction in wing area by providing additional lift. Total length is estimated to have been up to 1.4 m (4 ft 7 in) in females, with a standing height of approximately 90 cm (2 ft 11 in) tall or perhaps slightly greater.

Haast's Eagles preyed on large, flightless bird species, including the moa, which was up to fifteen times the weight of the eagle. It is estimated to have attacked at speeds up to 80 km/h (50 mph), often seizing its prey's pelvis with the talons of one foot and killing with a blow to the head or neck with the other. Its size and weight indicate a bodily striking force equivalent to a cinder block falling from the top of an eight-storey building. Its large beak also could be used to rip into the internal organs of its prey and death then would have been caused by blood loss. In the absence of other large predators or scavengers, a Haast's Eagle easily could have monopolised a single large kill over a number of days.

Extinction



Skull

Early human settlers in New Zealand (the Māori arrived around 1280 CE) preyed heavily on large flightless birds, including all moa species, eventually hunting them to extinction. The loss of its natural prey caused the Haast's Eagle to become extinct as well around 1400 CE, when the last of its natural food sources were depleted.

A noted explorer, Charles Edward Douglas, claims in his journals that he had an encounter with two raptors of immense size in Landsborough River valley (probably during the 1870s), and that he shot and ate them. These birds might have been a last remnant of the species, but some might argue that there had not been suitable prey for a

population of Haast's Eagle to maintain itself for about five hundred years before that date, and 19th century Māori lore was adamant that the *pouakai* was a bird not seen in living memory. Still, Douglas' observations on wildlife generally are trustworthy; a more probable explanation, given that the alleged three-metre wingspan described by Douglas is likely to have been a rough estimate, is that the birds were Eyles' Harriers. This was the largest known harrier (the size of a small eagle) — and a generalist predator — and although it is also assumed to have become extinct in prehistoric times, its dietary habits alone make it a more likely candidate for late survival.

Until recent human colonisation that introduced rodents and cats, the only mammals found on the islands of New Zealand were three species of bat, one of which recently has become extinct. Free from terrestrial mammalian competition and predatory threat, birds occupied or dominated all major niches in the New Zealand animal ecology because there were no threats to their eggs and chicks by small terrestrial animals. Moa were grazers, functionally similar to deer or cattle in other habitats, and Haast's Eagles were the hunters who filled the same niche as top-niche mammalian predators, such as tigers or lions.

Classification

Comparative morphology of Haast's Eagle with its closest living relative, the Little Eagle

DNA analysis has shown that this raptor is related most closely to the much smaller Little Eagle as well as the Booted Eagle (both of these two species were recently reclassified as belonging to the genus *Aquila*) and not, as previously thought, to the large Wedge-tailed Eagle. Thus, *Harpagornis moorei* may be reclassified as *Aquila moorei*, pending confirmation. *H. moorei* may have diverged from these smaller eagles as recently as 700,000 to 1.8 million years ago. Its increase in weight by ten to fifteen times over that period is the greatest and quickest evolutionary increase in weight of any known vertebrate. This was made possible in part by the presence of large prey and the absence of competition from other large predators.

Haast's Eagle was first classified by Julius von Haast in the 1870s, who named it *Harpagornis moorei* after George Henry Moore, the owner of the Glenmark Estate where bones of the bird had been found.

Chapter 9

Lion's Mane Jellyfish

Lion's mane jellyfish

Conservation status
Not evaluated (IUCN 3.1)
Scientific classification [e]
Kingdom: Animalia
Phylum: Cnidaria
Subphylum: Medusozoa
Class: Scyphozoa
Order: Semaeostomeae
Family: Cyaneidae
Genus: *Cyanea*
Species: ***C. capillata***
Binomial name

Cyanea capillata
(Linnaeus, 1758)

The **lion's mane jellyfish** (***Cyanea capillata***) is the largest known species of jellyfish. Its range is confined to cold, boreal waters of the Arctic, northern Atlantic, and northern Pacific Oceans, seldom found farther south than 42°N latitude. Similar jellyfish, which may be the same species, are known to inhabit seas near Australia and New Zealand. The largest recorded specimen found, washed up on the shore of Massachusetts Bay in 1870, had a bell (body) with a diameter of 2.3 m (7 feet 6 inches) and tentacles 36.5 m (120 feet) long.

Taxonomy

Cyanea sp.

The taxonomy of *Cyanea* species is not fully agreed; some zoologists have suggested that all species within the genus should be treated as one. Two distinct taxa, however, occur together in at least the eastern North Atlantic, with the blue jellyfish (*Cyanea lamarckii* Péron & Lesueur, 1810) differing in blue (not red) color and smaller size (10–20 cm diameter, rarely 35 cm). Populations in the western Pacific around Japan are sometimes distinguished as *Cyanea nozakii* Kisinouye, 1891, or as a race, *Cyanea capillata nozakii*.

Sting

Most encounters cause temporary pain and localized redness. In normal circumstances, and in healthy individuals, their stings are not known to be fatal.

Description

Although capable of attaining a bell diameter of 2.5 m (8 feet), these jellyfish can greatly vary in size, those found in lower latitudes are much smaller than their far northern counterparts with bells about 50 cm (20 inches) in diameter. The tentacles of larger specimens may trail as long as 30 m (90 feet) or more. These extremely sticky tentacles are grouped into eight clusters, each cluster containing over 100 tentacles, arranged in a series of rows.

At 120 feet in length, the largest known specimen was longer than a Blue Whale and is generally considered the longest known animal in the world. However, in 1864, a Bootlace worm was found washed up on a Scottish shore that was 180 feet long. But because bootlace worms can easily stretch to several times their natural length, it is possible the worm did not actually grow to be that length.

The bell is divided into eight lobes, giving it the appearance of an eight-pointed star. An ostentatiously tangled arrangement of colorful arms emanates from the centre of the bell, much shorter than the silvery, thin tentacles which emanate from the bell's subumbrella.

Size also dictates coloration—larger specimens are a vivid crimson to dark purple while smaller specimens grade to a lighter orange or tan. These jellyfish are understandably named for their showy, trailing tentacles reminiscent of a lion's mane.

Ecology

A coldwater species, this jellyfish cannot cope with warmer waters. The jellyfish are pelagic for most of their lives but tend to settle in shallow, sheltered bays towards the end of their one-year lifespan. In the open ocean, lion's mane jellyfish act as floating oases for certain species, such as shrimp, medusafish, butterfish, harvestfish, and juvenile prowfish, providing both a reliable source of food and protection from predators.

Predators of the lion's mane jellyfish include seabirds, larger fish, other jellyfish species, and sea turtles. The jellyfish themselves feed mostly on zooplankton, small fish, ctenophores, and moon jellies.

Behavior and reproduction

Small, dead Lion's Mane jelly washing up on the beach

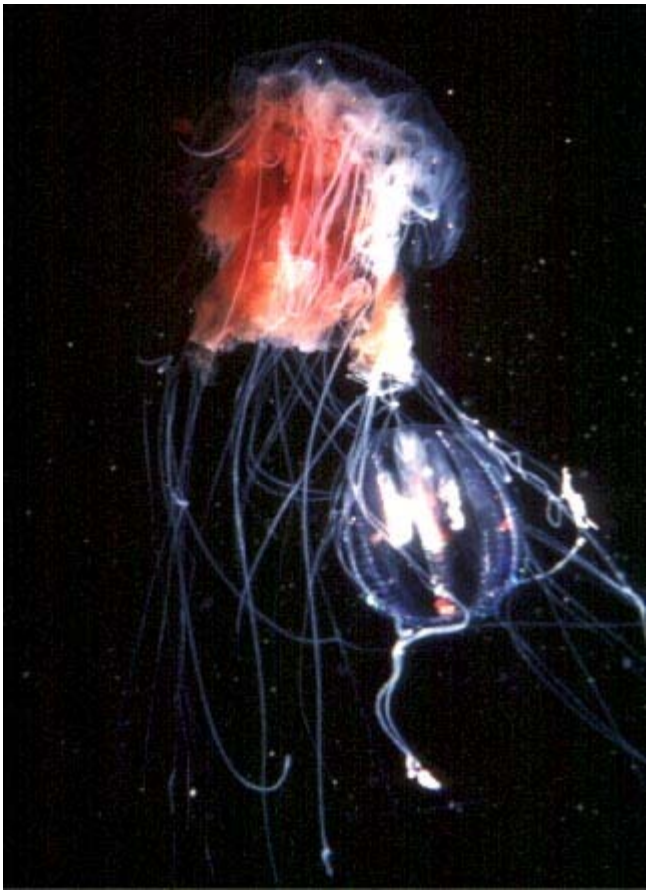
Lion's mane jellyfish remain mostly very near the surface at no more than 20 m depth, their slow pulsations weakly driving them forwards; they depend on ocean currents whereby the jellies travel great distances. The jellyfish are most often spotted during the late summer and autumn, when they have grown to a large size and the currents begin to sweep them closer to shore.

Like other jellyfish, Lions manes are capable of both sexual reproduction in the medusa stage and asexual reproduction in the polyp stage. Lion's mane jellyfish have four different stages in their year long life span, a larval stage, a polyp stage, an ephyrae stage

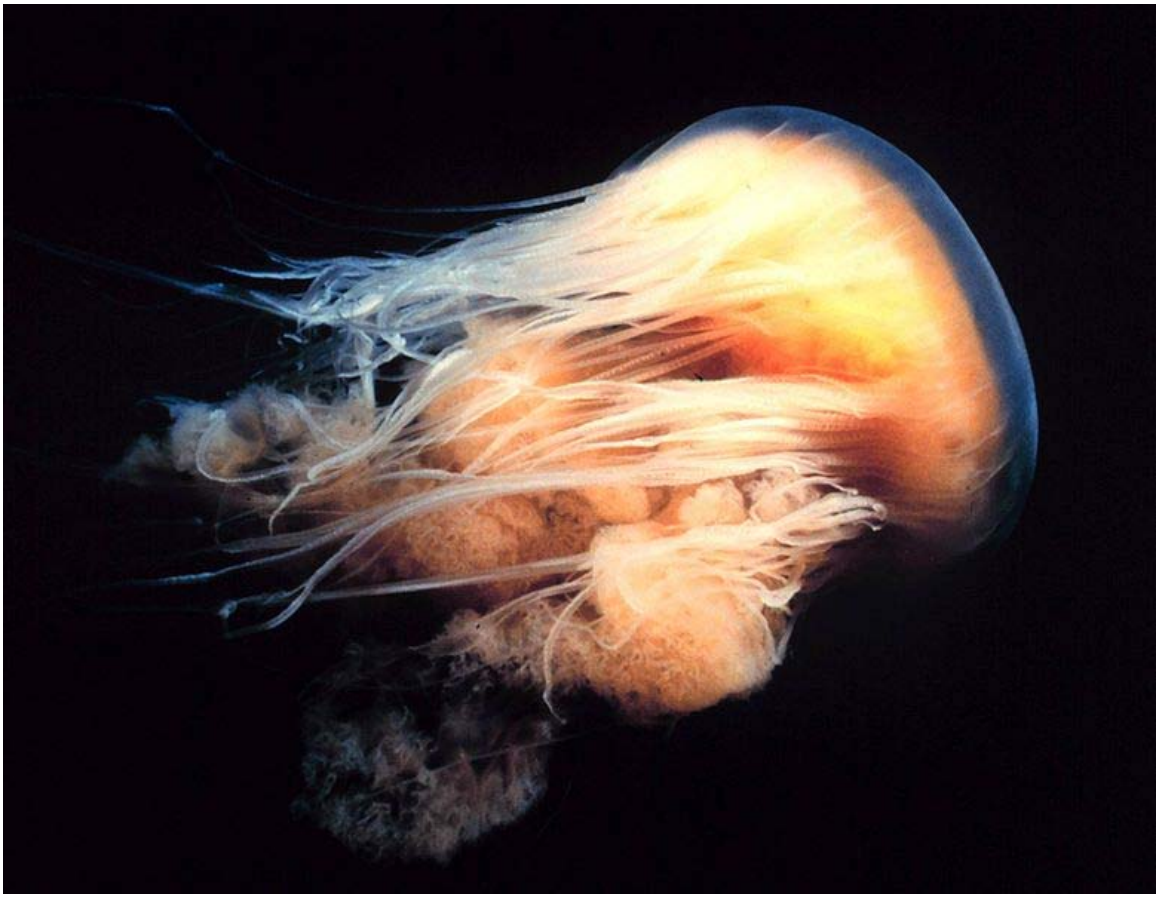
and the medusa stage. The female jellyfish carries its fertilized eggs in its tentacle where the eggs grow into larva. When the larva are old enough, the female deposits them on a hard surface where the larva soon grow into polyps. The polyps begin to reproduce asexually, creating stacks of small creatures called ephyraes. The individual ephyraes break off the stacks, where they eventually grow into the medusa stage and become full grown jellyfish.

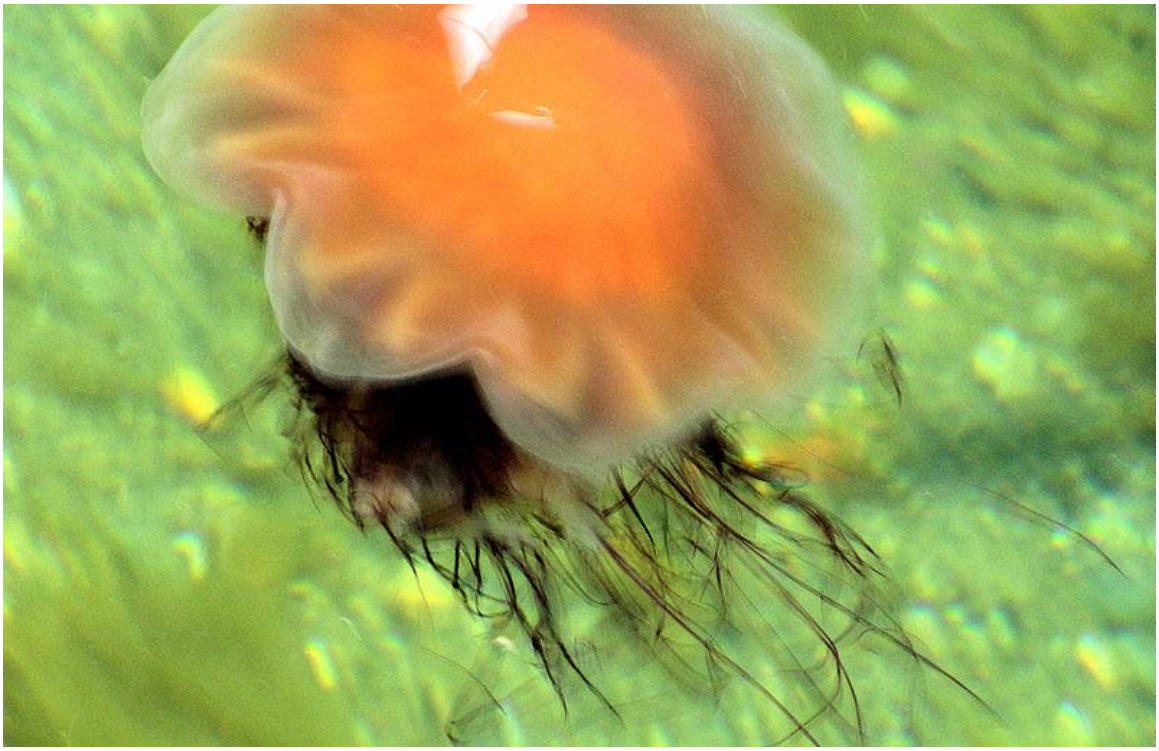
Human contact

On July 21, 2010, 50 to 100 people are thought to have been stung by the remains of a dead Lion's mane jellyfish that had broken up into countless pieces in Rye, New Hampshire in the United States. Considering the size of the species, it is possible but not likely that this mass incident was caused by a single specimen.



A lion's mane jelly capturing a sea gooseberry





Top view, Bonne Bay, NL, Canada

Chapter 10

Moa

Moa
Temporal range: Miocene–Holocene
Miocene - 1500 AD (Holocene)

Restoration of *Megalapteryx didinus*

Conservation status

Extinct (IUCN 3.1)

Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Aves
Superorder:	Paleognathae
Order:	Struthioniformes
Family:	†**Dinornithidae** (Bonaparte, 1853)

Genera

†*Anomalopteryx* bush moa or lesser moa
†*Euryapteryx* stout-legged moa or coastal moa
†*Megalapteryx* upland moa
†*Dinornis* giant moa
†*Emeus* eastern moa
†*Pachyornis* Mappin's moa, heavy-footed moa, or crested moa

Diversity

6 genera, 11 species

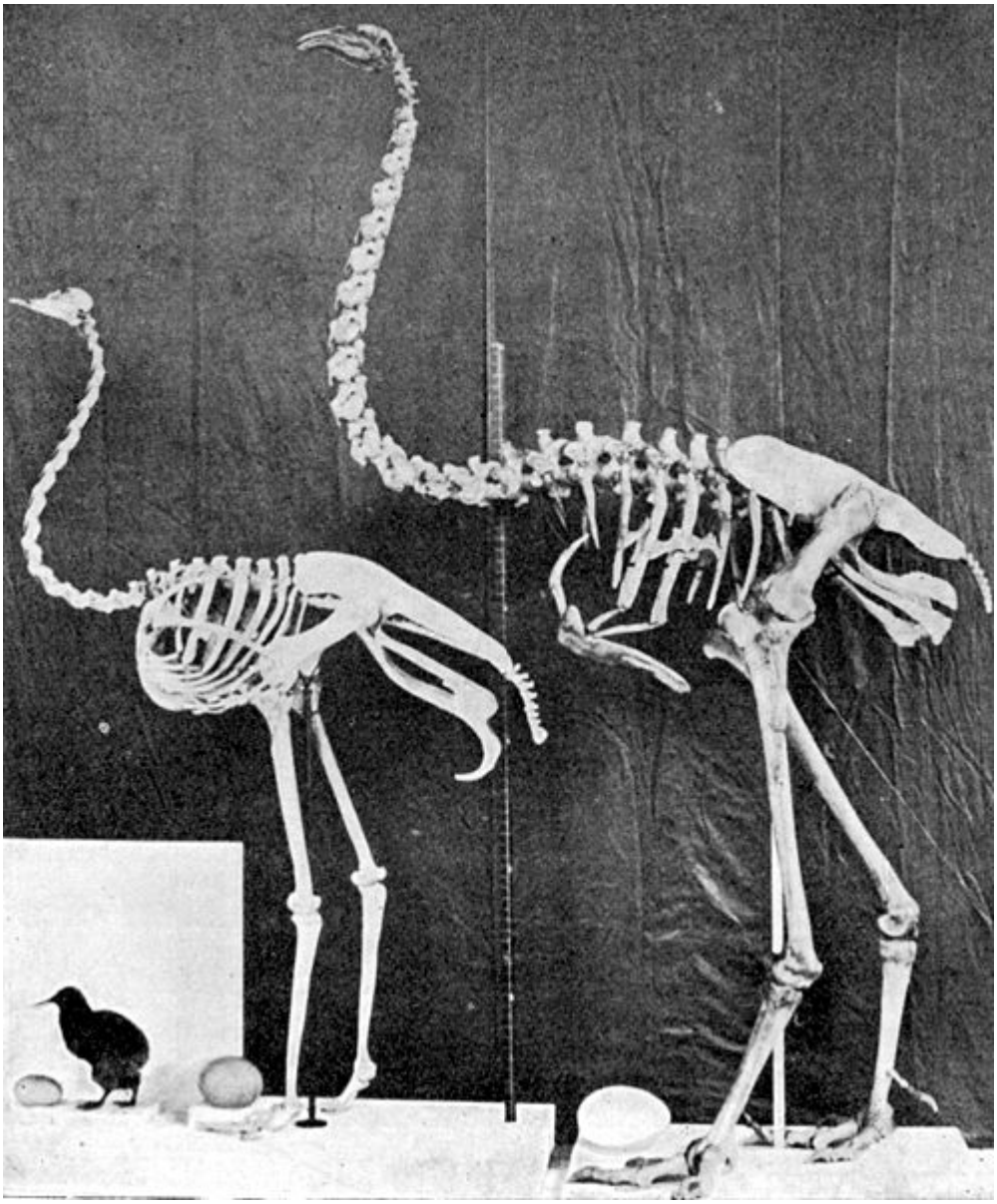
Synonyms

Dinornithes

The **moa** were eleven species (in six genera) of flightless birds endemic to New Zealand. The two largest species, *Dinornis robustus* and *Dinornis novaezelandiae*, reached about 3.7 m (12 ft) in height with neck outstretched, and weighed about 230 kg (510 lb).

Moa are members of the order Struthioniformes (or ratites) although some sources also recognise these as the separate order Dinornithiformes. The eleven species of moa are the only wingless birds, lacking even the vestigial wings which all other ratites have. They were the dominant herbivores in New Zealand forest, shrubland and subalpine ecosystems for thousands of years, and until the arrival of the Māori were hunted only by the Haast's Eagle. It is generally considered that most, if not all, species of Moa died out by Maori hunting and habitat decline before European discovery and settlement.

Taxonomy



Comparison of a kiwi, ostrich, and *Dinornis*, each with its egg

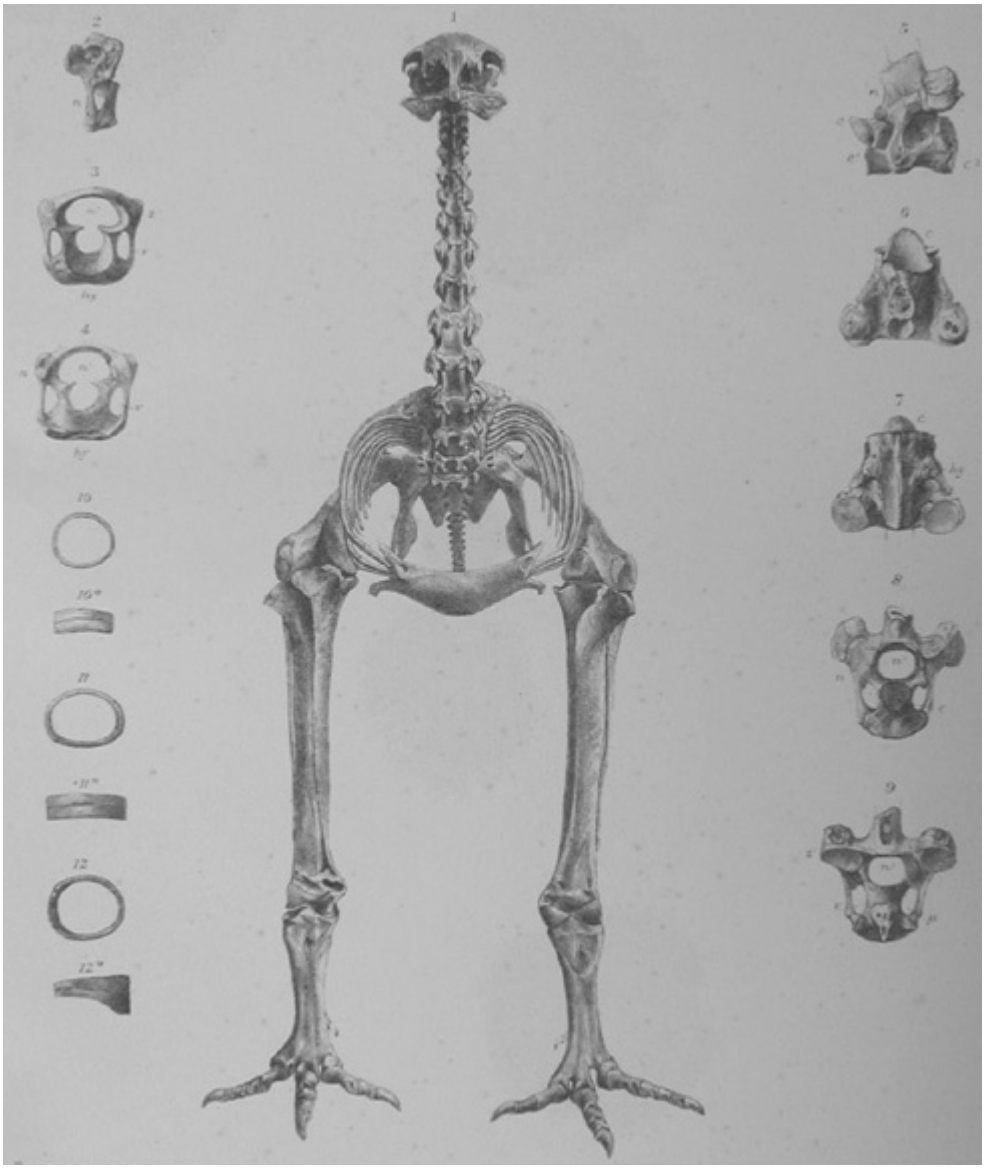
The kiwi were formerly regarded as the closest relatives of the moa, but comparisons of their DNA in a paper published in 2005 suggested moa were more closely related to the Australian emu and cassowary. However research published in 2010 found that the moa's closest cousins were not the emu and cassowary but smaller terrestrial South American birds called the tinamous which are able to fly.

Although dozens of species were described in the late 19th century and early 20th century, many were based on partial skeletons and turned out to be synonyms. Currently, eleven species are formally recognised, although recent studies using ancient DNA recovered from bones in museum collections suggest that distinct lineages exist within some of these. One factor that has caused much confusion in moa taxonomy is the intraspecific variation of bone sizes, between glacial and inter-glacial periods as well as sexual dimorphism being evident in several species. *Dinornis* seems to have had the most pronounced sexual dimorphism, with females being up to 150% as tall and 280% as heavy as males—so much bigger that they were formerly classified as separate species until 2003.

Although moa were traditionally reconstructed in an upright position to create impressive height, analysis of their vertebral articulation indicates that they probably carried their heads forward, in the manner of a kiwi. This would have allowed them to graze on low-level vegetation, while being able to lift their heads and browse trees when necessary.

Ancient DNA analyses have determined that there were a number of cryptic evolutionary lineages in several moa genera. These may eventually be classified as species or subspecies; *Megalapteryx benhami* (Archey) which is synonymised with *M. didinus* (Owen) because the bones of both share all essential characters. Size differences can be explained by a north-south cline combined with temporal variation such that specimens were larger during the Otiran glacial period (the last ice age in New Zealand). Similar temporal size variation is known for the North Island *Pachyornis mappini*. Some of the other 'Large' ranges in variation for moa species can probably be explained by similar geographic and temporal factors.

Sometimes, the Dinornithidae are considered to be a full order (Dinornithiformes), in which case the subfamilies listed below would be advanced to full family status (replacing "-inae" with "-idae").



Anomalopteryx didiformus skeleton

Emeus crassus fossil, Zoologisk Museum, Copenhagen

Thus, the currently recognised genera and species are:

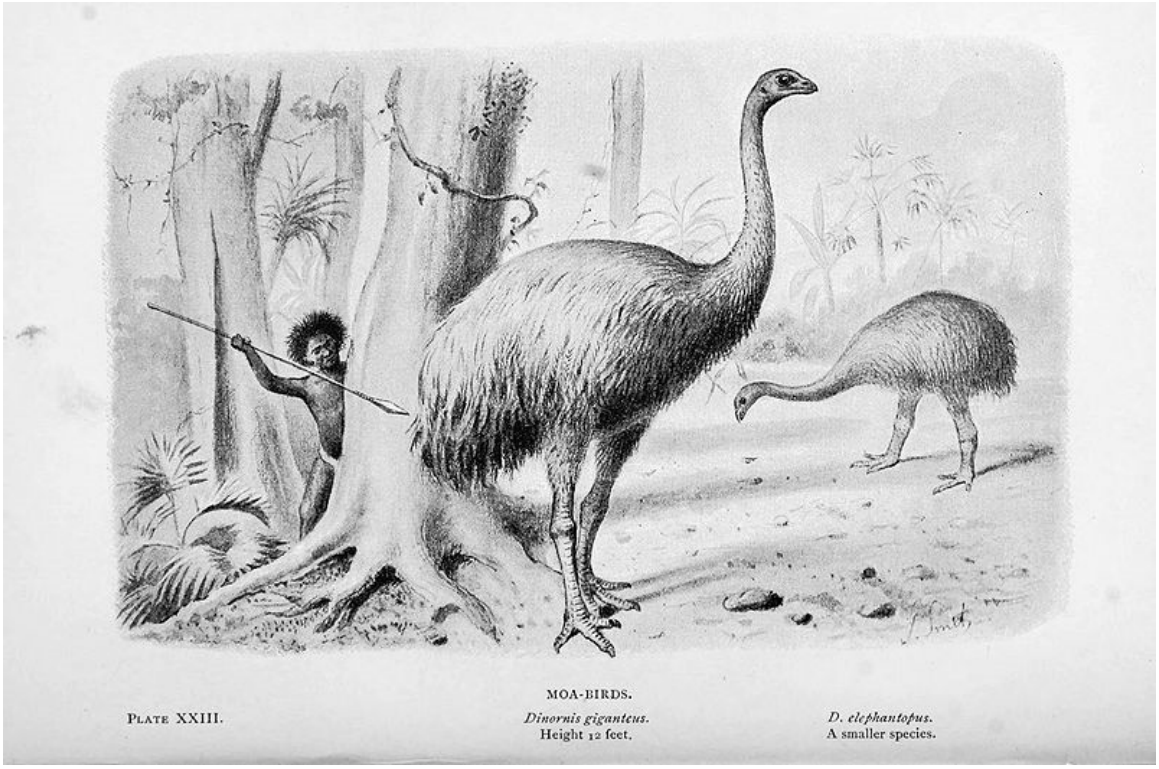
- Family †**Dinornithidae** - Moa
  - Subfamily **Megalapteryginae** - Megalapteryx Moa
    - Genus ***Megalapteryx***
      - Upland Moa, *Megalapteryx didinus (South Island, New Zealand)*
  - Subfamily **Anomalopteryginae** - Lesser Moa
    - Genus ***Anomalopteryx***
      - Bush Moa, *Anomalopteryx didiformis* (South Island, New Zealand)

        - Genus ***Euryapteryx***
            - North Island Broad-billed Moa, *Euryapteryx curtus* (North Island, New Zealand)
            - Stout-legged Moa, *Euryapteryx geranoides* (South Island, New Zealand)
        - Genus ***Emeus***
            - Eastern Moa, *Emeus crassus* (South Island, New Zealand)
        - Genus ***Pachyornis***
            - Heavy-footed Moa, *Pachyornis elephantopus* (South Island, New Zealand)
            - Mappin's Moa, *Pachyornis mappini* (North Island, New Zealand)
            - Crested Moa, *Pachyornis australis* (South Island, New Zealand)
            - *Pachyornis* new lineage A (North Island, New Zealand)
            - *Pachyornis* new lineage B (South Island, New Zealand)
    - Subfamily **Dinornithinae** - Giant Moa
        - Genus ***Dinornis***
            - *Dinornis struthoides* (South Island, New Zealand)
            - North Island Giant Moa, *Dinornis novaezealandiae* (North Island, New Zealand)
            - South Island Giant Moa, *Dinornis giganteus* (South Island, New Zealand)
            - *Dinornis* new lineage A (South Island, New Zealand)
            - *Dinornis* new lineage B (South Island, New Zealand)

Regional faunas

Analyses of fossil moa bone assemblages have provided detailed data on the habitat preferences of individual moa species, and revealed distinctive regional moa faunas:

South Island



Restoration of *Dinornis giganteus* and *Pachyornis elephantopus*, both from the South Island

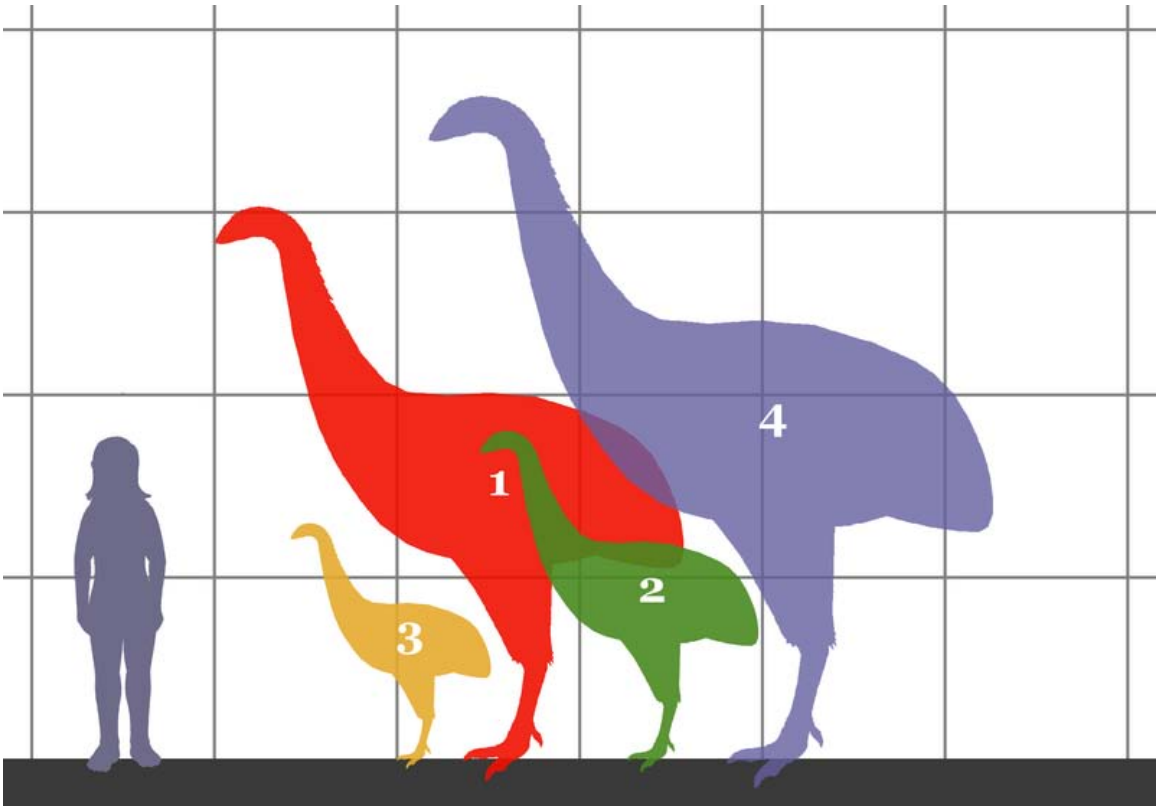
The two main faunas identified in the South Island include: 1. The fauna of the high rainfall west coast beech (*Nothofagus*) forests that included *Anomalopteryx didiformis* and *Dinornis giganteus*; and 2. The fauna of the dry rainshadow forest and shrublands east of the Southern Alps that included *Pachyornis elephantopus*, *Euryapteryx gravis*, *Emeus crassus* and *Dinornis robustus*. The two other moa species that existed in the South Island; *Pachyornis australis* and *Megalapteryx didinus* might be included in a 'subalpine fauna', along with the widespread *Dinornis robustus*. *P. australis* is the rarest of the moa species, and the only one yet to have been found in Maori middens. Its bones have been found in caves in the northwest Nelson and Karamea districts (such as Honeycomb Hill Cave), and some sites around the Wanaka district. *M. didinus* is more widespread. Its name 'upland moa' reflects the fact its bones are commonly found in the subalpine zone. However, it also occurred down to sea level where there was suitable steep and rocky terrain (such as Punakaiki on the west coast and Central Otago).

North Island

Significantly less is known about North Island paleofaunas, due to a paucity of fossil sites compared to the South Island; however, the basic pattern of moa-habitat relationships were the same. Although the South Island and the North Island shared some moa species

(*Euryapteryx gravis*, *Anomalopteryx didiformis*), most were exclusive to one island, reflecting divergence over several thousand years since lower sea level had resulted in a land bridge across Cook Strait. In the North Island, *Dinornis novaezealandiae* and *Anomalopteryx didiformis* dominated in high rainfall forest habitat; a similar pattern to the South Island. The other moa species present in the North Island (*Euryapteryx gravis*, *E. curtus*, and *Pachyornis geranoides*) tended to inhabit drier forest and shrubland habitats. *P. geranoides* occurred throughout the North Island, while the distributions of *E. gravis* and *E. curtus* were almost mutually exclusive, the former having only been found in coastal sites around the southern half of the North Island.

Biology



Size comparison between 4 moa species and a human. **1.** *D. giganteus*. **2.** *E.crassus*. **3.** *A. didiformis* **4.** *D. novaezelandiae*

Evolution

Because moa are a group of flightless birds with no vestiges of wing bones, questions have been raised about how they arrived in New Zealand, and from where. It is suggested that ancestral moa were already in New Zealand as it broke away from Antarctica 70 million years ago. Cretaceous Antarctica, as evidenced by plant fossils, was subtropical, and supported an environment lush with vegetation. Richard Dawkins suggests that Antarctica, "provided a clement and ratite-friendly land bridge linking Africa and South America on one side of the world to Australia and New Zealand on the other...".

Sexual Dimorphism

It has been long suspected that the pairs of species of moa described as *Euryapteryx curtus*/*E. exilis*, *Emeus huttonii*/*E. crassus*, and *Pachyornis septentrionalis*/*P. mappini* constituted males and females, respectively. This has been confirmed by analysis for sex-specific genetic markers of DNA extracted from bone material. For example, prior to 2003 there were three species of *Dinornis* recognised: South Island giant moa (*D. giganteus*), North Island giant moa (*D. novaezealandiae*) and slender moa (*D. struthioides*). However, DNA showed that all *D. struthioides* were in fact males, and all *D. giganteus* were females. Therefore the three species of *Dinornis* were reclassified as two species, one each formerly occurring on New Zealand's North Island (*D. novaezealandiae*) and South Island (*D. robustus*); *robustus* however, comprises three distinct genetic lineages and may eventually be classified as many species as discussed above.

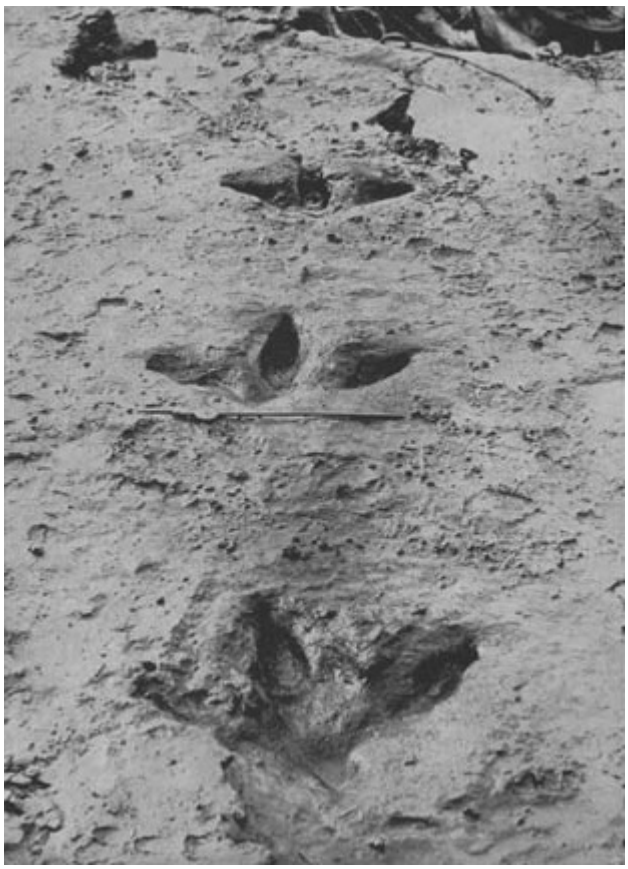
Diet

Dinornis giganteus skull at the Museum für Naturkunde, Berlin

Although feeding moa were never observed by scientists their diet has been deduced from fossilised contents of their gizzards, coprolites, as well as indirectly through morphological analysis of skull and beak, and stable isotope analysis of their bones. Moa fed on a range of plant species and plant parts, including fibrous twigs and leaves taken from low trees and shrubs. The beak of *Pachyornis elephantopus* was analogous to a pair of secateurs, and was able to clip the fibrous leaves of New Zealand flax (*Phormium tenax*) and twigs up to at least 8mm in diameter. Like many other birds, moa swallowed *gizzard stones* (gastroliths), which were retained in their muscular gizzards, providing a grinding action that allowed them to eat coarse plant material. These stones were commonly smooth, rounded quartz pebbles, but stones over 110 millimetres (4 in) in

length have been found amongst preserved moa gizzard contents. *Dinornis* gizzards could often contain several kilograms of stones.

Locomotion



Preserved footprints of a large moa found in 1911

Approximately eight moa trackways, with fossilised moa footprint impressions in fluvial silts have been found throughout the North Island, including Waikanae Creek (1872), Napier (1887), Manawatu River (1895), Marton (1896), Palmerston North (1911), Ragitikei River (1939), and underwater in Lake Taupo (1973). Analysis of the spacing of these tracks indicate walking speeds of between 3 and 5 km/h (1.75–3 mph).

Breeding

Examination of growth rings present in moa cortical bone has revealed that these birds were K-strategists, as are many other large endemic New Zealand birds. They are characterised by having low fecundity and a long maturation period, taking approximately ten years to reach adult size. The large *Dinornis* species took the same length of time to reach adult size as small moa species, and as a result had accelerated rate of skeletal growth during their juvenile years.

Eggs

Fragments of moa eggshell are often encountered in archaeological sites and sand dunes around the New Zealand coast. Thirty six whole moa eggs exist in museum collections and vary greatly in size (from 120–240 millimetres (4.7–9.4 in) in length and 91–178 millimetres (3.6–7.0 in) wide). The outer surface of moa eggshell is characterised by small slit-shaped pores. The eggs of most moa species were white, although those of the upland moa (*Megalapteryx didinus*) were blue-green. A 2010 study by Huynen et al. has found that the eggs of certain species were fragile, only around a millimeter in thickness: "Unexpectedly, several thin-shelled eggs were also shown to belong to the heaviest moa of the genera *Dinornis*, *Euryapteryx* and *Emeus*, making these, to our knowledge, the most fragile of all avian eggs measured to date. Moreover, sex-specific DNA recovered from the outer surfaces of eggshells belonging to species of *Dinornis* and *Euryapteryx* suggest that these very thin eggs were likely to have been incubated by the lighter males. The thin nature of the eggshells of these larger species of moa, even if incubated by the male, suggests that egg breakage in these species would have been common if the typical contact method of avian egg incubation was used." Despite the bird's extinction, the high yield of DNA available from recovered fossilized eggs has allowed the moa to have its genome sequenced.

Nests

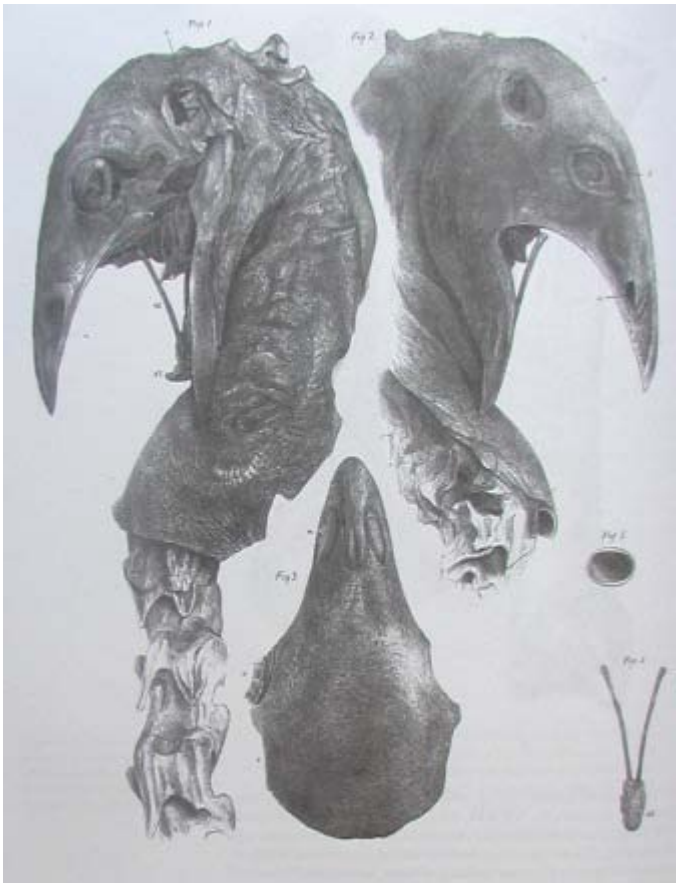
There is no evidence to suggest that moa were colonial nesters. While evidence of moa nesting is often inferred from accumulations of eggshell fragments found in caves and rock shelters, little evidence exists of the nests themselves. Excavations of rock shelters in the eastern North Island during the 1940s uncovered moa nests, which were described as "*small depressions obviously scratched out in the soft dry pumice*". Moa nesting material has also been recovered from rock shelters in the Central Otago region of the South Island, where the dry climate has resulted in the preservation of plant material used to construct the nesting platform (including twigs that have been clipped by moa bills). Seeds and pollen within moa coprolites found amongst the nesting material provide evidence that the nesting season was late spring to summer.

Vocalisation

Although there is no surviving record of what sounds moa made, some idea of their calls can be gained from fossil evidence. The trachea of moa were supported by many small rings of bone known as tracheal rings. Excavation of these rings from articulated skeletons has shown that at least two moa genera (*Euryapteryx* and *Emeus*) exhibited tracheal elongation, that is, their trachea were up to 1 metre (3 ft) long and formed a large loop within the body cavity. These are the only ratites known to exhibit this feature, which is also present in several other bird groups including swans, cranes and guinea fowl. The feature is associated with deep, resonant vocalisations that can travel long distances.

Feathers and soft tissues

Preserved *Megalapteryx* foot, Natural History Museum



Megalapteryx didinus head

Several remarkable examples of moa remains have been found that exhibit soft tissues (muscle, skin, feathers), preserved through desiccation when the bird died in a naturally dry site (for example, a cave with a constant dry breeze blowing through it). Most of these specimens have been found in the semi-arid Central Otago region, the driest part of New Zealand. These include:

- Dried muscle on bones of a female *Dinornis robustus* found at Tiger Hill in the Manuherikia River Valley by gold miners in 1864 (currently held by Yorkshire Museum)
- Several bones of *Emeus crassus* with muscle attached, and a row of neck vertebrae with muscle, skin and feathers collected from Earnscleugh Cave near the town of Alexandra in 1870 (currently held by Otago Museum)
- An articulated foot of a male *Dinornis robustus* with skin and foot pads preserved found in a crevice on the Knobby Range in 1874 (currently held by Otago Museum)
- The type specimen of *Megalapteryx didinus* found near Queenstown in 1878
- The lower leg of *Pachyornis elephantopus* with skin and muscle from the Hector Range in 1884; (currently held by the Zoology Department, Cambridge University)

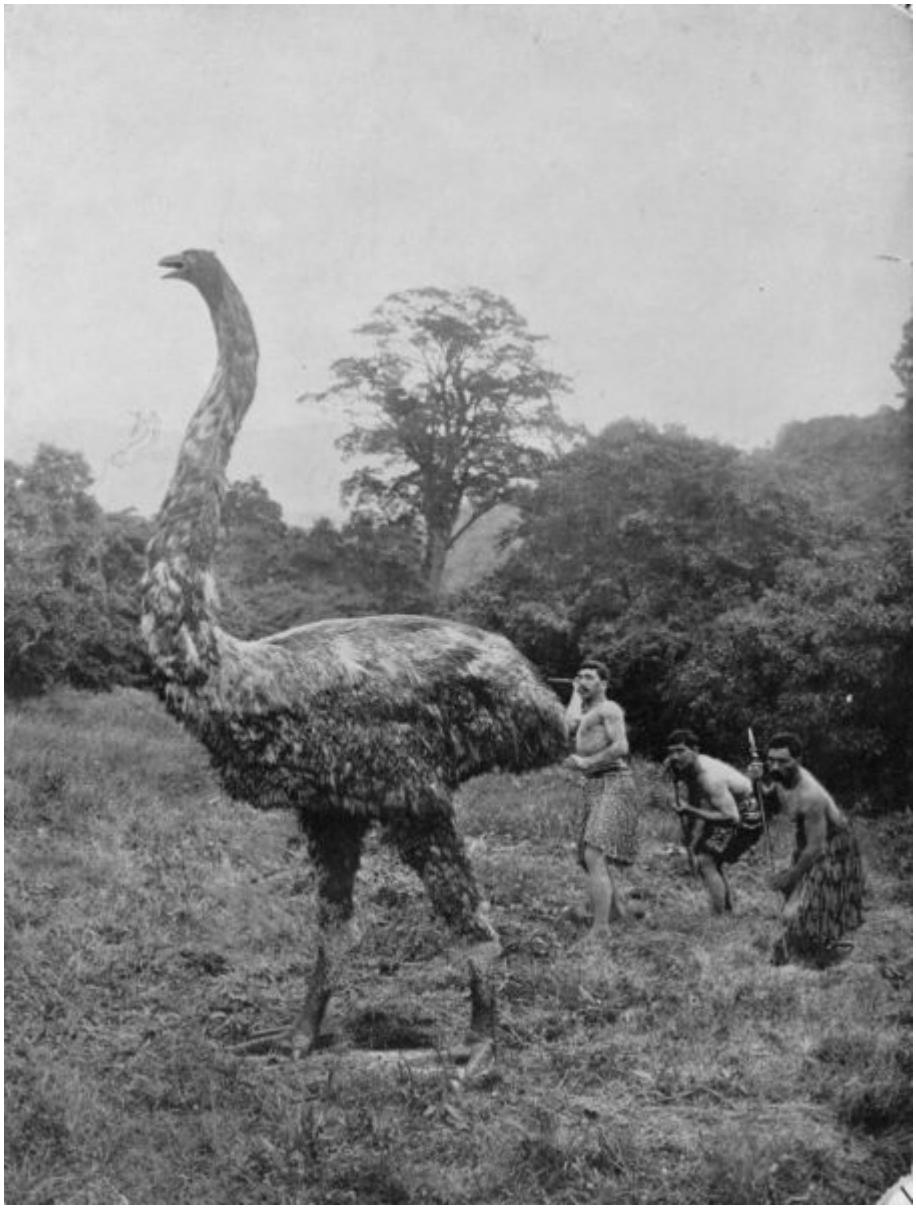
- The complete feathered leg of a *Megalapteryx didinus* from Old Man Range in 1894 (currently held by Otago Museum)
- The head of a *Megalapteryx didinus* found near Cromwell sometime prior to 1949 (currently held by the Museum of New Zealand).

Two specimens are known from outside the Central Otago region:

- A complete foot of *Megalapteryx didinus* found in a cave on Mount Owen near Nelson in 1980s (currently held by the Museum of New Zealand)
- A skeleton of *Anomalopteryx didiformis* with muscle, skin and feather bases collected from a cave near Te Anau in 1980.

In addition to these specimens, loose moa feathers have been collected from caves and rockshelters in the southern South Island, and so some idea of the moa plumage can be gained. The preserved leg of *Megalapteryx didinus* from the Old Man Range reveals that this species was feathered right down to the foot. This is likely to have been an adaptation to living in high altitude snowy environments, and is also seen in the Darwin's Rhea which lives in a similar seasonally snowy habitat. Moa feathers are up to 23 centimetres (9 in) long and a range of colours have been reported, including reddish brown, white, yellowish and purplish. Dark feathers with white or creamy tips have also been found, and indicate that some moa species may have had plumage with a speckled appearance.

Extinction



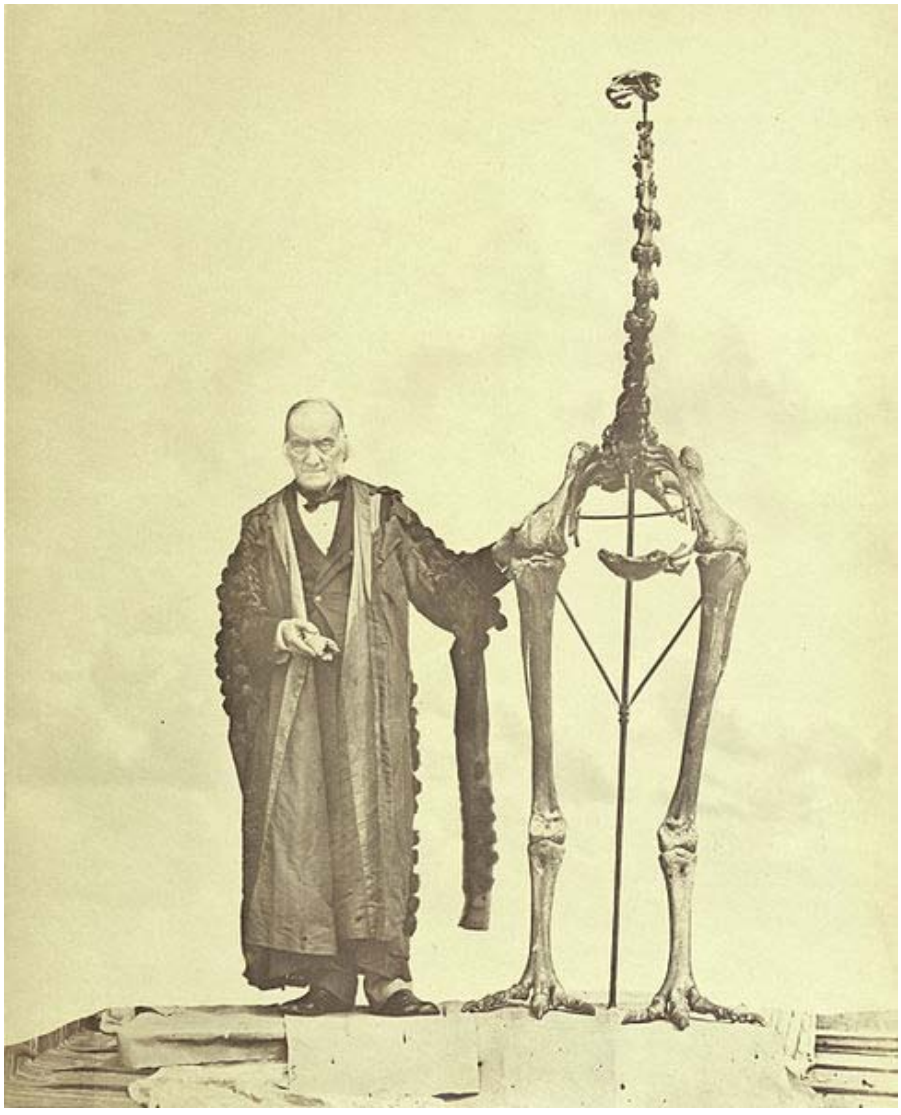
Early 20th century reconstruction of a moa hunt

The moa's only predator was the massive Haast's Eagle—until the arrival of human settlers.

The Māori arrived sometime before A.D. 1300, and all moa genera were soon driven to extinction by hunting and, to a lesser extent, forest clearance. By about A.D. 1400 almost all moa are generally thought to have become extinct, along with the Haast's Eagle which had relied on them for food. Recent research using carbon-14 dating of middens strongly suggests that this took less than a hundred years, rather than the period of exploitation lasting several hundred years which had been earlier believed.

Some authors have speculated that a few *Megalapteryx didinus* may have persisted in remote corners of New Zealand until the 18th and even 19th centuries, but the view is not widely accepted. Some Māori hunters claimed to be in pursuit of the moa as late as the 1770s. Whalers and sealers recalled seeing monstrous birds along the coast of the South Island, and in the 1820s a man named George Pauley made an unverified claim of seeing a moa in the Otago Region of New Zealand. An expedition in the 1850s under Lieutenant A. Impey reported two Emu-like birds on a hillside, on the South Island, and an 1861 story from the Nelson Examiner told of three-toed footprints measuring 36 centimetres (14 in) between Takaka and Riwaka, found by a surveying party, and finally in 1878 the Otago Witness published an account from a farmer and his shepherd.

Discovery by science



Sir Richard Owen with *Dinornis robustus* skeleton

Joel Polack, a trader who lived on the East Coast of the North Island from 1834 to 1837, records in 1838 that he had been shown 'several large fossil ossifications' found near Mt Hikurangi. He was certain that these were the bones of a species of emu or ostrich, noting that 'the Natives add that in times long past they received the traditions that very large birds had existed, but the scarcity of animal food, as well as the easy method of entrapping them, has caused their extermination'. Polack further noted that he had received reports from Māori that a 'species of Struthio' still existed in remote parts of the South Island. Dieffenbach also refers to a fossil from the area near Mt Hikurangi, and surmises that it belongs to 'a bird, now extinct, called Moa (or Movie) by the natives'. In 1839, John W. Harris, a Poverty Bay flax trader who was a natural history enthusiast, was given a piece of unusual bone by a Māori who had found it in a river bank. He showed the 15 centimetres (6 in) fragment of bone to his uncle, John Rule, a Sydney surgeon, who sent it to Richard Owen who at that time was working at the Hunterian Museum at the Royal College of Surgeons in London. Owen became a noted biologist, anatomist and paleontologist at the British Museum.

Owen puzzled over the fragment for almost four years. He established it was part of the femur of a big animal, but it was uncharacteristically light and honeycombed. Owen announced to a skeptical scientific community and the world that it was from a giant extinct bird like an ostrich, and named it *Dinornis*. His deduction was ridiculed in some quarters but was proved correct with the subsequent discoveries of considerable quantities of moa bones throughout the country, sufficient to reconstruct skeletons of the birds.

In July 2004, the Natural History Museum in London placed on display the moa bone fragment Owen had first examined, to celebrate 200 years since his birth, and in memory of Owen as founder of the museum.

Moa bone deposits

Since the discovery of the first moa bones in the late 1830s, thousands more have been found. They occur in a range of late Quaternary and Holocene sedimentary deposits, but are most common in three main types of site:

Caves

Moa bones scattered across the floor of 'Moa Cave', Honeycomb Hill Cave System. This cave is a closed scientific reserve.

Bones are commonly found in Caves or ‘tomo’ (Maori word for doline or sinkhole; often used to refer to pitfalls or vertical cave shafts). The two main ways that the moa bones were deposited in such sites were: 1. Birds that entered the cave to nest or escape bad weather, and subsequently died in the cave; and 2. Birds that fell into a vertical shaft and were unable to escape. Moa bones (and the bones of other extinct birds) have been found in caves throughout New Zealand, especially in the limestone/marble areas of northwest Nelson, Karamea, Waitomo and Te Anau.

Dunes

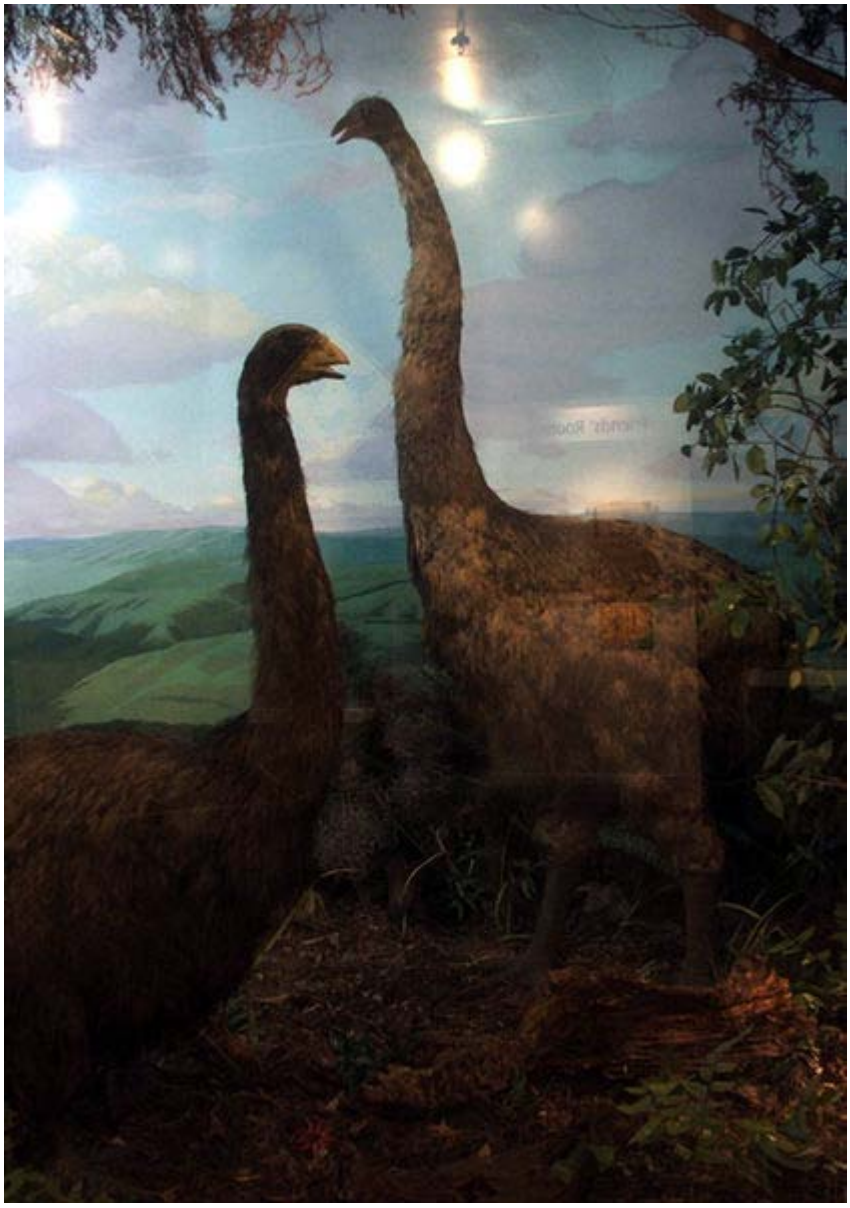
Moa bones and eggshell fragments sometimes occur in active coastal sand dunes, where they may erode from paleosols and concentrate in ‘blowouts’ between dune ridges. Many such moa bones predate human settlement, although some can originate from Maori midden sites which frequently occur in dunes near harbours and river mouths (for example the large moa hunter sites at Shag River, Otago and Wairau Bar, Marlborough).

Swamps/mirings

Densely intermingled moa bones have been encountered in swamps throughout New Zealand. The most well-known example is at Pyramid Valley in north Canterbury, where

bones from at least 183 individual moa have been excavated. Many explanations were proposed to account for how these deposits had formed, ranging from poisonous spring waters to floods and wildfires. However the currently accepted explanation is that the bones accumulated at a slow rate over thousands of years, from birds that had entered the swamps to feed and became trapped in the soft sediment.

Claims of moa survival



Reconstruction of two moa species, Otago Museum, Dunedin. Otago Museum holds the world's largest collection of moa remains.

The moa is thought to be extinct, but there has been occasional speculation—since at least the late 19th century, and as recently as 1993 and 2008—that some moa may still

exist, particularly in the rugged wilderness of South Westland and Fiordland. Cryptozoologists and others reputedly continue to search for them, but their claims and supporting evidence (such as of purported footprints or blurry photos) have earned little attention from mainstream experts, and are widely considered pseudoscientific.

The rediscovery of the takahē in 1948 after none had been seen since 1898 showed that rare birds may exist undiscovered for a long time. However, the takahē is a much smaller bird than the moa, and was rediscovered after its tracks were identified—yet no reliable evidence of moa tracks has ever been found, and experts still contend that moa survival is extremely unlikely, since this would involve the ground-dwelling birds living unnoticed in a region visited often by hunters and hikers.

Chapter 11

Sei Whale

Sei Whale

A sei whale feeding at the surface.

Size compared to an average human

Conservation status

Endangered (IUCN 3.1)

Scientific classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Order:	Cetacea
Suborder:	Mysticeti
Family:	Balaenopteridae
Genus:	*Balaenoptera*

Species: ***B. borealis***

Binomial name

Balaenoptera borealis
Lesson, 1828

Sei whale range,

The **sei whale** is a baleen whale, the third-largest rorqual after the blue whale and the fin whale. It inhabits most oceans and adjoining seas, and prefers deep offshore waters. It avoids polar and tropical waters and semi-enclosed bodies of water. The sei whale migrates annually from cool and subpolar waters in summer to winter in temperate and subtropical waters.

Reaching 20 meters (66 ft) long and weighing as much as 45 tonnes (44 LT; 50 ST), the sei whale daily consumes an average of 900 kilograms (1,984 lb) of food, primarily copepods, krill, and other zooplankton. It is among the fastest of all cetaceans, and can reach speeds of up to 50 kilometres per hour (31 mph) (27 knots) over short distances. The whale's name comes from the Norwegian word for pollock, a fish that appears off the coast of Norway at the same time of the year as the sei whale.

Following large-scale commercial whaling during the late-nineteenth and twentieth centuries, when over 238,000 whales were taken, the sei whale is now internationally protected, although limited hunting occurs under controversial research programmes conducted by Iceland and Japan. As of 2006, its worldwide population was about 54,000, about a fifth of its pre-whaling population.

Etymology

The species was first officially described by French naturalist René Primevère Lesson in 1828, but an earlier description was given by Karl Rudolphi in 1822 (although he assumed it was a minke whale, *Balaenoptera acutorostrala*), leading to occasional references to sei whales as **Rudolphi's rorqual**. Additional names include **pollack whale**, **coalfish whale**, **sardine whale**, or **Japan finner**. Additionally, it has been referred to as the **lesser fin whale** because it somewhat resembles the fin whale. The American naturalist Roy Chapman Andrews compared the sei whale to the cheetah, because it can swim at great speeds "for a few hundred yards", but it "soon tires if the chase is long" and "does not have the strength and staying power of its larger relatives".

Sei is the Norwegian word for pollock, also referred to as coalfish, a close relative of codfish. Sei whales appeared off the coast of Norway at the same time as the pollock, both coming to feed on the abundant plankton. The specific name is the Latin word

borealis, meaning northern. In the Pacific, the whale has been called the Japan finner; "finner" was a common term used to refer to rorquals. In Japanese, the whale was called *iwashi kujira*, or sardine whale, named for a fish that the whale has been observed to eat in the Pacific.

Taxonomy

The sei was classified as *Balaena rostraia*, *Balaena borealis*, *Bataenoptera laticeps*, and *Eulama physalus*, among others, before Lesson's alternative *Balaenoptera borealis* was formalized.

Sei whales are rorquals (family Balaenopteridae), baleens that includes the humpback whale, the blue whale, the Bryde's whale, the fin whale, and the minke whale. Rorquals take their name from the Norwegian word *røyrkval*, meaning "furrow whale", because family members have a series of longitudinal pleats or grooves below the mouth that continue along the body's underside. Balaenopteridae diverged from the other families of suborder Mysticeti, also called the whalebone whales or great whales, as long ago as the middle Miocene. However, little is known about when members of the various families in the Mysticeti, including the Balaenopteridae, diverged from each other.

Two subspecies have been identified—the **northern sei whale** (*Balaenoptera borealis borealis*) and **southern sei whale** (*Balaenoptera borealis schlegelii*). Their ranges do not overlap.

Description

The sei whale is the third-largest Balaenopteridae, after the blue whale (up to 180 tonnes, 200 tons) and the fin whale (up to 70 tonnes, 77 tons). Mature adults typically measure between 12–15 metres (39–49 ft) and weigh 20–30 tonnes (20–30 LT; 22–33 ST). The southern sei whale is larger than the northern. Females are considerably larger than males. The largest known sei whale measured 20 meters (66 ft), and weighed between 40–45 tonnes (39–44 LT; 44–50 ST). The largest specimens taken off Iceland were slightly longer than 16 meters (52 ft). At birth, a calf typically measures 4–5 metres (13–16 ft) in length.

Anatomy

The whale's body is typically a dark steel grey with irregular light grey to white markings on the ventral surface, or towards the front of the lower body. The whale has a series of 32–60 pleats or grooves along the bottom of the body that allow the throat area to expand greatly during feeding. The rostrum is pointed and the pectoral fins are relatively short, only 9%–10% of body length, and pointed at the tips. It has a single ridge extending from the tip of the rostrum to the paired blowholes that are a distinctive characteristic of baleen whales.

The whale's skin is often marked by pits or wounds, which after healing become white scars. These are believed to be caused by ectoparasitic copepods (*Penella* spp.), lampreys (family Petromyzontidae), or possibly "cookie-cutter" sharks (*Isistius brasiliensis*). It has a tall, sickle-shaped dorsal fin that ranges in height from 25–61 centimetres (9.8–24 in), about two-thirds of the way back from the tip of the rostrum. Dorsal fin shape, pigmentation pattern, and scarring have been used to a limited extent in photo-identification studies. The tail is thick and the fluke, or lobe, is relatively small in relation to the size of the whale's body.

A close-up view of baleen plates. The plates are used to strain food from the water

Adults have 300–380 ashy-black baleen plates on each side of the mouth, each about 48 centimeters (18.9 in) long. Each plate is made of fingernail-like keratin that frays out into whitish fine hairs on the ends inside the mouth near the tongue. The sei's very fine baleen bristles, about 0.1 millimetres (0.004 in) are the most reliable characteristic that distinguishes it from other baleen whales.

The sei whale looks similar to other large baleen whales. The best way to distinguish between it and Bryde's whale, apart from differences in baleen plates, is by the presence of lateral ridges on the dorsal surface of the Bryde's whale's rostrum. Large individuals can be confused with fin whales, unless the fin whale's asymmetrical head coloration is clearly seen. The fin whale's lower jaw's right side is white, and the left side is grey. When viewed from the side, the upper edge of the sei's head has a small arch between the tip of the rostrum and eye, while the fin whale's profile is relatively flat.

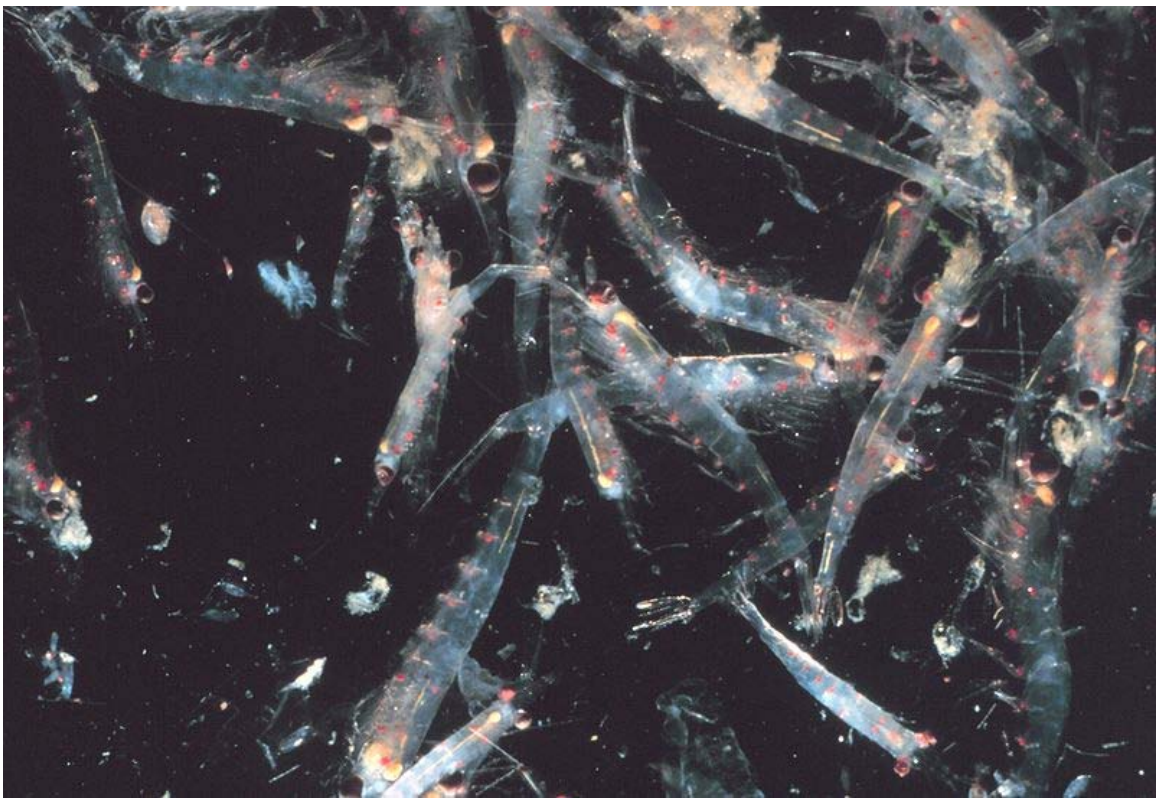
Life history

Sei whales usually travel alone or in groups of up to six individuals. Larger groups may assemble at particularly abundant feeding grounds. Very little is known about their social structure. Males and females may bond, but this is uncertain.

The sei whale is among the fastest cetaceans. It can reach speeds of up to 50 kilometres per hour (27 kn) over short distances. However, it is not a remarkable diver, reaching relatively shallow depths for five to fifteen minutes. Between dives, the whale surfaces

for a few minutes, remaining visible in clear, calm waters, with blows occurring at intervals of about 40–60 seconds. Unlike the fin whale, the sei whale tends not to rise high out of the water as it dives. The blowholes and dorsal fin are often exposed above the water surface simultaneously. The whale almost never extends its flukes above the surface, and it rarely breaches.

Feeding



Krill, shrimp-like marine invertebrate animals, are one of the sei whale's primary foods.

This rorqual is a filter feeder, using its baleen plates to obtain its food by opening its mouth, engulfing large amounts of the water containing the food, then straining the water out through the baleen, trapping any food items inside its mouth.

The sei whale feeds near the surface of the ocean, swimming on its side through swarms of prey to obtain its average of about 900 kilograms (1,984 lb) of food each day. For an animal of its size, for the most part, its preferred foods lie unusually relatively low in the food chain, including zooplankton and small fish. The whale's diet preferences has been determined from stomach analyses, direct observation of feeding behavior., and analyzing fecal matter collected near them, which appears as a dilute brown cloud. The feces are collected in nets and DNA is separated, individually identified, and matched with known species. The whale competes for food against clupeid fish (herring and its relatives), basking sharks, and right whales.

In the North Atlantic, it feeds primarily on calanoid copepods, specifically *Calanus finmarchicus*, with a secondary preference for euphausiids, in particular *Meganyctiphanes norvegica* and *Thysanoessa inermis*. In the North Pacific, it feeds on similar zooplankton, including the copepod species *Calanus cristatus*, *Calanus plumchrus*, and *Calanus pacificus*, and euphausid species *Euphausia pacifica*, *Thysanoessa inermis*, *Thysanoessa longipes*, and *Thysanoessa spinifera*. In addition, it eats larger organisms, such as the Japanese flying squid, *Todarodes pacificus pacificus*, and small fish, including members of the *Engraulis* (anchovies), *Cololabis* (sauries), *Sardinops* (pilchards), and *Trachurus* (jack mackerels) genera. Some of these fish are commercially important. Off central California, the whale may feed on anchovies between June and August, and on krill (*Euphausia pacifica*) during September and October. In the Southern Hemisphere, prey species include the copepods *Calanus tonsus*, *Calanus simillimus*, and *Drepanopus pectinatus*, as well as the euphausids *Euphausia superba* and *Euphausia vallentini*. Sei whales also eat sardines.

Reproduction

Mating occurs in temperate, subtropical seas during the winter. Gestation is estimated to vary around 10 3/4 months, 11 1/4 months, or one year, depending which model of foetal growth is used. The different estimates result from scientists' inability to observe an entire pregnancy; most reproductive data for baleen whales were obtained from animals caught by commercial whalers, which offers only a single snapshot of fetal growth. Researchers attempt to extrapolate conception dates by comparing fetus size and characteristics with newborns.

A newborn is weaned from its mother at 6–9 months of age, when it is 11–12 metres (36–39 ft) in length, so weaning takes place at the summer or autumn feeding grounds. Females reproduce every 2–3 years, with as many as six fetuses reported, but single births are far more common. The average age of sexual maturity of both sexes is 8–10 years, at a length of around 12 meters (39 ft) for males and 13 meters (43 ft) for females. The whales can reach ages of up to 65 years.

Vocalizations

The sei whale makes long, loud, low-frequency sounds. Relatively little is known about specific calls, but in 2003, observers noted sei whale calls in addition to sounds that could be described as "growls" or "whooshes" off the coast of the Antarctic Peninsula. Many calls consisted of multiple parts at different frequencies. This combination distinguishes the their calls from those of other whales. Most calls lasted about a half second, and occurred in the 240–625 hertz range, well within the range of human hearing. The maximum volume of the vocal sequences is reported as 156 decibels relative to 1 micropascal (μPa) at a reference distance of one meter. An observer situated one meter from a vocalizing whale would perceive a volume roughly equivalent to the volume of a jackhammer operating two meters away.

Range and migration

Sei whales live in all oceans, although rarely in polar or tropical waters. The difficulty of distinguishing the at sea from their close relatives, Bryde's whales and in some cases from fin whales, creates confusion about their range and population, especially in warmer waters where Bryde's whales are most common.

In the North Atlantic, its range extends from southern Europe or northwestern Africa to Norway, and from the southern United States to Greenland. The southernmost confirmed records are strandings along the northern Gulf of Mexico and in the Greater Antilles. Throughout its range, the whale tends to avoid semi-enclosed bodies of water, such as the Gulf of Mexico, the Gulf of Saint Lawrence, Hudson Bay, the North Sea, and the Mediterranean Sea. It occurs predominantly in deep water, occurring most commonly over the continental slope, in basins situated between banks, or submarine canyon areas.

In the North Pacific, it ranges from 20°N–23°N latitude in the winter, and from 35°N–50°N latitude in the summer. Approximately 75% of the North Pacific population lives east of the International Date Line, but there is little information regarding the North Pacific distribution. Two whales tagged in deep waters off California were later recaptured off Washington and British Columbia, revealing a possible link between these areas, but the lack of other tag recovery data makes these two cases inconclusive. In the Southern Hemisphere, summer distribution based upon historic catch data is between 40–50°S latitude, while winter distribution is unknown.

Migration

In general, the sei whale migrates annually from cool and subpolar waters in summer to temperate and subtropical waters for winter, where food is more abundant. In the northwest Atlantic, sightings and catch records suggest the whales move north along the shelf edge to arrive in the areas of Georges Bank, Northeast Channel, and Browns Bank by mid to late June. They are present off the south coast of Newfoundland in August and September, and a southbound migration begins moving west and south along the Nova Scotian shelf from mid-September to mid-November. Whales in the Labrador Sea as early as the first week of June may move farther northward to waters southwest of Greenland later in the summer. In the northeast Atlantic, the sei whale winters as far south as West Africa, and follows the continental slope northward in spring. Large females lead the northward migration and reach the Denmark Strait earlier and more reliably than other sexes and classes, arriving in mid-July and remaining through mid-September. In some years, males and younger females remain at lower latitudes during the summer months.

Despite knowing some general migration patterns, exact routes are not known and scientists cannot readily predict exactly where groups will appear from one year to the next. F.O. Kapel noted a correlation between appearances west of Greenland and the incursion of relatively warm waters from the Irminger Current into that area. Some

evidence from tagging data indicates individuals return off the coast of Iceland on an annual basis.

Whaling

Photo of harpoon in anchored harpoon gun

The development of explosive harpoons and steam-powered whaling ships in the late nineteenth century brought previously unobtainable large whales within reach of commercial whalers. Initially their speed and elusiveness, and later the comparatively small yield of oil and meat partially protected them. Once stocks of more profitable right whales, blue whales, fin whales, and humpback whales became depleted, sei whales were hunted in earnest, particularly from 1950-1980.

North Atlantic

In the North Atlantic between 1885 and 1984, 14,295 sei whales were taken. They were hunted in large numbers off the coast of Norway and Scotland beginning in the late

nineteenth and early twentieth centuries, and in 1885 alone, more than 700 were caught off Finnmark, Norway. Their meat was a popular Norwegian food. The meat's value made the hunting of this difficult-to-catch species profitable in the early twentieth century.

In Iceland, a total of 2,574 whales were taken from the Hvalfjörður whaling station between 1948 and 1985. Since the late 1960s to early 1970s, the sei whale has been second only to the fin whale as the preferred target of Icelandic whalers, with meat in greater demand than whale oil, the prior target.

Small numbers were taken off the Iberian Peninsula, beginning in the 1920s by Spanish whalers, off the Nova Scotian shelf in the late 1960s and early 1970s by Canadian whalers, and off the coast of West Greenland from the 1920s to the 1950s by Norwegian and Danish whalers.

North Pacific

In the North Pacific, the total reported catch by commercial whalers was 72,215 between 1910 and 1975; the majority were taken after 1947. Shore stations in Japan and Korea, processed 300–600 each year between 1911 and 1955. In 1959, the Japanese catch peaked at 1,340. Heavy exploitation in the North Pacific began in the early 1960s, with catches averaging 3,643 per year from 1963 to 1974 (total 43,719; annual range 1,280–6,053). In 1971, after a decade of high catches, it became scarce in Japanese waters, ending commercial whaling in 1975.

Off the coast of North America, sei whales were hunted off British Columbia from the late 1950s to the mid 1960s, when the number of whales captured dropped to around 14 per year. More than 2,000 were caught in British Columbia waters between 1962 and 1967. Between 1957 and 1971, California shore stations processed 386 whales. Commercial Sei whaling ended in the eastern North Pacific in 1971.

Southern Hemisphere

A total of 152,233 were taken in the Southern Hemisphere between 1910 and 1979. Whaling in southern oceans originally targeted humpback whales. By 1913, this species became rare, and the catch of fin and blue whales began to increase. As these species likewise became scarce, sei whale catches increased rapidly in the late 1950s and early 1960s. The catch peaked in 1964-65 at over 20,000 sei whales, but by 1976, this number had dropped to below 2,000 and commercial whaling for the species ended in 1977.

Post-protection whaling

Since the moratorium on commercial whaling, some sei whales have been taken by Icelandic and Japanese whalers under the IWC's scientific research programme. Iceland carried out four years of scientific whaling between 1986 and 1989, killing up to 40 sei whales a year. Japanese scientists catch about 50 sei whales each year for this purpose.

The research is conducted by the Institute of Cetacean Research (ICR) in Tokyo, a privately-funded, nonprofit institution. The main focus of the research is to examine what they eat and to assess the competition between whales and fisheries. Dr. Seiji Ohsumi, Director General of the ICR, said,

> "It is estimated that whales consume 3 to 5 times the amount of marine resources as are caught for human consumption, so our whale research is providing valuable information required for improving the management of all our marine resources."

He later added,

> "...Sei whales are the second most abundant species of whale in the western North Pacific, with an estimated population of over 28,000 animals. [It is] clearly not endangered."

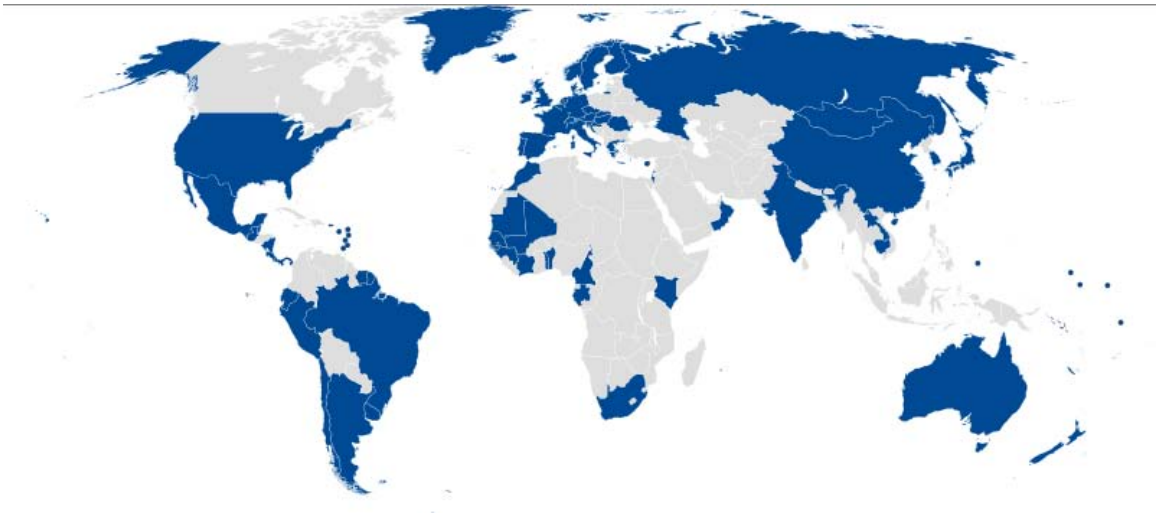
Conservation groups, such as the World Wildlife Fund, dispute the value of this research, claiming that sei whales feed primarily on squid and plankton which are not hunted by humans, and only rarely on fish. They say that the program is

> "nothing more than a plan designed to keep the whaling fleet in business, and the need to use whales as the scapegoat for overfishing by humans."

At the 2001 meeting of the IWC Scientific Committee, 32 scientists submitted a document expressing their belief that the Japanese program lacked scientific rigour and would not meet minimum standards of academic review.

In 2010, a Los Angeles restaurant confirmed to be serving sei whale meat was closed by its owners after prosecution by authorities for handling a protected species.

Conservation status



Member states of the International Whaling Commission (in blue)

The sei whale did not have meaningful international protection until 1970, when the International Whaling Commission (IWC) first set catch quotas for the North Pacific for individual species. Before quotas, there were no legal limits. Complete protection from commercial whaling in the North Pacific came in 1976.

Quotas on sei whales in the North Atlantic began in 1977. Southern Hemisphere stocks were protected in 1979. Facing mounting evidence that several whale species were threatened with extinction, the IWC established a complete moratorium on commercial whaling beginning in 1986.

In the late 1970s, some "pirate" whaling took place in the eastern North Atlantic. There is no direct evidence of illegal whaling in the North Pacific, although the acknowledged misreporting of whaling data by the Soviet Union means that catch data are not entirely reliable.

The species remained listed on the IUCN Red List of Threatened Species in 2000, categorized as "endangered". Northern Hemisphere populations are listed as CITES Appendix II, indicating they are not immediately threatened with extinction, but may become so if they are not listed. Populations in the Southern Hemisphere are listed as CITES Appendix I, indicating they are threatened with extinction if trade is not halted.

The species is listed as endangered by the U.S. government National Marine Fisheries Service under the U.S. Endangered Species Act.

Population estimates

The current population is estimated at 54,000, about one fifth of the pre-whaling population. A 1991 study in the North Atlantic estimated only 4,000. Sei whales were said to have been scarce in the 1960s and early 1970s off northern Norway. One possible explanation for this disappearance is that the whales were overexploited. The drastic reduction in northeastern Atlantic copepod stocks during the late 1960s may be another culprit. Surveys in the Denmark Strait found 1,290 whales in 1987, and 1,590 whales in 1989. Nova Scotia's population estimates are between 1,393 and 2,248, with a minimum of 870.

A 1977 study estimated Pacific Ocean totals of 9,110, based upon catch and CPUE data. Japanese interests claim this figure is outdated, and in 2002 claimed the western North Pacific population was over 28,000, a figure not accepted by the scientific community. In California waters, there was only one confirmed and five possible sightings by 1991 to 1993 aerial and ship surveys, and there were no confirmed sightings off Oregon and Washington. Prior to commercial whaling, the North Pacific hosted an estimated 42,000. By the end of whaling, the population was down to between 7,260 and 12,620.

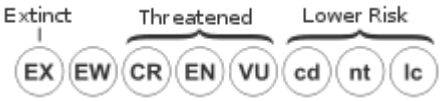
In the Southern Hemisphere, population estimates range between 9,800 and 12,000, based upon catch history and CPUE. The IWC estimated 9,718 whales based upon survey

data between 1978 and 1988. Prior to commercial whaling, there were an estimated 65,000.

Chapter 12

Swordfish

Swordfish Temporal range: 33.9–0 Ma Early Oligocene to Present

Conservation status

Data Deficient (IUCN 2.3)
Scientific classification
Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Subclass: Neopterygii
Infraclass: Teleostei
Order: Perciformes
Family: **Xiphiidae**
Genus: ***Xiphias***
Species: ***X. gladius***
Binomial name
Xiphias gladius Linnaeus, 1758

Swordfish also known as **broadbill** in some countries, are large, highly migratory, predatory fish characterized by a long, flat bill. They are a popular sport fish of the billfish category, though elusive. Swordfish are elongated, round-bodied, and lose all teeth and scales by adulthood. These fish can live close to shore. They reach a maximum

size of 14 ft 9 in (455 cm) and 1,400 lb (650 kg). The International Game Fish Association's all-tackle angling record for a swordfish was a 1,182 lb (536.15 kg) specimen taken off Chile in 1953.

They are the sole member of their family **Xiphiidae**.

Physiology

The swordfish is named after its sharp beak resembling a sword (Latin **gladius**), which together with its streamlined physique allows it to cut through the water with great ease and agility. Contrary to popular belief, the "sword" is not used to spear, but instead may be used to slash at its prey in order to injure the prey animal, to make for an easier catch. Mainly the swordfish relies on its great speed, capable of reaching speeds up to 50 mph (80 km/h), and agility in the water to catch its prey. One possible defensive use for the sword-like bill is for protection from its few natural predators. The shortfin mako shark is one of the rare sea creatures big enough and fast enough to chase down and kill an adult swordfish, but they don't always win. Sometimes in the struggle with a shark a swordfish can kill it by ramming it in the gills or belly.

Like most fish, the females grow larger than the males, with males over 300 lb (135 kg) being rare. Females mature at 4–5 years of age in northwest Pacific while males mature first at about 3 to 4 years. In the North Pacific, batch spawning occurs in water warmer than 24°C from March to July and year round in the equatorial Pacific. Adult swordfish forage includes pelagic fish including small tuna, dorado, barracuda, flying fish, mackerel, forage fish as well as benthic species of hake and rockfish. Squid are important when available. Swordfish are thought to have few predators as adults although juveniles are vulnerable to predation by large pelagic fish.

Swordfish skeleton at the National Museum of Natural History, Washington, DC

While swordfish are cold-blooded animals, they have special organs next to their eyes to heat their eyes and also their brain. Temperatures of 10 to 15 °C above the surrounding water temperature have been measured. The heating of the eyes greatly improves the vision, and consequently improves their ability to catch prey. Out of the 25,000+ species of bony fish, only about 22 are known to have the ability to heat selected body parts above the temperature of the surrounding water. These include the swordfish, marlin, and tuna.

Swordfish are not schooling fish. They swim alone or in very loose aggregations, separated by as much as 10 meters from a neighboring swordfish. They are frequently found basking at the surface, airing their first dorsal fin. Boaters report this to be a beautiful sight, as is the powerful jumping for which the species is known. This jumping, also called breaching, is thought by some researchers to be an effort to dislodge pests, such as remora or lampreys. It could also be a way of surface feeding by stunning small fish as they jump out of the water, making the fish more easily captured for food.

Swordfish feed daily, most often at night when they rise to surface and near-surface waters in search of smaller fish. They have been observed moving through schools of fish, thrashing their swords to kill or stun their prey and then quickly turning to consume their catch. In the western North Atlantic, squid is the most popular food item consumed. But fish, such as menhaden, mackerel, bluefish, silver hake, butterfish, and herring also contribute to the swordfish diet.

Swordfish are vigorous, powerful fighters. When hooked or harpooned, they have been known to dive so quickly that they have impaled their swords into the ocean bottom up to their eyes. Although there are no reports of unprovoked attacks on humans, swordfish can be very dangerous when harpooned. They have run their swords through the planking of small boats when hurt.

The adults have few natural enemies, with the exception of large sharks, sperm whales, and orcas. They are easily frightened by small boats, yet paradoxically, large craft are often able to draw very near without scaring them. This makes swordfish easy to harpoon.

The swordfish is often mistaken for other billfish (like marlin), but upon examination their physiology is quite different.

Reproduction

Swordfish have been observed spawning in the Atlantic Ocean, in water less than 250 ft (75 m) deep. Estimates vary considerably, but females may carry from 1 million to 29 million eggs in their gonads. Solitary males and females appear to pair up during the spawning season. Spawning occurs year-round in the Caribbean Sea, Gulf of Mexico, the Florida coast and other warm equatorial waters, while it occurs in the spring and summer in cooler regions. The most recognized spawning site is in the Mediterranean, off the coast of Italy. The height of this well-known spawning season is in July and August,

when males are often observed chasing females. The pelagic eggs are buoyant, measuring 1.6–1.8 mm in diameter. Embryonic development occurs during the 2 ½ days following fertilization. As the only member of its family, the swordfish has unique-looking larvae. The pelagic larvae are 4 mm long at hatching and live near the surface. At this stage, the body is only lightly pigmented. The snout is relatively short and the body has many distinct, prickly scales. With growth, the body narrows. By the time the larvae reach half an inch long (12 mm), the bill is notably elongated, but both the upper and lower portions are equal in length. The dorsal fin runs the length of the body. As growth continues, the upper portion of the bill grows proportionately faster than the lower bill, eventually producing the characteristic prolonged upper bill. Specimens up to approximately 9 inches (23 cm) in length have a dorsal fin that extends the entire length of the body. With further growth, the fin develops a single large lobe, followed by a short portion that still reaches to the caudal peduncle. By approximately 20 inches (52 cm), the second dorsal fin has developed, and at approximately 60 inches (150 cm), only the large lobe remains of the first dorsal fin. They have been known to eat their own young due to lack of nutrition.

Conservation status

Swordfish are not listed as an endangered species.

In 1998, the United States Natural Resources Defense Council and SeaWeb hired Fenton Communications to conduct an advertising campaign to promote their assertion that the swordfish population was in danger due to its popularity as a restaurant entree.

The resulting "Give Swordfish a Break" promotion was wildly successful, with 750 prominent U.S. chefs agreeing to remove North Atlantic swordfish from their menus, and also persuaded many supermarkets and consumers across the country.

The advertising campaign was repeated by the national media in hundreds of print and broadcast stories, as well as extensive regional coverage. It earned the Silver Anvil award from the Public Relations Society of America as well as Time magazine's award for the top five environmental stories of 1998.

Subsequently, the US National Marine Fisheries Service proposed a swordfish protection plan that incorporated the campaign's policy suggestions. Then-US President Bill Clinton called for a ban on the sale and import of swordfish and in a landmark decision by the federal government, 132,670 square miles (343,600 km^2) of the Atlantic ocean were placed off-limits to fishing as recommended by the sponsors.

In the North Atlantic, the swordfish stock is fully rebuilt, with biomass estimates currently 5% above the target level. There are no robust stock assessments for swordfish in the northwestern Pacific or South Atlantic, and there is a paucity of data concerning stock status in these regions. These stocks are considered unknown and a moderate conservation concern. The southwestern Pacific stock is a moderate concern due to model uncertainty, increasing catches, and declining CPUEs (catch per unit effort). Overfishing

is likely occurring in the Indian Ocean, and fishing mortality exceeds the maximum recommended level in the Mediterranean, thus these stocks are considered of high conservation concern.

In 2010, Greenpeace International has added the swordfish to its seafood red list. "The Greenpeace International seafood red list is a list of fish that are commonly sold in supermarkets around the world, and which have a very high risk of being sourced from unsustainable fisheries."

Recreational importance

Recreational fishing has developed a sub-specialty called sword fishing. It has become quite popular throughout many parts of the world. Because there is a ban on long lining along many parts of seashore, swordfish populations are showing signs of recovery from the overfishing caused by Long lining along the coast. The population recovery is far from complete and the swordfish population is still at a much lower level than it once was.

There are various different ways to fish for swordfish, but the most common and popular method seems to be deep sea fishing. Because many swordfish used to be caught by long lining near shore, the remaining population of swordfish lives about 40 miles or more off the coast of most locations, and as such is only accessible by boat. Standard practice usually to let the boat being fished from to drift, as the ocean bottom is too deep for any conventional fishing boat to anchor as the bottom is often thousands of feet deep. It requires a specialized, strengthened fishing rod as swordfish are extremely large fish. Standard bait that is used to attract the fish would be either large chunks of mackerel, herring, mullet, bonito or squid, and if the bait is small enough then the fisherman can use live bait. Imitation squids and other imitation fish lures can also be used, and specialized lures made specifically for sword fishing using plastic glow sticks are also used.

"Swordfish" as a ship's name

- HMS Swordfish, three Royal Navy ships.
- USS Swordfish (SS-193) and USS Swordfish (SSN-579), both of them United States Navy ships.
- HNLMS Zwaardvisch (P322), Netherlands Navy World War II submarine. *Zwaardvisch* is the Dutch word for *swordfish*
- KRI Todak, an Indonesian Navy ship. *Todak* is the Indonesian word for *swordfish*.

Chapter 13

Whale Shark

Whale shark

Whale shark from Taiwan in the Georgia Aquarium

Size compared to an average human

Conservation status

Vulnerable (IUCN 2.3)

Scientific classification	
Kingdom:	Animalia
Phylum:	Chordata
Class:	Chondrichthyes
Subclass:	Elasmobranchii
Order:	Orectolobiformes
Family:	**Rhincodontidae** (Müller and Henle, 1839)
Genus:	***Rhincodon*** Smith, 1829
Species:	***R. typus***

Binomial name

Rhincodon typus
(Smith, 1828)

Range of whale shark

The **whale shark**, *Rhincodon typus*, is a slow-moving filter feeding shark, the largest living fish species. The largest confirmed individual was 12.65 metres (41.50 ft) in length. The heaviest weighed more than 36 tonnes (79,000 lb), but unconfirmed claims report considerably larger whale sharks. This distinctively-marked fish is the only member of its genus ***Rhincodon*** and its family, **Rhincodontidae** (called Rhinodontes before 1984), which belongs to the subclass Elasmobranchii in the class Chondrichthyes. The shark is found in tropical and warm oceans, lives in the open sea with a lifespan of about 70 years. The species originated about 60 million years ago. Although whale sharks have very large mouths, they feed mainly, though not exclusively, on plankton, microscopic plants and animals, although the BBC program *Planet Earth* filmed a whale shark feeding on a school of small fish.

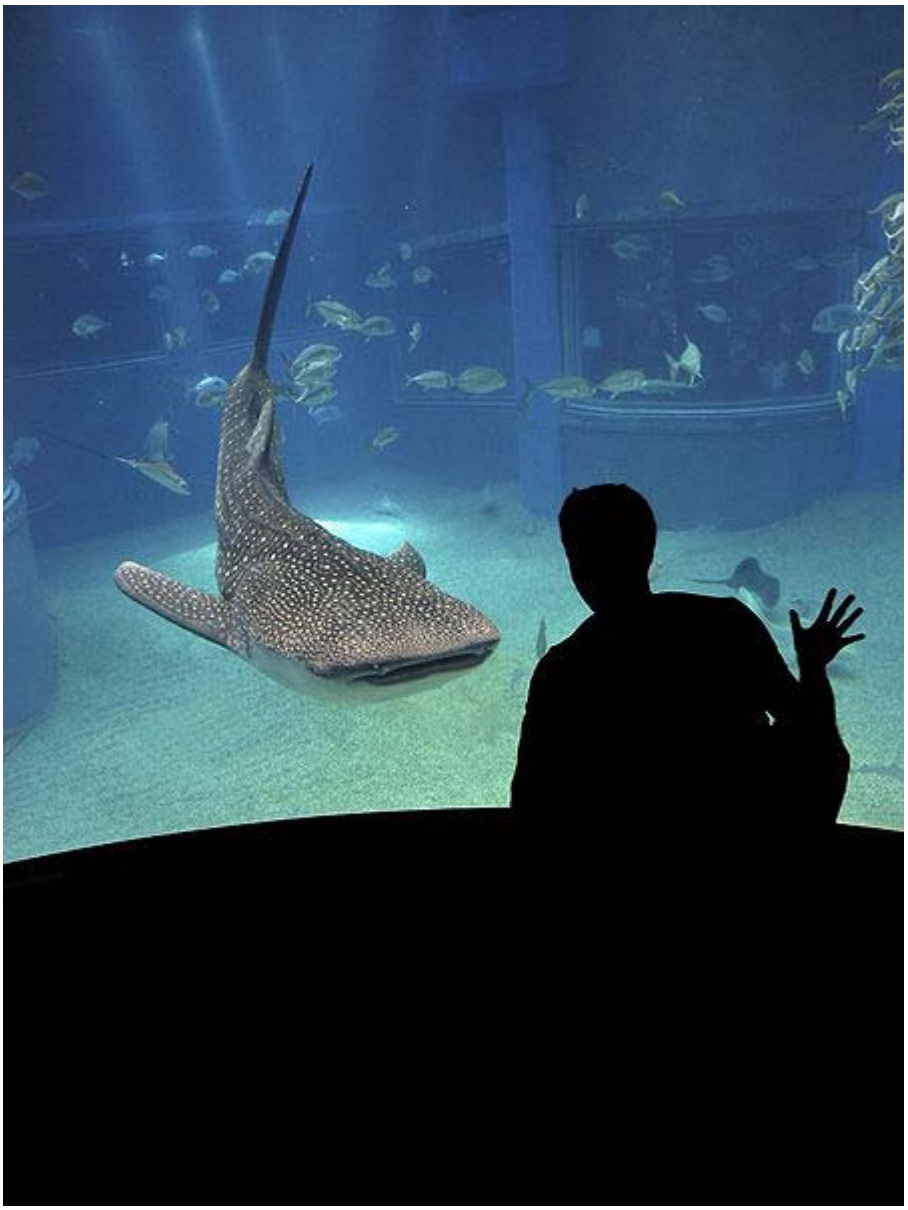
The species was distinguished in April 1828, following the harpooning of a 4.6-metre (15.1 ft) specimen in Table Bay, South Africa. Andrew Smith, a military doctor associated with British troops stationed in Cape Town described it the following year. He published a more detailed description in 1849. The name "whale shark" comes from the fish's physiology; as large as a whale, it too is a filter feeder.

Distribution and habitat

The whale shark inhabits all tropical and warm-temperate seas.They are known to migrate every spring to the continental shelf of the central west coast of Australia. The coral spawning of the area's Ningaloo Reef provides the whale shark with an abundant supply of plankton. Primarily pelagic, seasonal feeding aggregations occur at several coastal sites such as the southern and eastern parts of South Africa; Gladden Spit in Belize; Ningaloo Reef in Western Australia; Útila in Honduras; Donsol, Pasacao and Batangas in the Philippines; off Isla Mujeres and Isla Holbox in Yucatan, Mexico; Ujung Kulon National Park in Indonesia; Nosy Be in Madagascar Off Tofo Reef near Inhambane in Mozambique, and the Tanzanian islands of Mafia, Pemba, Zanzibar and, very rarely, Eilat, Israel. Although typically seen offshore, it has been found closer to land, entering lagoons or coral atolls, and near the mouths of estuaries and rivers. Its range is generally restricted to about ±30° latitude. It is capable of diving to depths of 700 metres (2,300 ft), and is migratory.

Anatomy and appearance

As a filter feeder it has a capacious mouth which can be up to 1.5 metres (4.9 ft) wide and can contain between 300 and 350 rows of tiny teeth. It has five large pairs of gills. Two small eyes are located towards the front of the shark's wide, flat head. The body is mostly grey with a white belly; three prominent ridges run along each side of the animal and the skin is marked with a "checkerboard" of pale yellow spots and stripes. These spots are unique to each individual and are useful for counting populations. Its skin can be up to 10 centimetres (3.9 in) thick. The shark has a pair each of dorsal fins and pectoral fins. Juveniles' tails have a larger upper than lower fin while the adult tail becomes semi-lunate (crescent-shaped). Spiracles are just behind the eyes.



Whale shark in main tank at Osaka Aquarium

The whale shark is not an efficient swimmer since it uses its entire body, unusual for fish, to attain an average speed of around 5-kilometre-per-hour (3.1 mph). The largest specimen was caught on November 11, 1947, near Baba Island, in Karachi, Pakistan. It was 12.65 metres (41.50 ft) long, weighed more than 21.5 tonnes (47,000 lb), and had a girth of 7 metres (23.0 ft). Stories exist of vastly larger specimens — quoted lengths of 18 metres (59 ft) are not uncommon in the popular shark literature — but no scientific records support their existence. In 1868 the Irish natural scientist Edward Perceval Wright obtained several small whale shark specimens in the Seychelles, but claimed to have observed specimens in excess of 15 metres (49.2 ft), and tells of reports of specimens surpassing 21 metres (68.9 ft).

In a 1925 publication, Hugh M. Smith described a huge animal caught in a bamboo fish trap in Thailand in 1919. The shark was too heavy to pull ashore, but Smith estimated that the shark was at least 17 metres (56 ft) long, and weighed approximately 37 tonnes (82,000 lb), which have been exaggerated to a more precise measurement of 17.98 metres (58.99 ft) and weight 43 tonnes (95,000 lb) in recent years. A shark caught in 1994 near Tainan in Southern Taiwan reportedly weighed 35.8 tonnes (79,000 lb). There have even been claims of whale sharks of up to 23 metres (75 ft). In 1934 a ship named the *Maurguani* came across a whale shark in the Southern Pacific Ocean, rammed it, and the shark consequently became stuck on the prow of the ship, supposedly with 4.6 metres (15.1 ft) on one side and 12.2 metres (40.0 ft) on the other. No reliable documentation exists for these claims and they remain "fish-stories".

Diet

The whale shark is a filter feeder — one of only three known filter feeding shark species (along with the basking shark and the megamouth shark). It feeds on macro-algae, plankton, krill, Christmas Island red crab larvae, and small nektonic life such as small squid or vertebrates. The many rows of teeth play no role in feeding; in fact, they are reduced in size in the whale shark. Instead, the shark sucks in a mouthful of water, closes its mouth and expels the water through its gills. During the slight delay between closing the mouth and opening the gill flaps, plankton is trapped against the dermal denticles which line its gill plates and pharynx. This fine sieve-like apparatus, which is a unique modification of the gill rakers, prevents the passage of anything but fluid out through the gills, trapping anything above 2 to 3 millimetres (0.079 to 0.12 in) in diameter. Material caught in the filter between the gill bars is swallowed. Whale sharks have been observed "coughing" and it is presumed that this is a method of clearing a build up of food particles in the gill rakers. Whale sharks migrate to feed and possibly to breed.

The whale shark is an active feeder, targeting concentrations of plankton or fish. It is able to ram filter feed or can gulp in a stationary position. This is in contrast to the passive feeding basking shark, which does not pump water. Instead, it swims to force water across its gills.

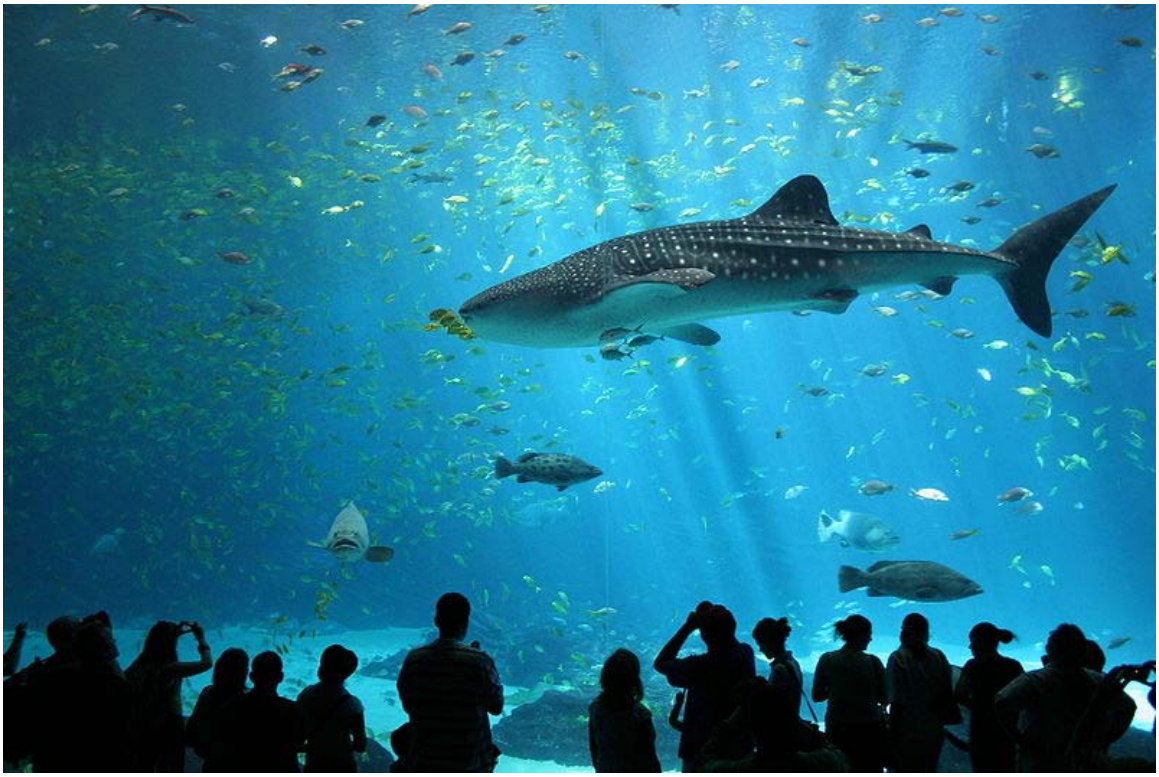
Behaviour toward divers

A whale shark at Ningaloo Reef

Despite its size, the whale shark does not pose significant danger to humans. Although massive, whale sharks are docile fish and sometimes allow swimmers to hitch a ride. Whale sharks are actually quite gentle and can play with divers. Divers and snorkelers can swim with this giant fish without risk, apart from unintentional blows from the shark's large tail fin.

The shark is seen by divers in many places, including the Bay Islands in Honduras, Thailand, the Philippines, the Maldives, the Red Sea, Western Australia (Ningaloo Reef, Christmas Island), Panama (Isla Coiba), Belize, Tofo Beach in Mozambique, Sodwana Bay (Greater St. Lucia Wetland Park) in South Africa, the Galapagos Islands, Isla Mujeres in Mexico, the Seychelles, West Malaysia, islands off eastern peninsular Malaysia, Sri Lanka, Oman, Fujairah, and Puerto Rico.

Whale sharks in captivity



A whale shark in the Georgia Aquarium

Two whale sharks are featured as the main attraction of Osaka Aquarium Kaiyukan and as of 2005, three whale sharks are in captivity at the Okinawa Churaumi Aquarium in Japan. The Ioworld Aquarium in Kagoshima, Japan also features a single adult whale shark as a major attraction. One is also on display in the Taiwan, Kenting National Museum of Biology and Aquarium. Four whale sharks, two males, Taroko, and Yushan, and two females, Alice and Trixie, live in the Georgia Aquarium, in Atlanta, USA. Two male whale sharks, Ralph and Norton, died in captivity at the Georgia Aquarium on January 11, 2007 and June 13, 2007 respectively. The two females were added on June 3, 2006 in hopes that reproduction in whale sharks could be studied in captivity. All six whale sharks were imported from Taiwan, where whale sharks are dubbed tofu sharks because of the taste and texture of the flesh. Two whale sharks live at Polar Ocean World in Qingdao, China. One whale shark was at the Atlantis Hotel in Dubai, but was released in March, 2010. One whale shark lives in Dalian, China.

Reproduction

The capture of a female in July 1996 which was pregnant with 300 pups indicates that whale sharks are ovoviviparous. The eggs remain in the body and the females give birth to live young which are 40 to 60 centimetres (16 to 24 in) long. It is believed that they reach sexual maturity at around 30 years and the life span is an estimated 70 to 100 years.

On March 7, 2009, marine scientists in the Philippines discovered what is believed to be the smallest living specimen of the whale shark. The young shark, measuring only 38 centimetres (15 in), was found with its tail tied to a stake at a beach in Pilar, Philippines, and was released into the wild. Based on this discovery some scientists no longer believe that this area is just a feeding ground; it may also be that this site is a birthing ground as well.

Conservation status

The whale shark is targeted by commercial fisheries in several areas where they seasonally aggregate. The population is unknown and the species is considered vulnerable by the IUCN. In 1998, the Philippines banned all fishing, selling, importing and exporting of whale sharks for commercial purposes, followed by India in May 2001, and Taiwan in May 2007.They are currently listed as a vulnerable species; however, they continue to be hunted in parts of Asia, such as Taiwan and the Philippines.

In 2006, Resorts World Sentosa announced its plans to bring in whale sharks for their marine life park. This was met with opposition from seven notable conservation societies. In 2009, the plan was shelved in favour of a search for other alternatives.

In 2010, the Gulf of Mexico oil spill resulted in 4,900,000 barrels (779,000 m^3) of oil flowing into an area south of the Mississippi River Delta, where one-third of all whale shark sightings in the northern part of the gulf have occurred in recent years. Sightings confirmed that the whale sharks were unable to avoid the oil slick which was situated on the surface of the sea where the whale sharks feed for several hours at a time. However, no dead whale sharks have been found. .

Chapter 14

Galápagos Tortoise

Galápagos tortoise

Conservation status

Vulnerable (IUCN 2.3)
Scientific classification
Kingdom: Animalia
Phylum: Chordata
Class: Reptilia
Order: Testudines
Suborder: Cryptodira
Family: Testudinidae
Genus: *Chelonoidis*
Species: ***C. nigra***
Binomial name
Chelonoidis nigra (Quoy & Gaimard, 1824b)

The **Galápagos tortoise** or **Galápagos giant tortoise** (*Chelonoidis nigra*) is the largest living species of tortoise, reaching weights of over 400 kg (880 lb) and lengths of over

1.8 meters (6 ft). With life spans in the wild of over 100 years, it is one of the longest lived vertebrates. A captive individual lived at least 170 years.

The tortoise is native to seven of the Galápagos Islands, a volcanic archipelago about 1,000 km (620 mi) west of Ecuador. Spanish explorers who discovered the islands in the 16th century named them after the Spanish "galápago", meaning tortoise.

Shell size and shape vary between populations. On islands with humid highlands, the tortoises are larger, with domed shells and short necks. On islands with dry lowlands, the tortoises are smaller, with 'saddleback' shells and long necks. These island to island differences played a role in the inception of Charles Darwin's theory of evolution.

Tortoise numbers declined from over 250,000 in the 16th century to a low of around 3,000 in the 1970s. The decline was caused by hunting for tortoise meat and oil, habitat clearance for agriculture, and introduction of non-native animals such as rats, goats, and pigs. Seven subspecies of the original ten survive in the wild. An eighth subspecies (*C. n. abingdoni*) has only a single living individual, in captivity, nicknamed Lonesome George. Conservation efforts beginning in the 20th century have resulted in thousands of captive-bred juveniles being released onto their home islands, and it is estimated that numbers exceeded 19,000 at the start of the 21st century. Despite this rebound, the species as a whole is classified as 'Vulnerable' by the International Union for Conservation of Nature (IUCN).

Taxonomy

Early classification

The Galápagos Islands were discovered in 1535, but first appeared on maps, of Gerardus Mercator and Abraham Ortelius, in about 1570. The islands were named "Insulae de los Galopegos" (Islands of the Tortoises) in reference to the giant tortoises found there.

Initially, the giant tortoises of the Indian Ocean and those from the Galápagos were considered to be the same species. Naturalists thought that sailors had transported the tortoises. In 1676, the pre-Linnaean authority Claude Perrault referred to both species as *Tortue des Indes*. In 1783, Johann Gottlob Schneider classified all giant tortoises as *Testudo indica* ("Indian tortoise"). In 1812, August Friedrich Schweigger named them *Testudo gigantea* ("gigantic tortoise"). In 1834, André Marie Constant Duméril and Gabriel Bibron classified the Galápagos tortoises as a separate species, which they named *Testudo nigrita* ("black tortoise").

Walter Rothschild, cataloguer of two Galápagos tortoise subspecies

Recognition of subpopulations

The first systematic survey of giant tortoises was by Albert Günther of the British Museum, in 1875. Günther identified at least five distinct populations from the Galápagos, and three from the Indian Ocean islands. He expanded the list in 1877 to six from the Galápagos, four from the Seychelles, and four from the Mascarenes. Günther theorised that all the giant tortoises descended from a single ancestral population which spread by sunken land bridges. This theory was later disproven by the understanding that the Galápagos, Seychelles and Mascarene islands are all of recent volcanic origin and therefore could not have been linked by land bridges. It is now thought that the Galápagos tortoises descended from an ancestor from South America. The Indian Ocean tortoises derived from Madagascar.

At the end of the 19th century, Georg Baur and Walter Rothschild recognised five more populations of Galápagos tortoise. In 1906, the Academy of Sciences collected specimens and gave them to John Van Denburgh for study. He identified four additional populations, and proposed the existence of 15 species. His list still guides the taxonomy of the Galápagos tortoise, though now ten populations are thought to have existed.

Current species and genus names

The current species designation of *nigra* ("black" – Quoy & Gaimard, 1824b) was resurrected in 1984 after it was discovered to be the senior synonym (an older taxonomic synonym taking historical precedence) for the then commonly used species name of *elephantopus* ("elephant footed" – Harlan, 1827). The use of *nigra* is explained by Quoy and Gaimard's Latin description: "*Testudo toto corpore nigro*", meaning "tortoise with completely black body". Quoy and Gairmard described *nigra* from a living specimen, but there is no evidence that they knew of its accurate provenance within the Galápagos – the locality was in fact given as California. Garman proposed the linking of *nigra* with the extinct Floreana subspecies. Later, Pritchard deemed it was convenient to accept this designation despite its tenuousness because this decision allowed minimal disruption to the already-confused nomenclature of the species. The even more senior species synonym of *californiana* ("californian" – Quoy & Gaimard, 1824a) is considered a *nomen oblitum* ("forgotten name").

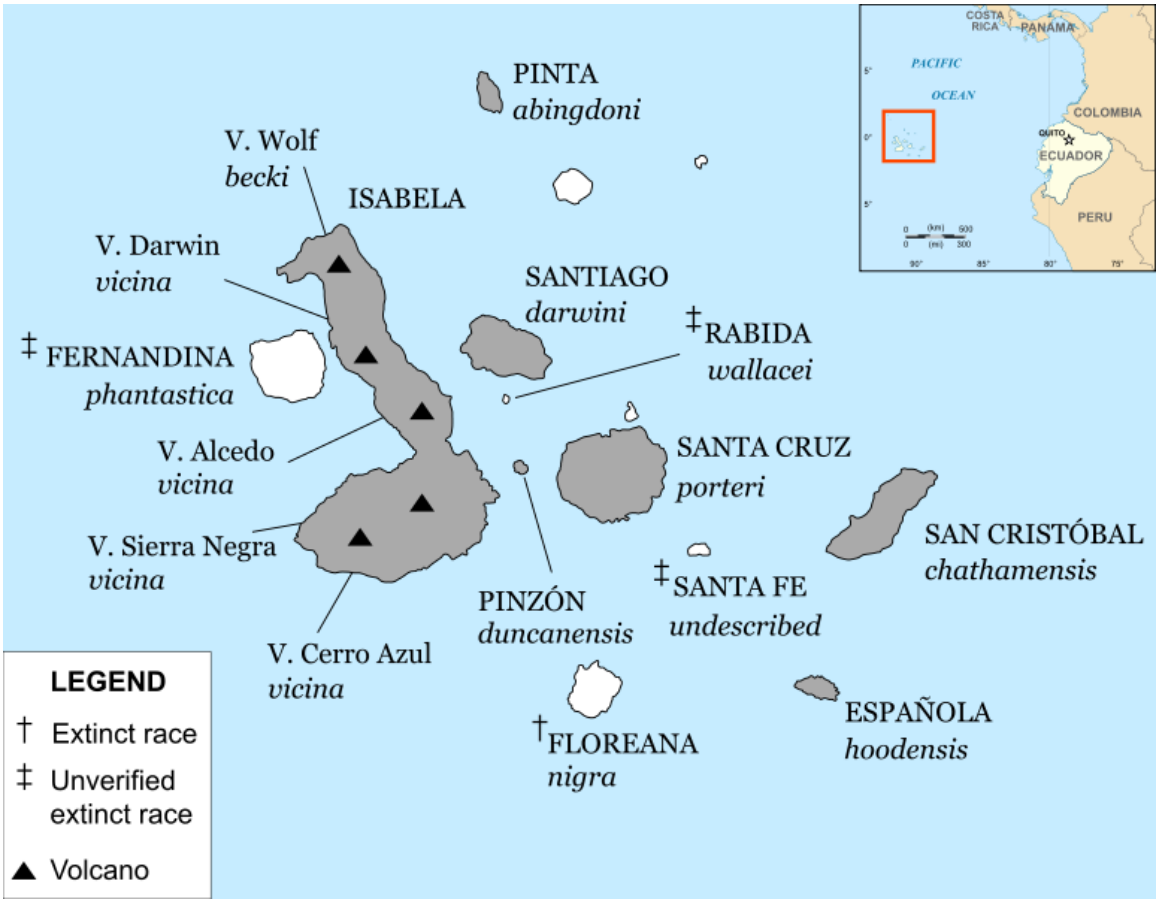
Previously, the Galápagos tortoise was considered to belong to the genus *Geochelone*, known as typical tortoises or terrestrial turtles. Subsequently, subgenus *Chelonoidis* was elevated to generic status based on phylogeneticevidence which grouped the South American members of *Geochelone* into an independent clade (branch of the tree of life). This nomenclature has been adopted by several authorities.

Subspecies

There were probably 10 subspecies of *Chelonoidis nigra*, although some recognise up to 15 subspecies. Only seven subspecies now exist in the wild, one on Santiago, Santa Cruz, San Cristóbal, Pinzón and Española, and two on Isabela. An eighth surviving subspecies, *abingdoni* from Pinta Island, is considered extinct in the wild and is represented by a single living specimen, 'Lonesome George'. The subspecies inhabiting Floreana island (*C. n. nigra*) is thought to have been hunted to extinction by 1850, only years after Charles Darwin's landmark visit of 1835 in which he saw shells but no live tortoises on the island. The *phantastica* subspecies of Fernandina is of disputed existence as it was described from a single specimen which may have been an artificial introduction to the island.

Prior to widespread knowledge of the differences between the populations (sometimes called races) from different islands and volcanoes, captive collections in zoos were indiscriminately mixed. Fertile offspring resulted from pairings of animals from different races, confirming that they are subspecies and not distinct species. However captive crosses between tortoises from different races have lower fertility and higher mortality than those between tortoises of the same race and captives in mixed herds normally direct courtship only toward members of the same race.

The valid scientific names of each the individual populations are not universally accepted, and some researchers consider each subspecies to be a full species. The taxonomic status of the various races is not fully resolved.



Galápagos archipelago annotated with ranges of currently recognised subspecies of Galápagos tortoise. Islands with surviving subspecies are shaded.

Evolutionary history

All subspecies of Galápagos tortoise evolved from common ancestors that arrived from mainland South America by overwater dispersal. The minimal founding population was a pregnant female or a breeding pair. Survival on the 1000 km oceanic journey is accounted for by the fact that the tortoises are buoyant, can breathe by extending their necks above the water, and are able to survive months without food or fresh water. As they are poor swimmers, the journey was probably a passive one facilitated by the Humboldt Current, which diverts westwards towards the Galápagos Islands from the mainland.

The closest living relative (though not a direct ancestor) of the Galápagos giant tortoise is the Argentine tortoise (*Chelonoidis chilensis*), a much smaller species from South America. The divergence between *C. chilensis* and *C. nigra* probably occurred 6–12 million years ago, an evolutionary event preceding the volcanic formation of the oldest modern Galápagos Islands 5 million years ago. Mitochondrial DNA analysis indicates that the oldest existing islands (Española and San Cristóbal) were colonised first, and that these populations seeded the younger islands via dispersal in a 'stepping stone' fashion via

local currents. Restricted gene flow between isolated islands then resulted in the independent evolution of the populations into the divergent forms observed in the modern subspecies. The evolutionary relationships between the subspecies thus echo the volcanic history of the islands.

Subspecies genetics

Modern DNA methods have revealed new information on the relationships between the subspecies:

Isabela Island

A distinct population was once thought to inhabit each of the five main volcanoes of the largest island Isabela: (Wolf, Darwin, Alcedo, Sierra Negra, and Cerro Azul). The four southern populations on Isabela, though separated from each other by barren stretches of lava between volcanoes, are in fact a single genetic unit derived from colonists from Santa Cruz. The genetically distinct Volcán Wolf subspecies in northern Isabela (*becki*) is probably the result of a separate colonisation event from Santiago. Tortoises from Sierra Negra in southern Isabela (formerly *guentheri*) are possibly the ancestral source of dispersal to the volcanoes Darwin (formely *microphyes*), Alcedo (formerly *vandenburghi*) and Cerro Azul (*vicina*). On this basis the southern populations on Isabela may be considered as a single subspecies *vicina*, with morphological differences attributable to age, sex or local environment.

Floreana Island

Phylogenetic analysis may help to 'resurrect' the extinct subspecies of Floreana (*nigra*). The subspecies was only known from subfossil remains. Some tortoises from Isabela were found to be a partial match for the genetic profile of Floreana specimens from museum collections, possibly indicating the presence of hybrids from a population transposed by humans from Floreana to Isabela speculated to be caused either by deliberate moving between the islands or from individuals thrown overboard ships to lighten loads. Nine Floreana descendants have been identified in the captive population of the Fausto Llerena Breeding Center on Santa Cruz. This permits the possibility of re-establishing a reconstructed subspecies from selective breeding of the hybrid animals.

Pinta Island

The Pinta Island subspecies (*abingdoni*, now extinct in the wild) is most closely related to the subspecies on the islands of San Cristóbal (*chathamensis*) and Española (*hoodensis*) which lie over 300 km away, rather than neighbouring Isabela as previously assumed. This relationship is attributable to dispersal by the strong local current from San Cristóbal towards Pinta. The discovery informed further attempts for the preservation of the *abingdoni* lineage and the search for an appropriate mate for Lonesome George, who had been penned with females from Isabela. This hope was bolstered by the discovery of an

abingdoni hybrid male in the Volcán Wolf population on northern Isabela, raising the possibility that there are more living undiscovered Pinta descendants.

Santa Cruz Island

Mitochondrial DNA studies of tortoises on Santa Cruz show up to three genetically distinct lineages found in non-overlapping population distributions around the regions of Cerro Monturra, Cerro Fatal and La Caseta. Although currently united in a single subspecies (*porteri*), the lineages are all more closely related to tortoises on other islands than to each other; Cerro Monturra tortoises are most closely related to *duncanensis* from Pinzón, Cerro Fatal to *chathamensis* from San Cristóbal, and La Caseta to the four southern races of Isabela.

Subspecies of doubtful existence

Subspecies were described from three other islands, but their existence is based on scant evidence. The purported Rabida island subspecies (*wallacei*) was described from a single specimen removed by the Academy of Sciences in 1906, which has since been lost. This individual was probably an artificial introduction from another island that was originally penned on Rabida next to a good anchorage, as no contemporary whaling or sealing logs mention removing tortoises from this island. The *phantastica* subspecies from Fernandina is known from a single specimen from the voyage of 1906, an old male. No other tortoises or remains have been found on the island, suggesting the specimen was an artificial introduction from elsewhere. Fernandina has neither human settlements nor feral mammals, so if this subspecies ever did exist its extinction must have been by natural means, such as volcanic activity. The Santa Fe subspecies has no binomial name, having been described from the limited evidence of bone fragments (but no shells, the most durable part) of 14 individuals, old eggs and old dung found on the island in 1906. The island has never been inhabited by man nor had any introduced predators. The remains are considered artificial introductions, possibly from camping at the good anchorage on the island.

Description

The tortoises have a large bony shell (carapace) of a dull brown colour. The plates of the carapace are fused with the ribs in a rigid protective structure that is integral to the skeleton. Lichen can grow on the shells of the slow-moving animals. Tortoises keep a characteristic scute (shell segment) pattern on their shell throughout life, though the annual growth bands are not useful for aging as the outer layers are worn off with time. A tortoise can withdraw its head, neck and forelimbs into its shell for protection. The legs are large, stumpy, with dry scaly skin and hard scales. The front legs are five-clawed, and the back legs are four-clawed.

Gigantism

The discoverer of the Galápagos Islands, Fray Tomás de Berlanga, Bishop of Panama, wrote in 1535 of "such big tortoises that each could carry a man on top of himself." Naturalist Charles Darwin remarked after his trip exactly three centuries later in 1835, "These animals grow to an immense size ... several so large that it required six or eight men to lift them from the ground". The largest recorded individuals have reached weights of over 400 kilograms (882 lb) and lengths of 1.87 meters (6 ft). The tortoises' gigantism was probably a preadapted condition for successful colonisation of these remote oceanic islands rather than an example of evolved insular gigantism. Large tortoises would have a greater chance of surviving the journey over water from the mainland as they can hold their heads a greater height above the water level and have a surface area/volume ratio reducing osmotic water loss. Their significant water and fat reserves would allow the tortoises to survive long ocean crossings without food or fresh water, and to endure the drought-prone climate of the islands. A larger size allowed them to better tolerate extremes of temperature due to gigantothermy. Fossil giant tortoises from mainland South America have been described which support this hypothesis of preadapted gigantism.

Shell shape

Galápagos tortoise shell varieties

Saddleback (*abingdoni*)

Intermediate (*chathamensis*)

Domed (*porteri*)

Galapágos tortoises are the only lineage of giant tortoise exhibiting different types of shell shape. They exhibit a spectrum of carapace morphology from 'saddleback' (denoting upward arching of the front edge of the shell resembling a saddle) to 'domed' (denoting a rounded convex surface resembling a dome). When saddleback tortoises withdraw their head and forelimbs into their shells a large unprotected gap remains over their neck, evidence of the lack of predation during the evolution of this structure. There is no saddleback/domed dualism, as tortoises can be of intermediate type with characteristics of both. Larger islands with humid highlands over 800 m in elevation, such as Santa Cruz have abundant vegetation near the ground. Native tortoises in these environments tend to have domed shells and are larger, with shorter necks and limbs. Saddleback tortoises originate from small islands less than 500 m in elevation with dry habitats (e.g. Española and Pinzón) that are more limited in food and other resources.

Evolutionary implications

In combination with proportionally longer necks and limbs, the unusual saddleback carapace structure is thought to be an adaptation to increase vertical reach, which enables the tortoise to browse tall vegetation, such as the *Opuntia* (prickly pear) cactus which grows in arid environments. Saddlebacks are more territorial and smaller than domed varieties, possibly adaptations to their limited resources. Alternatively, larger tortoises

may be better suited to high elevations, because they can resist the cooler temperatures when there is cloud cover or fog.

A competing hypothesis is that rather than being principally a feeding adaptation, the distinctive saddle shape and longer extremities might have been a secondary sexual characteristic of saddleback males. Male competition over mates is settled by dominance displays on the basis of vertical neck height rather than body size (see below). This correlates with the observation that saddleback males are more aggressive than domed males. The shell distortion and elongation of the limbs and neck in saddlebacks is probably the evolutionary compromise between the need for a small body size in dry conditions and a high vertical reach for dominance displays.

The saddleback carapace probably evolved independently several times in dry habitats, since genetic similarity between populations does not correspond to carapace shape. Saddleback tortoises are therefore not necessarily more closely related to each other than to domed counterparts, as shape is not determined by a similar genetic background, but by a similar ecological one.

Sexual dimorphism

Sexual dimorphism is most pronounced in saddleback populations, in which males have more angled and higher front openings, giving a more extreme saddled appearance. Males of all varieties generally have a longer tail and a shorter, concave undershell with thickened knobs at the back edge to facilitate mating. Males are larger than females: adult males weigh around 272–317 kilograms (600–700 lb) while females are 136–181 kilograms (300–400 lb).

Behaviour

A tortoise bathing in a pool.

Routine

The tortoises are ectothermic (cold-blooded) and therefore bask for 1–2 hours after dawn to absorb the sun's heat through their dark shells before actively foraging for 8–9 hours a day. They travel mostly in the early morning or late afternoon between resting and grazing areas. They have been observed to walk at a speed of 0.3 kilometres per hour (0.19 mph). On the larger and more humid islands, the tortoises seasonally migrate down between low elevations, which become grassy plains in the wet season, to meadowed areas of higher elevation (up to 2,000 ft) in the dry season. The same routes have been used for many generations, creating well-defined paths through the undergrowth known as 'tortoise highways'. On these wetter islands, the domed tortoises are gregarious and often found in large herds, in contrast to the more solitary and territorial disposition of the saddleback tortoises.

Tortoises sometimes rest in mud wallows or rain-formed pools, which may be both a thermoregulatory response during cool nights, and a protection from parasites such as mosquitoes and ticks. Parasites are countered by taking dust baths in loose soil. Tortoises have been noted to shelter at night under overhanging rocks. Other tortoises are observed to sleep in a snug depression in the earth or brush called a 'pallet'. Local tortoises using the same pallet sites, such as on Volcán Alcedo, results in the formation of small sandy pits.

Diet

A tortoise feeding.

The tortoises are herbivores that consume a diet of cactus, grasses, leaves, lichen, and berries. They have been documented to feed on *Hippomane mancinella* ('poison apple'), the endemic guava *Psidium galapageium*, the water fern *Azolla microphylla*, and the bromeliad *Tillandsia insularis*. A tortoise eats an average of 70–80 pounds (32–36 kg) per day, though inefficient digestion means that much of this passes through without nutritional extraction.

Tortoises acquire most of their moisture from the dew and sap in vegetation (particularly the *Opuntia* cactus); therefore, they can spend long periods without drinking water. They can endure 18 months when deprived of all food and water, surviving by breaking down their body fat to produce water as a by-product. When thirsty they may drink large quantities of water very quickly, storing it in their bladders and the 'root of the neck' (the pericardium), both of which used to make them useful water sources on ships. On arid islands, tortoises lick morning dew from boulders, and the repeated action over many generations has formed half-sphere depressions in the rock.

Senses

Regarding their senses, Charles Darwin observed that: "The inhabitants believe that these animals are absolutely deaf; certainly they do not overhear a person walking near behind them. I was always amused, when overtaking one of these great monsters as it was quietly pacing along, to see how suddenly, the instant I passed, it would draw in its head and legs, and uttering a deep hiss fall to the ground with a heavy sound, as if struck dead". Although they are not deaf, tortoises depend far more on vision and smell as stimuli.

Mutualism

Tortoises share a mutualistic relationship with some species of Galápagos finch and mockingbirds. Small groups of finches initiate the process by hopping on the ground in an exaggerated fashion facing the tortoise. The tortoise signals it is ready by rising up and extending its neck and legs, enabling the birds to reach otherwise inaccessible spots on the tortoise's body such as the neck, rear legs, cloacal opening, and skin between plastron and carapace. The birds benefit from the food source and the tortoises get rid of irritating ectoparasites.

Some tortoises have been observed to insidiously exploit this mutualistic relationship. After rising and extending its limbs, the bird may go beneath the tortoise to investigate, whereupon suddenly the tortoise withdraws its limbs to drop flat and kill the bird. It then steps back to eat the bird, presumably to supplement its diet with protein.

Mating

A pair of tortoises engaging in a dominance display.

Mating occurs at any time of the year, although it does have seasonal peaks between February and June in the humid uplands during the rainy season. When mature males meet in the mating season they will face each other in a ritualised dominance display, rise up on their legs and stretch up their necks with their mouths gaping open. Occasionally, head-biting occurs, but usually the shorter tortoise will back off, conceding mating rights to the victor. The behaviour is most pronounced in saddleback subspecies, which are more aggressive and have longer necks.

The prelude to mating can be very aggressive, as the male forcefully rams the female's shell with his own and nips her legs. Mounting is an awkward process and the male must stretch and tense to maintain equilibrium in a slanting position. The concave underside of the male's shell helps him to balance when straddled over the female's shell, and brings his cloacal vent (which houses the penis) closer to the female's dilated cloaca. During mating, the male vocalises with hoarse bellows and grunts, described as 'rhythmic groans'. This is one of the few vocalisations the tortoise makes; other noises are made during aggressive encounters, when struggling to right themselves, and hissing as they withdraw into their shells due to the forceful expulsion of air.

A young tortoise and a tortoise egg.

Egg-laying

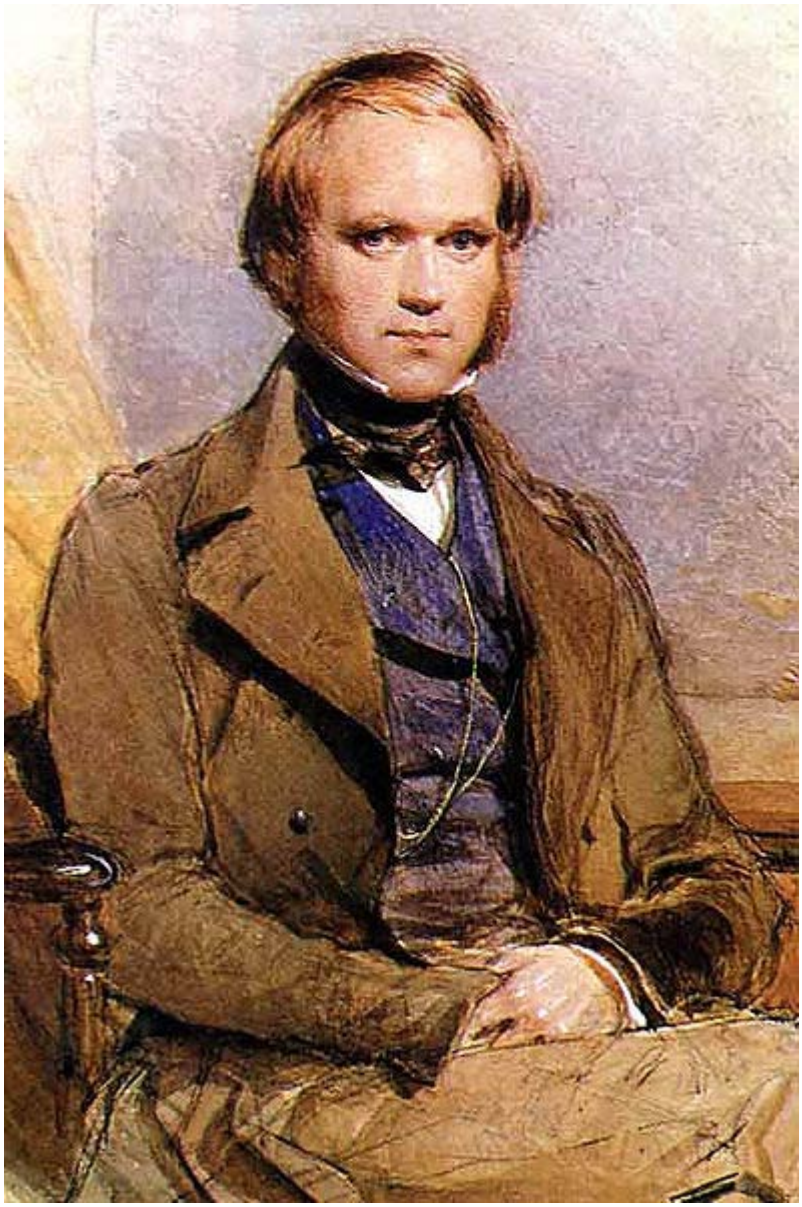
Females then journey up to several kilometres in July to November to reach nesting areas of dry, sandy coast. Nest digging is a tiring and elaborate task which may take the female several hours a day over many days to complete. It is carried out blindly using only the hind legs to dig a 30 cm (12 in) deep cylindrical hole, into which she lays up to sixteen spherical, hard-shelled eggs ranging from 82 to 157 g in mass, and the size of a billiard ball. Some observations suggest that the average clutch size for domed populations (9.6 per clutch for *porteri* on Santa Cruz) is larger than that of saddlebacks (4.6 per clutch for *duncanensis* on Pinzón). The female makes a muddy plug for the nest hole out of soil mixed with urine, seals the nest by pressing down firmly with her plastron, and leaves them to be incubated by the sun. Females may lay 1–4 clutches per season. Temperature plays a role in the sex of the hatchling, with lower temperature nests producing more males and higher temperature nests producing more females. This is related closely to incubation time, since clutches laid early will incubate during the cool season and have longer incubation periods (producing more males), while nests that are laid later incubate for a shorter period in the hot season (producing more females).

Early life and maturation

Young animals emerge from the nest after 4 to 8 months and may weigh only 50 grams (1.8 oz) and measure 6 centimetres (2.4 in). When the young tortoises emerge from their shells, they must dig their way to the surface, which can take up several weeks, though their yolk sac can sustain them for up to seven months. In particularly dry conditions, the hatchlings may die underground if they are encased by hardened soil, while flooding of the nest area can drown them. Subspecies are initially indistinguishable as they all have domed carapaces. The young stay in warmer lowland areas for the their first 10–15 years, encountering hazards such as falling into cracks, being crushed by falling rock, or excessive heat stress. The Galápagos Hawk was formerly the sole native predator of the tortoise hatchlings, as Darwin wrote: "The young tortoises, as soon as they are hatched, fall prey in great numbers to the buzzard". The hawk is now much rarer, but introduced feral pigs, dogs, cats and black rats have become predators of eggs and young tortoises. The adult tortoises have no natural predators apart from humans, as Darwin noted: "The old ones seem generally to die from accidents, as from falling down precipices. At least several of the inhabitants told me, they had never found one dead without some such apparent cause".

Sex can be determined only when the tortoise is about 15 years old, and sexual maturity is reached at around 20–25 in captivity, possibly 40 years in the wild (when they reach their full size). Life expectancy in the wild is thought to be over 100 years, making it one of the longest lived species in the animal kingdom. Harriet was the oldest known Galápagos tortoise, having reached an estimated age of more than 170 years before her death in 2006 in Australia Zoo. Chambers notes that Harriet was probably 169 years old in 2004. The individual died in 2006 (although media outlets claimed the greater age of 175 based on a less reliable timeline.

Darwin's development of theory of evolution



Charles Darwin as a young man, probably subsequent to the Galápagos visit

Charles Darwin visited the Galápagos for five weeks on the second voyage of HMS *Beagle* in 1835 and saw Galápagos tortoises on San Cristobal (Chatham) and Santiago (James) Islands. They appeared several times in his writings and journals, and played a role in the development of the theory of evolution.

Darwin wrote in his account of the voyage:

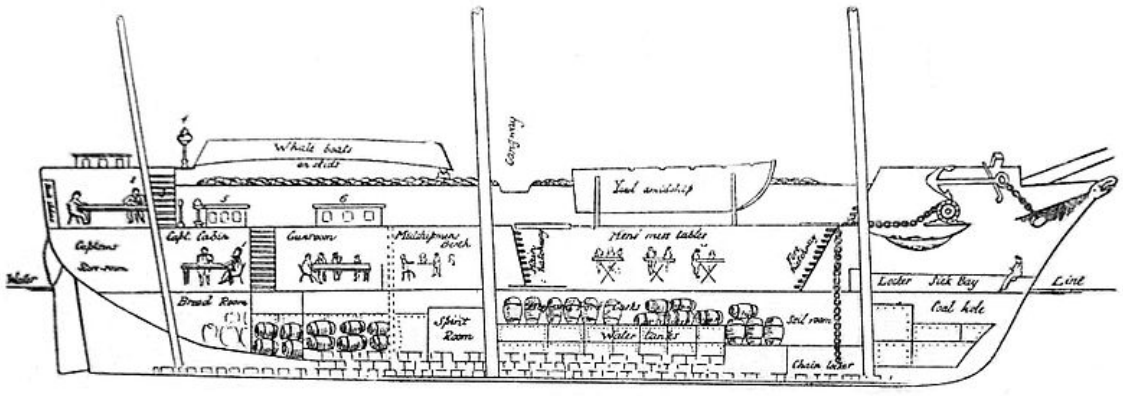
"I have not as yet noticed by far the most remarkable feature in the natural history of this archipelago; it is, that the different islands to a considerable extent are inhabited by a

different set of beings. My attention was first called to this fact by the Vice-Governor, Mr. Lawson, declaring that the tortoises differed from the different islands, and that he could with certainty tell from which island any one was brought ... The inhabitants, as I have said, state that they can distinguish the tortoises from the different islands; and that they differ not only in size, but in other characters. Captain Porter has described* those from Charles and from the nearest island to it, namely, Hood Island, as having their shells in front thick and turned up like a Spanish saddle, while the tortoises from James Island are rounder, blacker, and have a better taste when cooked."

The significance of the differences in tortoises between islands did not strike him as important until it was too late, as he continued,

"I did not for some time pay sufficient attention to this statement, and I had already partially mingled together the collections from two of the islands. I never dreamed that islands, about fifty or sixty miles apart, and most of them in sight of each other, formed of precisely the same rocks, placed under a quite similar climate, rising to a nearly equal height, would have been differently tenanted".

Although the *Beagle* departed from the Galápagos with over 30 adult tortoises on deck, these were not for scientific study but a source of fresh meat for their Pacific crossing. Their shells and bones were thrown overboard, leaving no remains with which to test any hypotheses. It has been suggested that this oversight was made because Darwin only reported seeing tortoises on San Cristóbal (*chathamensis*) and Santiago (*darwini*), both of which have an intermediate type of shell shape and are not particularly morphologically distinct from each other. Though he did visit Floreana, the *nigra* subspecies found there was already nearly extinct and he was unlikely to have seen any mature animals.



H.M.S. Beagle 1832

Line drawing of the HMS *Beagle* by F. G. King, a colleague of Darwin's. Galápagos tortoises were stacked in the lower hold.

Darwin did however have four live juvenile specimens to compare from different islands. These were pet tortoises taken by himself (from San Salvador), his captain FitzRoy (two from Española) and his servant Syms Covington (from Floreana). Unfortunately they

could not help to determine whether each island had its own variety because the specimens were not mature enough to exhibit morphological differences. Although the British Museum had a few specimens, their provenance within the Galápagos was unknown. However, conversations with the naturalist Gabriel Bibron, who had seen the mature tortoises of the Paris Natural History Museum confirmed to Darwin that there were distinct varieties.

Darwin later compared the different tortoise forms with those of mockingbirds, in the first tentative statement linking his observations from the Galapagos with the possibility of species transmuting:

"When I recollect the fact that [from] the form of the body, shape of scales and general size, the Spaniards can at once pronounce from which island any tortoise may have been brought; when I see these islands in sight of each other and possessed of but a scanty stock of animals, tenanted by these birds, but slightly differing in structure and filling the same place in nature; I must suspect they are only varieties ... If there is the slightest foundation for these remarks, the zoology of archipelagos will be well worth examining; for such facts would undermine the stability of species."

His views on the mutability of species were restated in his notebooks: "animals on separate islands ought to become different if kept long enough apart with slightly differing circumstances. – Now Galapagos Tortoises, Mocking birds, Falkland Fox, Chiloe fox, – Inglish and Irish Hare." These observations served as counterexamples to the prevailing contemporary view that species were individually created.

Darwin also found these "antediluvian animals" to be a source of diversion: "I frequently got on their backs, and then giving a few raps on the hinder part of their shells, they would rise up and walk away;—but I found it very difficult to keep my balance".

Conservation

Several waves of human exploitation of the tortoises as a food source caused a decline in the total wild population from around 250,000 when first discovered in the 16th century to a low of 3,060 individuals in a 1974 census. Modern conservation efforts have subsequently brought tortoise numbers up to 19,317 (estimate for 1995–2009).

The subspecies *C. n. nigra* became extinct by human exploitation in the 19th century. Another subspecies, *C. n. abingdoni*, is now extinct in the wild and represented in captivity by a single male specimen, Lonesome George. It is the only known living specimen of the Pinta Island tortoise and the world's "rarest living creature". All the other surviving subspecies are listed by the IUCN as at least 'Vulnerable' in conservation status, if not worse.

Historical exploitation

An estimated 200,000 animals were taken before the 20th century. The relatively immobile and defenceless tortoises were collected and stored live on board ships, where they could survive for at least a year without food or water (some anecdotal reports suggest individuals surviving two years), providing valuable fresh meat, while their diluted urine and water stored in their neck bags could be used as drinking water. The 17th century British pirate, explorer and naturalist William Dampier wrote that 'They are so extraordinarily large and fat, and so sweet, that no pullet eats more pleasantly,' while Captain James Colnett of the British Navy wrote of "the land tortoise which in whatever way it was dressed, was considered by all of us as the most delicious food we had ever tasted." US Navy captain David Porter declared that, "after once tasting the Gallipagos tortoises, every other animal food fell off greatly in our estimation ... The meat of this animal is the easiest of digestion, and a quantity of it, exceeding that of any other food, can be eaten without experiencing the slightest of inconvenience." Darwin was less enthusiastic about tortoise meat, writing "the breast-plate roasted (as the Gauchos do "carne con cuero"), with the flesh on it, is very good; and the young tortoises make excellent soup; but otherwise the meat to my taste is indifferent."

In the 17th century, pirates started to use the Galápagos Islands as a base for resupply, restocking on food, water and repairing vessels before attacking Spanish colonies on the South American mainland. However, the Galápagos tortoises did not struggle for survival at this point because the islands were distant to busy shipping routes and harboured few valuable natural resources. As such they remained unclaimed by any nation, uninhabited and uncharted. In comparison, the tortoises of the islands in the Indian Ocean were already facing extinction by the late 17th century.

Between the 1790s and the 1860s, whaling ships and fur-sealers systematically collected tortoises in far greater numbers than the buccaneers preceding them. They were used for food and many more were killed for high grade 'turtle oil' from the late 19th century onward for lucrative sale to continental Ecuador. A total of over 13,000 tortoises is recorded in the logs of whaling ships between 1831 and 1868, and an estimated 100,000 were taken before 1830. Since it was easiest to collect tortoises around coastal zones, females were most vulnerable to depletion during the nesting season. The collection by whalers came to a halt eventually through a combination of the scarcity of tortoises that they had created and the competition from crude oil as a cheaper energy source.

Population decline accelerated with the early settlement of the islands in the early 19th century leading to unregulated hunting for meat, habitat clearance for agriculture and the introduction of alien mammal species. Feral pigs, dogs, cats and black rats have become predators of eggs and young tortoises, whilst goats, donkeys and cattle compete for grazing and trample nest sites. The extinction of the Floreana subspecies in the mid-19th century has been attributed to the combined pressures of hunting for the penal colony on the relatively small island, the conversion of the grazing highlands into land for farming and fruit plantations, and the introduction of feral mammals.

Scientific collection expeditions took 661 tortoises between 1888 and 1930, and more than 120 tortoises have been taken by poachers since 1990. Threats continue today with the rapid expansion of the tourist industry and increasing size of human settlements on the islands.

Modern conservation

The remaining subspecies of tortoise range in IUCN classification from extinct in the wild to vulnerable. Slow growth rate, late sexual maturity and island endemism make the tortoises particularly prone to extinction without the efforts of conservationists. The Galápagos giant tortoise has become a flagship species for conservation efforts throughout the Galápagos.

Tourists see tortoises at the Charles Darwin Research station.

Legal protection

The Galápagos giant tortoise is now strictly protected and is listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora. The listing requires that trade in the taxon and its products is subject to strict regulation by ratifying states and international trade for primarily commercial purposes is prohibited. In 1936 the Ecuadorian government listed the giant tortoise as a protected species. In 1959,

it declared all uninhabited areas in the Galápagos to be a National Park and established the Charles Darwin Foundation. In 1970, capturing or removing many species from the islands (including tortoises and their eggs) was banned. To halt trade in the tortoises altogether, it became illegal to export the tortoises from Ecuador, captive or wild, continental or insular in provenance. The banning of their exportation resulted in automatic prohibition of importation to the United States under Public Law 91-135 (1969). A 1971 Ecuadorian decree made it illegal to damage, remove, alter or disturb any organism, rock or other natural object in the National Park.

Captive breeding

Breeding and releasing programs began in 1965 and have successfully brought 7 of the 8 endangered subspecies up to less perilous population levels. Young tortoises are raised at several breeding centres across the islands to improve their survival during their vulnerable early development. Eggs are collected from threatened nesting sites, and the hatched young are given a head start by being kept in captivity for 4 to 5 years to reach a size with a much better chance of survival to adulthood before release onto their native ranges.

The most significant population recovery was that of the Española Tortoise (*hoodensis*), which was saved from near-certain extinction. The population had been depleted to 3 males and 12 females that had been so widely dispersed that no mating in the wild had occurred. They were brought to the Charles Darwin Research Station in 1971 for a captive breeding program. In the following 33 years, these 15 tortoises gave rise to over 1,200 tortoises released onto their home island, which themselves have begun to reproduce naturally.

Island restoration

The Galápagos National Park Service systematically culls feral predators and competitors. Goat eradication on islands including Pinta was achieved by the technique of using 'Judas' goats with electronic collars to locate the herds. Marksmen shot all the goats except the Judas, then returned weeks later to find the 'Judas' and shoot the herd to which it had relocated, repeating until only the 'Judas' remained, which was then killed. Other measures have included dog eradication from San Cristóbal, and fencing off nests to protect them from feral pigs.

Efforts are now underway to repopulate islands formerly inhabited by tortoises in order to restore their ecosystems (island restoration) to their pre-human condition. The tortoises are a keystone species, acting as ecosystem engineers which help in plant seed dispersal, trampling down brush and thinning the understory of vegetation (allowing light to penetrate and germination to occur). Birds such as flycatchers perch on and fly around tortoises in order to hunt the insects they displace from the brush. In May 2010, 39 sterilised tortoises of hybrid origin were introduced to Pinta Island, the first tortoises there since the evacuation of Lonesome George 38 years ago in 1972. Sterile tortoises were released so that the problem of interbreeding between subspecies would be avoided

if any fertile tortoises were to be released in the future. It is hoped that with the recent identification of a hybrid *abingdoni* tortoise, the approximate genetic constitution of the original inhabitants of Pinta may eventually be restored with the identification and relocation of appropriate specimens to this island. This approach may be used to 're-tortoise' Floreana in the future, since captive individuals have been found to be descended from the extinct original stock.

Chapter 15

Polar Bear

Polar Bear

Conservation status

Vulnerable (IUCN 3.1)

Scientific classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Order:	Carnivora
Family:	Ursidae
Genus:	*Ursus*
Species:	***U. maritimus***

Binomial name

Ursus maritimus
Phipps, 1774

Polar bear range

Synonyms

Ursus eogroenlandicus
Ursus groenlandicus
Ursus jenaensis
Ursus labradorensis
Ursus marinus
Ursus polaris
Ursus spitzbergensis
Ursus ungavensis
Thalarctos maritimus

The **polar bear** (*Ursus maritimus*) is a bear native largely within the Arctic Circle encompassing the Arctic Ocean, its surrounding seas and surrounding land masses. It is the world's largest land carnivore and also the largest bear, together with the omnivorous Kodiak Bear, which is approximately the same size. An adult male weighs around 350–680 kg (770–1,500 lb), while an adult female is about half that size. Although it is closely related to the Brown Bear, it has evolved to occupy a narrow ecological niche, with many body characteristics adapted for cold temperatures, for moving across snow, ice, and open water, and for hunting the seals which make up most of its diet. Although most polar bears are born on land, they spend most of their time at sea. Their scientific name means "maritime bear", and derives from this fact. Polar bears can hunt consistently only from sea ice, which is why they spend much of the year on and near the edge of the frozen sea.

The polar bear is classified as a vulnerable species, with 8 of the 19 polar bear subpopulations in decline. For decades, large scale hunting raised international concern for the future of the species; populations rebounded after controls and quotas began to take effect. For thousands of years, the polar bear has been a key figure in the material, spiritual, and cultural life of Arctic indigenous peoples, and the hunting of polar bears remains important in their cultures.

Naming and etymology

Constantine John Phipps was the first to describe the polar bear as a distinct species. He chose the scientific name *Ursus maritimus*, the Latin for 'maritime bear', due to the animal's native habitat. The Inuit refer to the animal as *nanook* (transliterated as *nanuq* in the Inupiat language). The Yupik also refer to the bear as *nanuuk* in Siberian Yupik. The bear is *umka* in the Chukchi language. In Russian, it is usually called бе́лый медве́дь (*bélyj medvédj*, the white bear), though an older word still in use is ошку́й (*Oshkúj*, which comes from the Komi *oski*, "bear"). In French, the polar bear is referred to as *ours blanc* ("white bear") or *ours polaire* ("polar bear"). In the Norwegian-administered Svalbard archipelago, the polar bear is referred to as *Isbjørn* ("ice bear").

The polar bear was previously considered to be in its own genus, *Thalarctos*. However, evidence of hybrids between polar bears and brown bears, and of the recent evolutionary divergence of the two species, does not support the establishment of this separate genus, and the accepted scientific name is now therefore *Ursus maritimus*, as Phipps originally proposed.

Taxonomy and evolution

Polar bears depend on sea ice as a platform for hunting seals. Large feet and short, sharp, stocky claws are evolutionary adaptations to this environment.

The bear family, Ursidae, is believed to have split off from other carnivorans about 38 million years ago. The Ursinae subfamily originated approximately 4.2 million years ago. According to both fossil and DNA evidence, the polar bear diverged from the brown bear, *Ursus arctos*, roughly 150,000 years ago. The oldest known polar bear fossil is a

130,000 to 110,000-year-old jaw bone, found on Prince Charles Foreland in 2004. Fossils show that between ten to twenty thousand years ago, the polar bear's molar teeth changed significantly from those of the brown bear. Polar bears are thought to have diverged from a population of brown bears that became isolated during a period of glaciation in the Pleistocene.

More recent genetic studies have shown that some clades of brown bear are more closely related to polar bears than to other brown bears, meaning that the polar bear is not a true species according to some species concepts. In addition, polar bears can breed with brown bears to produce fertile grizzly–polar bear hybrids, indicating that they have only recently diverged and are genetically similar. However, because neither species can survive long in the other's ecological niche, and because they have different morphology, metabolism, social and feeding behaviors, and other phenotypic characteristics, the two bears are generally classified as separate species.

When the polar bear was originally documented, two subspecies were identified: *Ursus maritimus maritimus* by Constantine J. Phipps in 1774, and *Ursus maritimus marinus* by Peter Simon Pallas in 1776. This distinction has since been invalidated.

One fossil subspecies has been identified. *Ursus maritimus tyrannus*—descended from *Ursus arctos*—became extinct during the Pleistocene. *U.m. tyrannus* was significantly larger than the living subspecies.

Population and distribution

Polar bears investigate the submarine *USS Honolulu* 280 miles (450 km) from the North Pole.

The polar bear is found in the Arctic Circle and adjacent land masses. Due to the absence of human development in its remote habitat, it retains more of its original range than any other extant carnivore. While they are rare north of 88°, there is evidence that they range all the way across the Arctic, and as far south as James Bay in Canada. They can occasionally drift widely with the sea ice, and there have been anecdotal sightings as far south as Berlevåg on the Norwegian mainland and the Kuril Islands in the Sea of Okhotsk. It is difficult to estimate a global population of polar bears as much of the range has been poorly studied, however biologists use a working estimate of about 20,000–25,000 polar bears worldwide.

There are 19 generally recognized discrete subpopulations. The subpopulations display seasonal fidelity to particular areas, but DNA studies show that they are not reproductively isolated. The thirteen North American subpopulations range from the Beaufort Sea south to Hudson Bay and east to Baffin Bay in western Greenland and account for about 70% of the global population. The Eurasian population is broken up into the eastern Greenland, Barents Sea, Kara Sea, Laptev Sea, and Chukchi Sea subpopulations, though there is considerable uncertainty about the structure of these populations due to limited mark and recapture data.

Polar bears play-fighting

The range includes the territory of five nations: Denmark (Greenland), Norway (Svalbard), Russia, the United States (Alaska) and Canada. These five nations are the signatories of the International Agreement on the Conservation of Polar Bears, which mandates cooperation on research and conservations efforts throughout the polar bear's range.

Modern methods of tracking polar bear populations have been implemented only since the mid-1980s, and are expensive to perform consistently over a large area. The most accurate counts require flying a helicopter in the Arctic climate to find polar bears, shooting a tranquilizer dart at the bear to sedate it, and then tagging the bear. In Nunavut, some Inuit have reported increases in bear sightings around human settlements in recent years, leading to a belief that populations are increasing. Scientists have responded by noting that hungry bears may be congregating around human settlements, leading to the illusion that populations are higher than they actually are. The Polar Bear Specialist Group of the IUCN takes the position that "estimates of subpopulation size or sustainable harvest levels should not be made solely on the basis of traditional ecological knowledge without supporting scientific studies."

Of the 19 recognized polar bear subpopulations, 8 are declining, 3 are stable, 1 is increasing, and 7 have insufficient data.

Habitat

A cub nursing

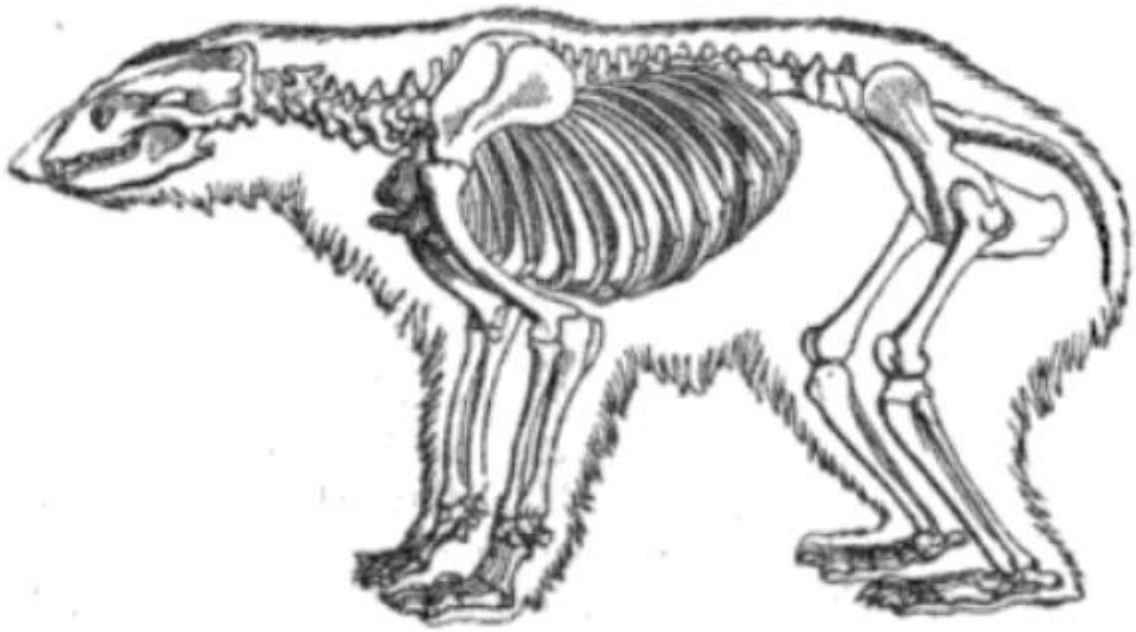
The polar bear is often regarded as a marine mammal because it spends many months of the year at sea. Its preferred habitat is the annual sea ice covering the waters over the continental shelf and the Arctic inter-island archipelagos. These areas, known as the "Arctic ring of life", have high biological productivity in comparison to the deep waters of the high Arctic. The polar bear tends to frequent areas where sea ice meets water, such as polynyas and leads (temporary stretches of open water in Arctic ice), to hunt the seals that make up most of its diet. Polar bears are therefore found primarily along the perimeter of the polar ice pack, rather than in the Polar Basin close to the North Pole where the density of seals is low.

A polar bear

Annual ice contains areas of water that appear and disappear throughout the year as the weather changes. Seals migrate in response to these changes, and polar bears must follow their prey. In Hudson Bay, James Bay, and some other areas, the ice melts completely each summer (an event often referred to as "ice-floe breakup"), forcing polar bears to go onto land and wait through the months until the next freeze-up. In the Chukchi and Beaufort seas, polar bears retreat each summer to the ice further north that remains frozen year-round.

Biology and behavior

Physical characteristics



Polar bear skeleton

The polar bear is the largest terrestrial carnivore, being more than twice as big as the Siberian tiger. It shares the title of largest land carnivore (and largest bear) with the Kodiak Bear. Adult males weigh 350–680 kg (770–1500 lbs) and measure 2.4–3 m (7.9–9.8 ft) in length. Adult females are roughly half the size of males and normally weigh 150–249 kg (330–550 lb), measuring 1.8–2.4 metres (5.9–7.9 ft) in length. When pregnant, however, they can weigh as much as 499 kg (1,100 lb). The polar bear is among the most sexually dimorphic of mammals, surpassed only by the pinnipeds. The largest polar bear on record, reportedly weighing 1,002 kg (2,210 lb), was a male shot at Kotzebue Sound in northwestern Alaska in 1960.

Polar bears have evolved unique features for Arctic life, including furred feet that have good traction on ice.

Compared with its closest relative, the brown bear, the polar bear has a more elongated body build and a longer skull and nose. As predicted by Allen's rule for a northerly animal, the legs are stocky and the ears and tail are small. However, the feet are very large to distribute load when walking on snow or thin ice and to provide propulsion when swimming; they may measure 30 cm (12 in) across in an adult. The pads of the paws are covered with small, soft papillae (dermal bumps) which provide traction on the ice. The polar bear's claws are short and stocky compared to those of the brown bear, perhaps to serve the former's need to grip heavy prey and ice. The claws are deeply scooped on the underside to assist in digging in the ice of the natural habitat. Despite a recurring Internet meme that all polar bears are left-handed, there is no scientific evidence to support this claim. Unlike the brown bear, Polar Bears in captivity are rarely overweight or particularly large, possibly as a reaction to the warm temperatures of most zoos.

The 42 teeth of a polar bear reflect its highly carnivorous diet. The cheek teeth are smaller and more jagged than in the brown bear, and the canines are larger and sharper. The dental formula is:

Dentition

3.1.4.2

3.1.4.3

Polar bears are superbly insulated by up to 10 cm (3.9 in) of blubber, their hide and their fur; they overheat at temperatures above 10 °C (50 °F), and are nearly invisible under infrared photography. Polar bear fur consists of a layer of dense underfur and an outer layer of guard hairs, which appear white to tan but are actually transparent. The guard hair is 5–15 cm (2.0–5.9 in) over most of the body. Polar bears gradually moult from May to August, but, unlike other Arctic mammals, they do not shed their coat for a darker shade to camouflage themselves in the summer conditions. The hollow guard hairs of a polar bear coat were once thought to act as fiber-optic tubes to conduct light to its black skin, where it could be absorbed; however, this theory was disproved by recent studies.

Polar bear swimming underwater at San Diego Zoo, USA

A polar bear in a synthetic arctic zoo environment

The white coat usually yellows with age. When kept in captivity in warm, humid conditions, the fur may turn a pale shade of green due to algae growing inside the guard hairs. Males have significantly longer hairs on their forelegs, that increase in length until the bear reaches 14 years of age. The male's ornamental foreleg hair is thought to attract females, serving a similar function to the lion's mane.

The polar bear has an extremely well-developed sense of smell, being able to detect seals nearly 1 mi (1.6 km) away and buried under 3 ft (0.91 m) of snow. Its hearing is about as acute as that of a human, and its vision is also good at long distances.

The polar bear is an excellent swimmer and individuals have been seen in open Arctic waters as far as 200 mi (320 km) from land. With its body fat providing buoyancy, it swims in a dog paddle fashion using its large forepaws for propulsion. Polar bears can swim 6 mph (9.7 km/h). When walking, the polar bear tends to have a lumbering gait and maintains an average speed of around 3.5 mph (5.6 km/h). When sprinting, they can reach up to 25 mph (40 km/h).

Hunting and diet

The long muzzle and neck of the polar bear help it to search in deep holes for seals, while powerful hindquarters enable it to drag massive prey.

The polar bear is the most carnivorous member of the bear family, and most of its diet consists of ringed and bearded seals. The Arctic is home to millions of seals, which become prey when they surface in holes in the ice in order to breathe, or when they haul out on the ice to rest. Polar bears hunt primarily at the interface between ice, water, and air; they only rarely catch seals on land or in open water.

The polar bear's most common hunting method is called *still-hunting*: The bear uses its excellent sense of smell to locate a seal breathing hole, and crouches nearby in silence for a seal to appear. When the seal exhales, the bear smells its breath, reaches into the hole with a forepaw, and drags it out onto the ice. The polar bear kills the seal by biting its head to crush its skull. The polar bear also hunts by stalking seals resting on the ice: Upon spotting a seal, it walks to within 100 yd (91 m), and then crouches. If the seal does not notice, the bear creeps to within 30 to 40 feet (9.1 to 12 m) of the seal and then suddenly rushes forth to attack. A third hunting method is to raid the birth lairs that female seals create in the snow.

Polar bear at a whale carcass

A widespread legend tells that polar bears cover their black noses with their paws when hunting. This behavior, if it happens, is rare — although the story exists in native oral history and in accounts by early Arctic explorers, there is no record of an eyewitness account of the behavior in recent decades.

Mature bears tend to eat only the calorie-rich skin and blubber of the seal, whereas younger bears consume the protein-rich red meat. Studies have also photographed polar bears scaling near-vertical cliffs, to eat birds' chicks and eggs. For subadult bears which are independent of their mother but have not yet gained enough experience and body size to successfully hunt seals, scavenging the carcasses from other bears' kills is an important source of nutrition. Subadults may also be forced to accept a half-eaten carcass if they kill

a seal but cannot defend it from larger polar bears. After feeding, polar bears wash themselves with water or snow.

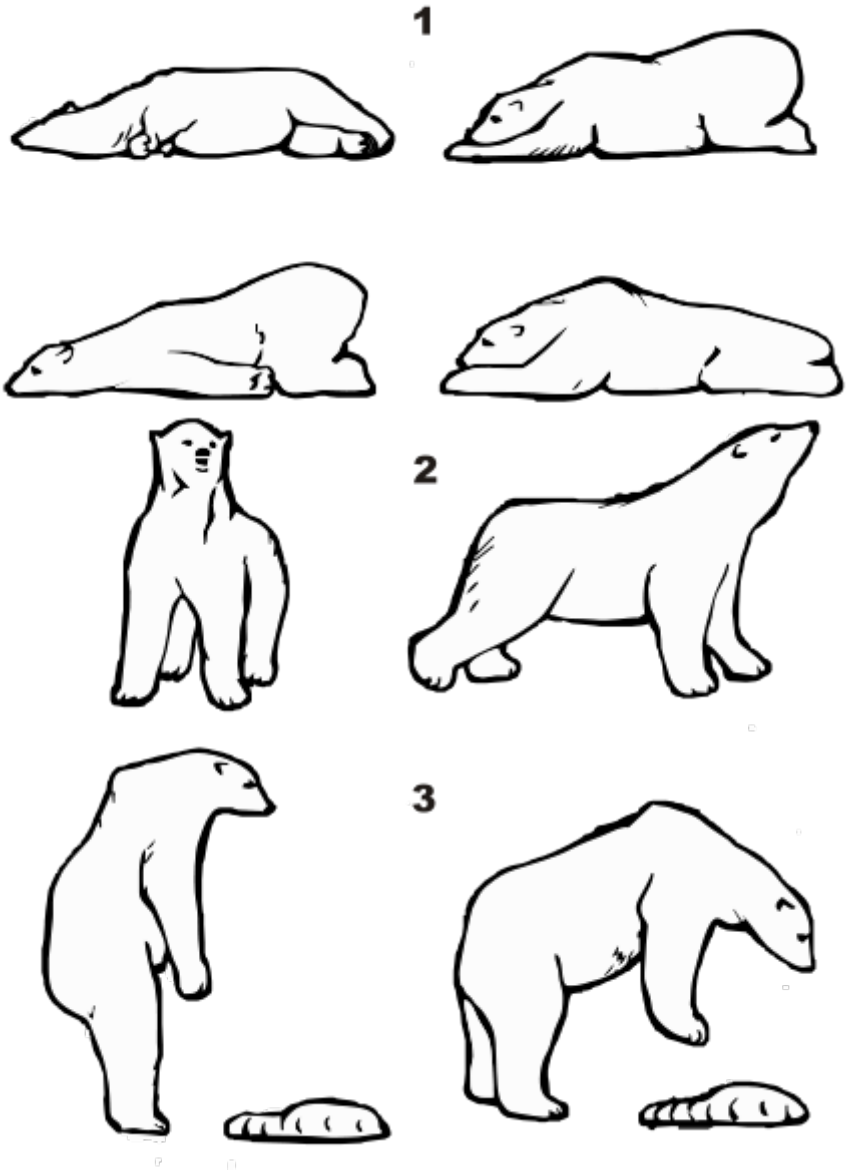
The polar bear is an enormously powerful predator. It can kill an adult walrus, although this is rarely attempted. A walrus can be more than twice the bear's weight, and has up to three feet long ivory tusks that can be used as formidable weapons. Polar bears also have been seen to prey on beluga whales, by swiping at them at breathing holes. The whales are of similar size to the walrus and nearly as difficult for the bear to subdue. Polar bears very seldom attack full-grown adult whales. Most terrestrial animals in the Arctic can outrun the polar bear on land as polar bears overheat quickly, and most marine animals the bear encounters can outswim it. In some areas, the polar bear's diet is supplemented by walrus calves and by the carcasses of dead adult walruses or whales, whose blubber is readily devoured even when rotten.

With the exception of pregnant females, polar bears are active year-round, although they have a vestigial hibernation induction trigger in their blood. Unlike brown and black bears, polar bears are capable of fasting for up to several months during late summer and early fall, when they cannot hunt for seals because the sea is unfrozen. When sea ice is unavailable during summer and early autumn, some populations live off fat reserves for months at a time. Polar bears have also been observed to eat a wide variety of other wild foods, including muskox, reindeer, birds, eggs, rodents, shellfish, crabs, and other polar bears. They may also eat plants, including berries, roots, and kelp, however none of these are a significant part of their diet. The polar bear's biology is specialized to require large amounts of fat from marine mammals, and it cannot derive sufficient caloric intake from terrestrial food.

Being both curious animals and scavengers, polar bears investigate and consume garbage where they come into contact with humans. Polar bears may attempt to consume almost anything they can find, including hazardous substances such as styrofoam, plastic, car batteries, ethylene glycol, hydraulic fluid, and motor oil. The dump in Churchill, Manitoba was closed in 2006 to protect bears, and waste is now recycled or transported to Thompson, Manitoba.

Polar bear males frequently play-fight. During the mating season, actual fighting is intense and often leaves scars or broken teeth.

Behavior



Some characteristic postures:
1. - at rest;
2. - at an estimated reaction;
3. - when feeding

Unlike grizzly bears, polar bears are not territorial. Although stereotyped as being voraciously aggressive, they are normally cautious in confrontations, and often choose to escape rather than fight. Satiated polar bears rarely attack humans unless severely provoked, whereas hungry polar bears are extremely unpredictable and are known to kill and sometimes eat humans. Polar bears are stealth hunters, and the victim is often

unaware of the bear's presence until the attack is underway. Whereas brown bears often maul a person and then leave, polar bear attacks are more likely to be predatory and are almost always fatal. However, due to the very small human population around the Arctic, such attacks are rare.

In general, adult polar bears live solitary lives. Yet, they have often been seen playing together for hours at a time and even sleeping in an embrace, and polar bear zoologist Nikita Ovsianikov has described adult males as having "well-developed friendships." Cubs are especially playful as well. Among young males in particular, play-fighting may be a means of practicing for serious competition during mating seasons later in life. Polar bears have a wide range of vocalisations, including bellows, roars, growls, chuffs and purrs.

In 1992, a photographer near Churchill took a now widely circulated set of photographs of a polar bear playing with a Canadian Eskimo Dog a tenth of its size. The pair wrestled harmlessly together each afternoon for ten days in a row for no apparent reason, although the bear may have been trying to demonstrate its friendliness in the hope of sharing the kennel's food. This kind of social interaction is uncommon; it is far more typical for polar bears to behave aggressively towards dogs.

Reproduction and lifecycle

A polar bear swimming

Courtship and mating take place on the sea ice in April and May, when polar bears congregate in the best seal hunting areas. A male may follow the tracks of a breeding female for 100 km (62 mi) or more, and after finding her engage in intense fighting with other males over mating rights, fights which often result in scars and broken teeth. Polar bears have a generally polygynous mating system; recent genetic testing of mothers and cubs, however, has uncovered cases of litters in which cubs have different fathers. Partners stay together and mate repeatedly for an entire week; the mating ritual induces ovulation in the female.

After mating, the fertilized egg remains in a suspended state until August or September. During these four months, the pregnant female eats prodigious amounts of food, gaining at least 200 kg (440 lb) and often more than doubling her body weight.

Maternity denning and early life

Cubs are born helpless, and typically nurse for two and a half years.

When the ice floes break up in the fall, ending the possibility of hunting, each pregnant female digs a *maternity den* consisting of a narrow entrance tunnel leading to one to three chambers. Most maternity dens are in snowdrifts, but may also be made underground in permafrost if it is not sufficiently cold yet for snow. In most subpopulations, maternity dens are situated on land a few kilometers from the coast, and the individuals in a subpopulation tend to reuse the same denning areas each year. The polar bears that do not den on land make their dens on the sea ice. In the den, she enters a dormant state similar to hibernation. This hibernation-like state does not consist of continuous sleeping;

however, the bear's heart rate slows from 46 to 27 beats per minute. Her body temperature does not decrease during this period as it would for a typical mammal in hibernation.

Between November and February, cubs are born blind, covered with a light down fur, and weighing less than 0.9 kg (2.0 lb). On average, each litter has two cubs. The family remains in the den until mid-February to mid-April, with the mother maintaining her fast while nursing her cubs on a fat-rich milk. By the time the mother breaks open the entrance to the den, her cubs weigh about 10 to 15 kilograms (22 to 33 lb). For about 12 to 15 days, the family spends time outside the den while remaining in its vicinity, the mother grazing on vegetation while the cubs become used to walking and playing. Then they begin the long walk from the denning area to the sea ice, where the mother can once again catch seals. Depending on the timing of ice-floe breakup in the fall, she may have fasted for up to eight months.

Cubs may fall prey to wolves or to starvation. Female polar bears are noted for both their affection towards their offspring, and their valiance in protecting them. One case of adoption of a wild cub has been confirmed by genetic testing. Adult male bears occasionally kill and eat polar bear cubs, for reasons that are unclear. In Alaska, 42% of cubs now reach 12 months of age, down from 65% 15 years ago. In most areas, cubs are weaned at two and a half years of age, when the mother chases them away or abandons them. The western coast of Hudson Bay is unusual in that its female polar bears sometimes wean their cubs at only one and a half years. This was the case for 40% of cubs there in the early 1980s; however by the 1990s, fewer than 20% of cubs were weaned this young. After the mother leaves, sibling cubs sometimes travel and share food together for weeks or months.

A female emerging from her maternity den

Later life

Females begin to breed at the age of four years in most areas, and five years in the Beaufort Sea area. Males usually reach sexual maturity at six years, however as competition for females is fierce, many do not breed until the age of eight or ten. A study in Hudson Bay indicated that both the reproductive success and the maternal weight of females peaked in their mid-teens.

Polar bears appear to be less affected by infectious diseases and parasites than most terrestrial mammals. Polar bears are especially susceptible to *Trichinella*, a parasitic

roundworm they contract through cannibalism, although infections are usually not fatal. Only one case of a polar bear with rabies has been documented, even though polar bears frequently interact with Arctic foxes, which often carry rabies. Bacterial Leptospirosis and Morbillivirus have been recorded. Polar bears sometimes have problems with various skin diseases which may be caused by mites or other parasites.

Life expectancy

Polar bears rarely live beyond 25 years. The oldest wild bears on record died at the age of 32, whereas the oldest captive was a female who died in 1991 at the age of 43. The oldest living polar bear was Debby of the Assiniboine Park Zoo, who was probably born in December, 1966 and died on November 17, 2008. The causes of death in wild adult polar bears are poorly understood, as carcasses are rarely found in the species's frigid habitat. In the wild, old polar bears eventually become too weak to catch food, and gradually starve to death. Polar bears injured in fights or accidents may either die from their injuries or become unable to hunt effectively, leading to starvation.

Ecological role

A female nursing a two-year-old cub

The polar bear is the apex predator within its range. Several animal species, particularly Arctic Foxes and Glaucous Gulls, routinely scavenge polar bear kills.

The relationship between ringed seals and polar bears is so close that the abundance of ringed seals in some areas appears to regulate the density of polar bears, while polar bear predation in turn, regulates density and reproductive success of ringed seals. The evolutionary pressure of polar bear predation on seals probably accounts for some significant differences between Arctic and Antarctic seals. Compared to the Antarctic, where there is no major surface predator, Arctic seals use more breathing holes per individual, appear more restless when hauled out on the ice, and rarely defecate on the ice. The baby fur of most Arctic seal species is white, presumably to provide camouflage from predators, whereas Antarctic seals all have dark fur at birth.

Polar bears rarely enter conflict with other predators, though recent brown bear encroachments into polar bear territories have led to antagonistic encounters. Brown bears tend to dominate polar bears in disputes over carcasses, and dead polar bear cubs have been found in brown bear dens. Wolves are rarely encountered by polar bears, though there are two records of wolf packs killing polar bear cubs. Polar bears are sometimes the host of arctic mites such as *Alaskozetes antarcticus*.

Hunting

Indigenous people

Skins of hunted polar bears in Ittoqqortoormiit, Greenland

Polar bears have long provided important raw materials for Arctic peoples, including the Inuit, Yupik, Chukchi, Nenets, Russian Pomors and others. Hunters commonly used teams of dogs to distract the bear, allowing the hunter to spear the bear or shoot it with arrows at closer range. Almost all parts of captured animals had a use. The fur was used in particular to sew trousers and, by the Nenets, to make galoshes-like outer footwear called *tobok*; the meat is edible, despite some risk of trichinosis; the fat was used in food and as a fuel for lighting homes, alongside seal and whale blubber; sinews were used as thread for sewing clothes; the gallbladder and sometimes heart were dried and powdered for medicinal purposes; the large canine teeth were highly valued as talismans. Only the liver was not used, as its high concentration of vitamin A is poisonous. Hunters make sure to either toss the liver into the sea or bury it in order to spare their dogs from potential poisoning. Traditional subsistence hunting was on a small enough scale to not significantly affect polar bear populations, mostly because of the sparseness of the human population in polar bear habitat.

History of commercial harvest

In Russia, polar bear furs were already being commercially traded in the 14th century, though it was of low value compared to Arctic Fox or even reindeer fur. The growth of the human population in the Eurasian Arctic in the 16th and 17th century, together with the advent of firearms and increasing trade, dramatically increased the harvest of polar bears. However, since polar bear fur has always played a marginal commercial role, data on the historical harvest is fragmentary. It is known, for example, that already in the winter of 1784/1785 Russian Pomors on Spitsbergen harvested 150 polar bears in Magdalenefjorden. In the early 20th century, Norwegian hunters were harvesting 300 bears a year at the same location. Estimates of total historical harvest suggest that from the beginning of the 18th century, roughly 400–500 animals were being harvested annually in northern Eurasia, reaching a peak of 1,300 to 1,500 animals in the early 20th century, and falling off as the numbers began dwindling.

In the first half of the 20th century, mechanized and overpoweringly efficient methods of hunting and trapping came into use in North America as well. Polar bears were chased from snowmobiles, icebreakers, and airplanes, the latter practice described in a 1965 *New York Times* editorial as being "about as sporting as machine gunning a cow." The numbers taken grew rapidly in the 1960s, peaking around 1968 with a global total of 1,250 bears that year.

Contemporary regulations

Concerns over the future survival of the species led to the development of national regulations on polar bear hunting, beginning in the mid-1950s. In 1973, the International Agreement on the Conservation of Polar Bears was signed by all five nations whose territory is inhabited by polar bears Canada, Denmark (Greenland), Norway (Svalbard), the USSR (now the Russian Federation) and the USA (Alaska).

A road sign on Svalbard, warning about the presence of polar bears.

Also known as the Oslo Agreement, it was a rare case of international cooperation during the Cold War. Biologist Ian Stirling commented, "For many years, the conservation of polar bears was the only subject in the entire Arctic that nations from both sides of the Iron Curtain could agree upon sufficiently to sign an agreement. Such was the intensity of human fascination with this magnificent predator, the only marine bear."

Although the agreement is not enforceable in itself, member countries agreed to place restrictions on recreational and commercial hunting, ban hunting from aircraft and icebreakers, and conduct further research. The treaty allows hunting "by local people using traditional methods," although this has been liberally interpreted by member nations. Norway is the only country of the five in which all harvest of polar bears is banned.

Agreements have been made between countries to co-manage their shared polar bear subpopulations. After several years of negotiations, Russia and the U.S. signed an agreement in October 2000 to jointly set quotas for indigenous subsistence hunting in Alaska and Chukotka. The treaty was ratified in October 2007.

Russia

The Soviet Union banned all harvest of polar bears in 1956, however poaching continued and is believed to pose a serious threat to the polar bear population. In recent years, polar

bears have approached coastal villages in Chukotka more frequently due to the shrinking of the sea ice, endangering humans and raising concerns that illegal hunting would become even more prevalent. In 2007, the Russian government made subsistence hunting legal for Chukotka natives only, a move supported by Russia's most prominent bear researchers and the World Wide Fund for Nature as a means to curb poaching.

Greenland

In Greenland, restrictions for the species were first introduced in 1994 and expanded by executive order in 2005. Until 2005, Greenland placed no limit on hunting by indigenous people. It imposed a limit of 150 for 2006. It also allowed recreational hunting for the first time. Other provisions included year-round protection of cubs and mothers, restrictions on weapons used, and various administrative requirements to catalogue kills.

Canada and the United States

Dogsleds are used for recreational hunting of polar bears in Canada. Use of motorized vehicles is forbidden.

About 500 bears are killed per year by humans across Canada, a rate believed by scientists to be unsustainable for some areas, notably Baffin Bay. Canada has allowed sport hunters accompanied by local guides and dog-sled teams since 1970, but the

practice was not common until the 1980s. The guiding of sport hunters provides meaningful employment and an important source of income for native communities in which economic opportunities are few. Sport hunting can bring CDN$20,000 to $35,000 per bear into northern communities, which until recently has been mostly from American hunters.

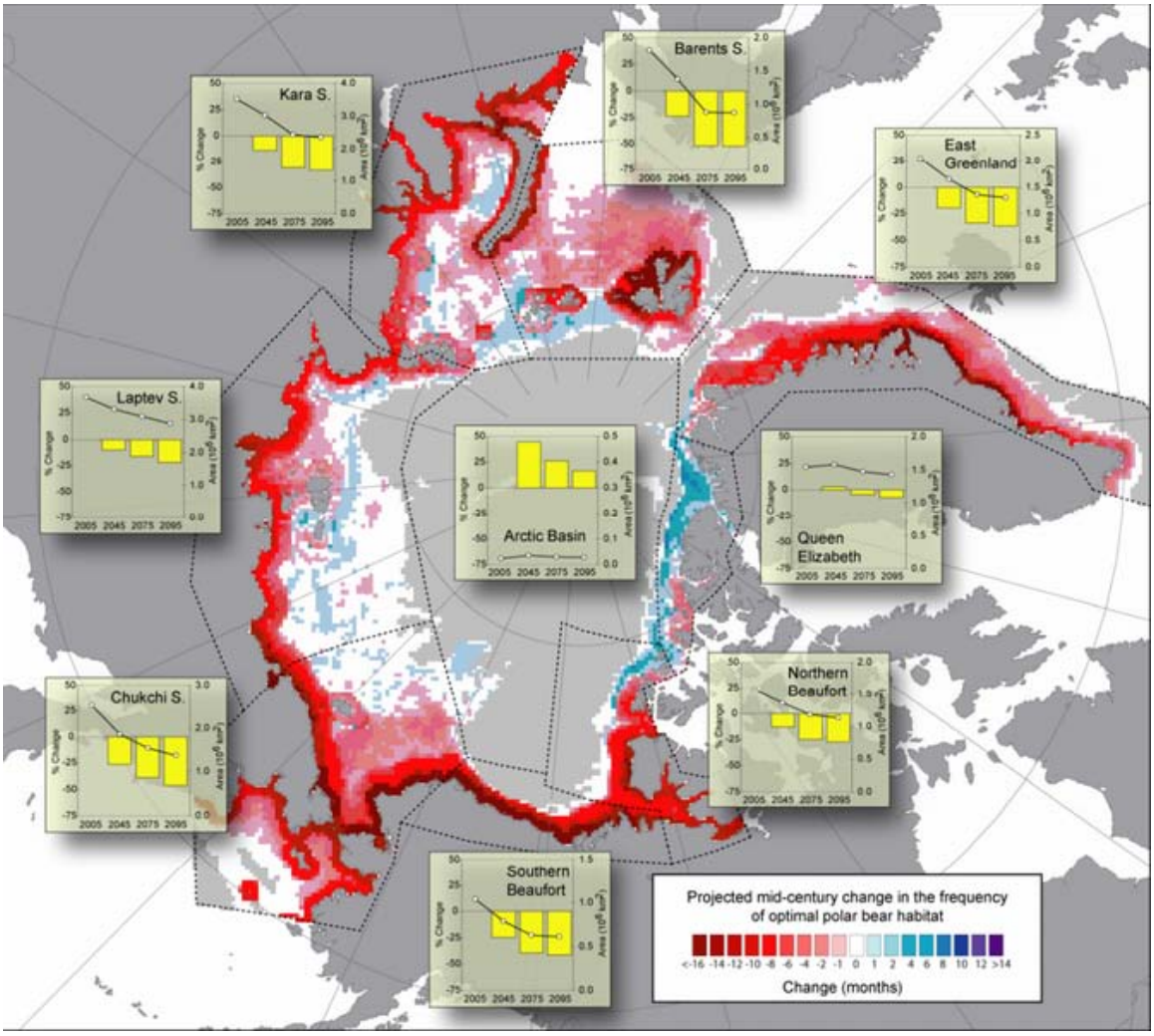
On 15 May 2008, the U.S. listed the polar bear as a threatened species under the Endangered Species Act and banned all importing of polar bear trophies. Importing products made from polar bears had been prohibited from 1972 to 1994 under the Marine Mammal Protection Act, and restricted between 1994 and 2008. Under those restrictions, permits from the United States Fish and Wildlife Service were required to import sport-hunted polar bear trophies taken in hunting expeditions in Canada. The permit process required that the bear be taken from an area with quotas based on sound management principles. Since 1994, more than 800 sport-hunted polar bear trophies have been imported into the U.S.

Ironically, because of the way polar bear hunting quotas are managed in Canada, attempts to discourage sport hunting would actually increase the number of bears killed in the short term. Canada allocates a certain number of permits each year to sport and subsistence hunting, and those that are not used for sport hunting are re-allocated to Native subsistence hunting. Whereas Native communities kill all the polar bears they are permitted to take each year, only half of sport hunters with permits actually manage to kill a polar bear. If a sport hunter does not kill a polar bear before his or her permit expires, the permit cannot be transferred to another hunter.

The territory of Nunavut accounts for 80% of Canadian kills. In 2005, the government of Nunavut increased the quota from 400 to 518 bears, despite protests from some scientific groups. In two areas where harvest levels have been increased based on increased sightings, science-based studies have indicated declining populations, and a third area is considered data-deficient. While most of that quota is hunted by the indigenous Inuit people, a growing share is sold to recreational hunters. (0.8% in the 1970s, 7.1% in the 1980s, and 14.6% in the 1990s) Nunavut polar bear biologist, Mitchell Taylor, who was formerly responsible for polar bear conservation in the territory, insists that bear numbers are being sustained under current hunting limits. The Government of the Northwest Territories maintain their own quota of 72–103 bears within the Inuvialuit communities of which some are set aside for sports hunters.

In 2010, the 2005 increase was partially reversed. Government of Nunavut officials announced that the polar bear quota for the Baffin Bay region would be gradually reduced from 105 per year to 65 by the year 2013. Environment Canada also banned the export from Canada of fur, claws, skulls and other products from polar bears harvested in Baffin Bay as of January 1, 2010.

Conservation status, efforts and controversies



This map from the U.S. Geological Survey shows projected changes in polar bear habitat from 2001–2010 to 2041–2050. Red areas indicate loss of optimal polar bear habitat; blue areas indicate gain.

As of 2008, the World Conservation Union (IUCN) reports that the global population of polar bears is 20,000 to 25,000, and is declining. In 2006, the IUCN upgraded the polar bear from a species of least concern to a vulnerable species. It cited a "suspected population reduction of >30% within three generations (45 years)", due primarily to global warming. Other risks to the polar bear include pollution in the form of toxic contaminants, conflicts with shipping, stresses from recreational polar-bear watching, and oil and gas exploration and development. The IUCN also cited a "potential risk of over-harvest" through legal and illegal hunting.

According to the World Wildlife Fund, the polar bear is important as an indicator of arctic ecosystem health. Polar bears are studied to gain understanding of what is

happening throughout the Arctic, because at-risk polar bears are often a sign of something wrong with the arctic marine ecosystem.

Global warming

The IUCN, Arctic Climate Impact Assessment, United States Geological Survey and many leading polar bear biologists have expressed grave concerns about the impact of global warming, including the belief that the current warming trend imperils the survival of the species.

The key danger posed by global warming is malnutrition or starvation due to habitat loss. Polar bears hunt seals from a platform of sea ice. Rising temperatures cause the sea ice to melt earlier in the year, driving the bears to shore before they have built sufficient fat reserves to survive the period of scarce food in the late summer and early fall. Reduction in sea-ice cover also forces bears to swim longer distances, which further depletes their energy stores and occasionally leads to drowning. Thinner sea ice tends to deform more easily, which appears to make it more difficult for polar bears to access seals. Insufficient nourishment leads to lower reproductive rates in adult females and lower survival rates in cubs and juvenile bears, in addition to poorer body condition in bears of all ages.

In addition to creating nutritional stress, a warming climate is expected to affect various other aspects of polar bear life: Changes in sea ice affect the ability of pregnant females to build suitable maternity dens. As the distance increases between the pack ice and the coast, females must swim longer distances to reach favored denning areas on land. Thawing of permafrost would affect the bears who traditionally den underground, and warm winters could result in den roofs collapsing or having reduced insulative value. For the polar bears that currently den on multi-year ice, increased ice mobility may result in longer distances for mothers and young cubs to walk when they return to seal-hunting areas in the spring. Disease-causing bacteria and parasites would flourish more readily in a warmer climate.

Problematic interactions between polar bears and humans, such as foraging by bears in garbage dumps, have historically been more prevalent in years when ice-floe breakup occurred early and local polar bears were relatively thin. Increased human-bear interactions, including fatal attacks on humans, are likely to increase as the sea ice shrinks and hungry bears try to find food on land.

Observations linked to global warming

Mothers and cubs have high nutritional requirements, which are not met if the seal-hunting season is too short.

The effects of global warming are most profound in the southern part of the polar bear's range, and this is indeed where significant degradation of local populations has been observed. The Western Hudson Bay subpopulation, in a southern part of the range, also happens to be one of the best-studied polar bear subpopulations. This subpopulation feeds heavily on ringed seals in late spring, when newly weaned and easily hunted seal pups are abundant. The late spring hunting season ends for polar bears when the ice begins to melt and break up, and they fast or eat little during the summer until the sea freezes again.

Due to warming air temperatures, ice-floe breakup in western Hudson Bay is currently occurring three weeks earlier than it did 30 years ago, reducing the duration of the polar bear feeding season. The body condition of polar bears has declined during this period; the average weight of lone (and likely pregnant) female polar bears was approximately 290 kg (640 lb) in 1980 and 230 kg (510 lb) in 2004. Between 1987 and 2004, the Western Hudson Bay population declined by 22%.

In Alaska, the effects of sea ice shrinkage have contributed to higher mortality rates in polar bear cubs, and have led to changes in the denning locations of pregnant females. Recently, polar bears in the Arctic have undertaken longer than usual swims to find prey, resulting in four recorded drownings in the unusually large ice pack regression of 2005.

Pollution

Polar bears accumulate high levels of persistent organic pollutants such as polychlorinated biphenyl (PCBs) and chlorinated pesticides. Due to their position at the top of the food pyramid, with a diet heavy in blubber in which halocarbons concentrate, their bodies are among the most contaminated of Arctic mammals. Halocarbons are known to be toxic to other animals because they mimic hormone chemistry, and biomarkers such as immunoglobulin G and retinol suggest similar effects on polar bears. PCBs have received the most study, and they have been associated with birth defects and immune system deficiency.

The most notorious of these chemicals, such as PCBs and DDT, have been internationally banned. Their concentrations in polar bear tissues continued to rise for decades after the ban as these chemicals spread through the food chain. But the trend seems to have abated, with tissue concentrations of PCBs declining between studies performed in 1989–1993 and studies performed in 1996–2002.

Sometimes excess heavy metals have also been observed in the polar bear.

Oil and gas development

Oil and gas development in polar bear habitat can affect the bears in a variety of ways. An oil spill in the Arctic would most likely concentrate in the areas where polar bears and their prey are also concentrated, such as sea ice leads. Because polar bears rely partly on their fur for insulation and soiling of the fur by oil reduces its insulative value, oil spills put bears at risk of dying from hypothermia. Polar bears exposed to oil spill conditions have been observed to lick the oil from their fur, leading to fatal kidney failure. Maternity dens, used by pregnant females and by females with infants, can also be disturbed by nearby oil exploration and development. Disturbance of these sensitive sites may trigger the mother to abandon her den prematurely, or abandon her litter altogether.

Predictions

The U.S. Geological Survey predicts two-thirds of the world's polar bears will disappear by 2050, based on moderate projections for the shrinking of summer sea ice caused by global warming. The bears would disappear from Europe, Asia, and Alaska, and be depleted from the Arctic archipelago of Canada and areas off the northern Greenland coast. By 2080, they would disappear from Greenland entirely and from the northern Canadian coast, leaving only dwindling numbers in the interior Arctic archipelago.

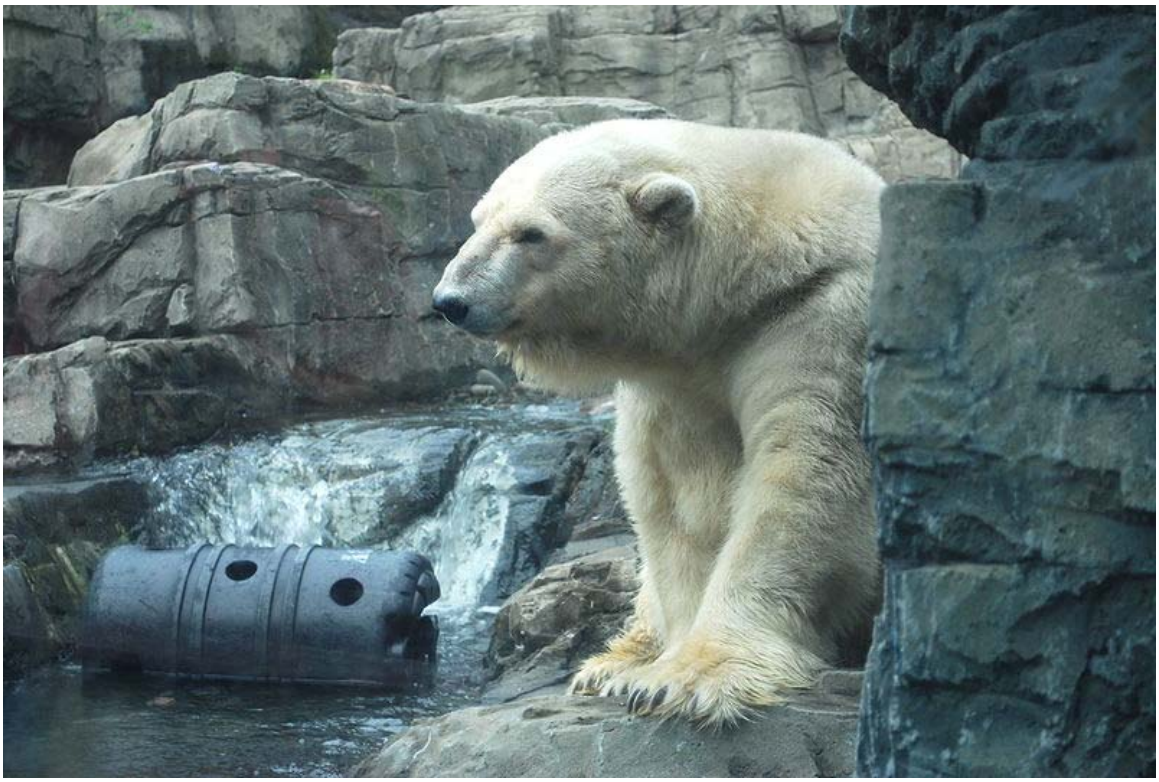
Predictions vary on the extent to which polar bears could adapt to climate change by switching to terrestrial food sources. Mitchell Taylor, who was director of Wildlife Research for the Government of Nunavut, wrote to the US Fish and Wildlife Service arguing that local studies are insufficient evidence for global protection at this time. The letter stated, "At present, the polar bear is one of the best managed of the large Arctic mammals. If all Arctic nations continue to abide by the terms and intent of the Polar Bear

Agreement, the future of polar bears is secure.... Clearly polar bears can adapt to climate change. They have evolved and perisisted for thousands of years in a period characterized by fluctuating climate." Ken Taylor, deputy commissioner for the Alaska Department of Fish and Game, has said, "I wouldn't be surprised if polar bears learned to feed on spawning salmon like grizzly bears."

However, many scientists consider these theories to be naive; it is noted that black and brown bears at high latitudes are smaller than elsewhere, because of the scarcity of terrestrial food resources. An additional risk to the species is that if individuals spend more time on land, they will hybridize with brown or grizzly bears. The IUCN wrote:

> “ Polar bears exhibit low reproductive rates with long generational spans. These factors make facultative adaptation by polar bears to significantly reduced ice coverage scenarios unlikely. Polar bears did adapt to warmer climate periods of the past. Due to their long generation time and the current greater speed of global warming, it seems unlikely that polar bear will be able to adapt to the current warming trend in the Arctic. If climatic trends continue polar bears may become extirpated from most of their range within 100 years. ”

Controversy over species protection



Polar bear at Central Park Zoo, New York City, USA

Warnings about the future of the polar bear are often contrasted with the fact that worldwide population estimates have increased over the past 50 years and are relatively stable today. Some estimates of the global population are around 5,000–10,000 in the early 1970s; other estimates were 20,000–40,000 during the 1980s. Current estimates put the global population at between 20,000 and 25,000.

There are several reasons for the apparent discordance between past and projected population trends: Estimates from the 1950s and 1960s were based on stories from explorers and hunters rather than on scientific surveys. Second, controls of harvesting were introduced that allowed this previously overhunted species to recover. Third, the recent effects of global warming have affected sea ice abundance in different areas to varying degrees.

Debate over the listing of the polar bear under endangered species legislation has put conservation groups and Canada's Inuit at opposing positions; the Nunavut government and many northern residents have condemned the U.S. initiative to list the polar bear under the Endangered Species Act. Many Inuit believe the polar bear population is increasing, and restrictions on sport-hunting are likely to lead to a loss of income to their communities.

U.S. endangered species legislation

On 14 May 2008 the U.S. Department of the Interior listed the polar bear as a threatened species under the Endangered Species Act, citing the melting of Arctic sea ice as the primary threat to the polar bear. However, the department immediately issued a statement that the listing could not be used to regulate greenhouse gas emissions, saying, "That would be a wholly inappropriate use of the Endangered Species Act. ESA is not the right tool to set U. S. climate policy." However, some policy analysts believe that despite the government's stance, the Endangered Species Act can be used to restrict the issuing of federal permits for projects that would threaten the polar bear by increasing greenhouse gas emissions. Environmental groups have pledged to go to court to have the Endangered Species Act interpreted in such a way. On 8 May 2009, the new administration of Barack Obama announced that it would continue the policy.

While listing the polar bear as a threatened species, the Interior Department added a seldom-used stipulation to allow oil and gas exploration and development to proceed in areas inhabited by polar bears, provided companies continue to comply with the existing restrictions of the Marine Mammal Protection Act. The main new protection for polar bears under the terms of the listing is that hunters will no longer be able to import trophies from the hunting of polar bears in Canada.

The polar bear is only the third species, after the elkhorn coral and the staghorn coral protected under the Endangered Species Act due to global warming. In 4 August 2008, the state of Alaska sued U.S. Interior Secretary Dirk Kempthorne, seeking to reverse the listing of the polar bear as a threatened species, out of concern that the listing would adversely affect oil and gas development in the state. Alaska Governor Sarah Palin said

that the listing was not based on the best scientific and commercial data available, a view rejected by polar bear experts.

The ruling followed several years of controversy. On 17 February 2005 the Center for Biological Diversity filed a petition asking that the polar bear be listed under the Endangered Species Act. An agreement was reached and filed in Federal district court on 5 June 2006. Pursuant to that agreement, on 9 January 2007, the US Fish and Wildlife Service proposed to list the polar bear as a threatened species. A final decision was required by law by 9 January 2008, at which time the agency said it needed another month.

On 7 March 2008, the inspector general of the U.S. Interior Department began a preliminary investigation into why the decision had been delayed for nearly two months. The investigation is in response to a letter signed by six environmental groups that U.S. Fish and Wildlife Director Dale Hall violated the agency's scientific code of conduct by delaying the decision unnecessarily, allowing the government to proceed with an auction for oil and gas leases in the Alaska's Chukchi Sea, an area of key habitat for polar bears. The auction took place in early February 2008. An editorial in *The New York Times* said that "these two moves are almost certainly, and cynically, related." Hall denied any political interference in the decision and said that the delay was needed to make sure the decision was in a form easily understood. On 28 April 2008, a Federal court ruled that a decision on the listing must be made by 15 May 2008; the decision came on 14 May to make the polar bear a protected species.

Canadian endangered species legislation

In Canada, the Committee on the Status of Endangered Wildlife in Canada recommended in April 2008 that the polar bear be assessed as a species of special concern under the federal Species at Risk Act (SARA). A listing would mandate that a management plan be written within five years, a timeline criticized by the World Wide Fund for Nature as being too long to prevent significant habitat loss from climate change.