

CHAPTER

1

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Before we embark on this book about the biology and conservation of marine mammals, we should first define exactly what they are. Marine mammals are a diverse collection of species grouped together not because of a common evolutionary history, but because they inhabit marine environments. Nevertheless, they are all mammals and as such have many characteristics in common.

Characteristics of Mammals

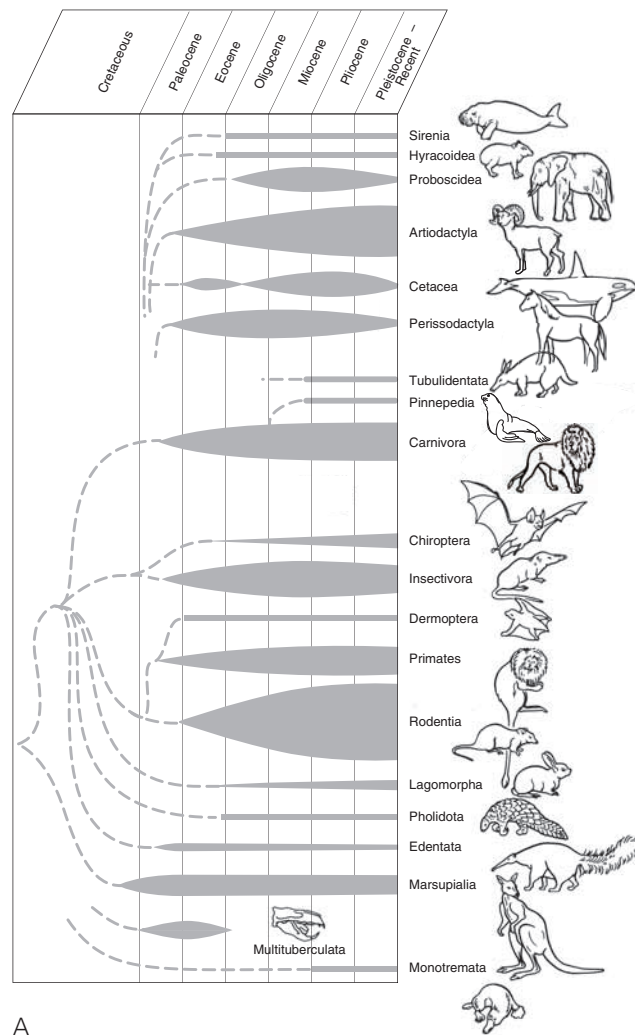
Mammals (members of Class Mammalia) have several features. They all possess hair composed of keratin, a protein; three bones in their inner ear; and sweat glands. In females some of these sweat glands have been modified to become milk-producing mammary glands, or *mammae*, which give this group of animals their name. Most mammals have teats or nipples except for the monotremes (Subclass Prototheria, Order Monotremata), which exude milk directly from their pores to be lapped up by their young. The monotremes, which include the echidna, or spiny anteater, and the aquatic platypus (**Figure 1.1**) are also unusual in that they lay eggs, unlike the rest of the mammals (Subclass Theria), which produce live young. The monotremes also have a common cloaca, or orifice, through which they lay eggs, urinate, and defecate. These remaining (Theria) mammals are separated into the Metatheria, which include the marsupials, and the Eutheria, or placental mammals. All marine mammals are members of the Eutheria.

In addition to hair, sweat, and mammary glands, mammals also possess specialized teeth and, like birds, are endothermic (or homeothermic, commonly referred to as warm-blooded), metabolically generating their own heat and maintaining a constant internal body temperature. They also possess a four-chambered heart and their brain has a neocortex (the outer part of the cerebral cortex that is responsible for sensory perception, spatial awareness, and “higher functions,” such as reasoning and language skills).

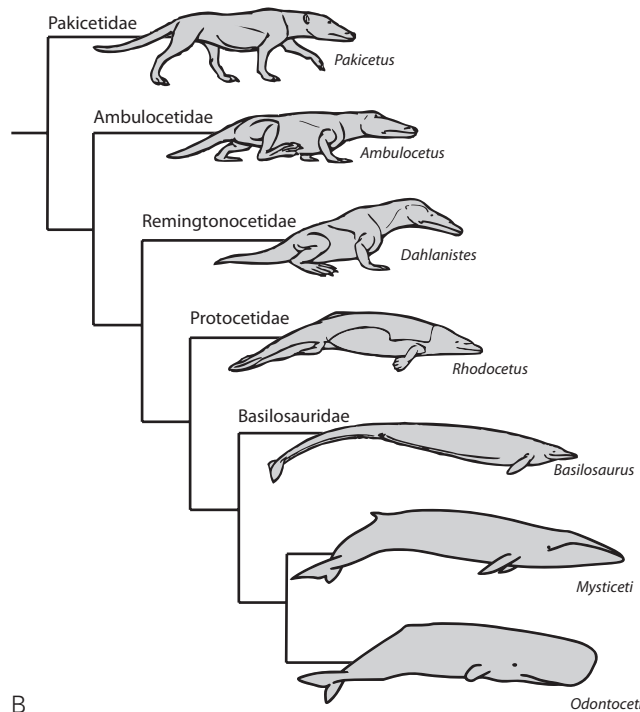


FIGURE 1.1 A member of the mammalian order Monotremata, the platypus.

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A



B

FIGURE 1.2 (A) A timeline showing mammalian evolution and (B) the sequence of evolution of various cetacean groups.

Mammalian Evolution

The evolution of the mammals really begins in the middle of the Permian period (299–251 million years ago) (**Figure 1.2**) when reptile-like therapsids were one of the main land-based predators. These creatures had several features in common, including similar skull structures and incisor teeth that were equal in size. A therapsid group that arose in the late Permian period was the cynodonts (**Figure 1.3**), animals with even more specialized teeth, including rear teeth that had crowns roughly resembling those of molar teeth. They also had a bony palate in the roof of the mouth that separated the mouth from their airways, so they could eat and breathe at the same time. Bones in their jaw also transformed, with two of the smaller jaw bones migrating to become the inner ear bones, presumably giving better hearing capabilities. It is hard to say to what extent or when these animals developed hair.

A mass extinction approximately 251 million years ago at the end of the Permian devastated terrestrial life, with approximately 70% of land vertebrate species going extinct. During the succeeding Triassic (251–199 million years ago) and Jurassic (199–145.5 million years ago) periods, the archosaurs (i.e., dinosaurs and crocodilians) overtook the therapsids as the dominant land predators and the proto-mammals appear to have shifted into a different ecological niche, becoming smaller, primarily nocturnal, and probably insectivorous, rodent-like creatures. This new niche may have led to further adaptations, such as hair to keep warm, improved hearing, and a higher metabolic rate. The first true mammals appeared in the early Jurassic, with the first marsupial, and possibly eutherians, appearing later in the fossil record at about 125 million years ago.

At the end of the Cretaceous period (145.5–65.5 million years ago) another extinction event wiped out many of the land and sea reptiles, including most of the (nonbird) dinosaurs. Mammals are then believed to have expanded and diversified, particularly in the Eocene (55.8–33.9 million years ago). Recent molecular studies confirm a peak in diversification at about 50 million years ago. However, they also suggest a (larger) peak in mammalian diversification between 100 and 85 million years ago, producing most current mammalian orders by around 75 million years ago, thus before the late Cretaceous extinction.

There are approximately 5,400 species of mammals ranging in size from the tiny Kitti's hog-nosed (or bumblebee) bat (*Craseonycteris thonglongyai*) and Etruscan shrew (*Suncus etruscus*), which weigh little more than a couple of grams, to the blue whale (*Balaenoptera musculus*), which is believed to be the largest animal that has ever lived (see Chapter 11). Mammals range from mouse-like rodents (Order Rodentia) and shrews (Order Soricomorpha) to

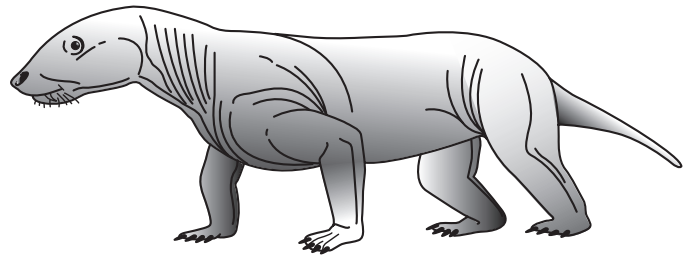


FIGURE 1.3 An artist's impression of how a cynodont could have appeared.

the wolves and cats (Order Carnivora), even-toed hoofed mammals such as deer, cows, and hippos (Order Artiodactyla), odd-toed horses (Order Perissodactyla), the elephants (Order Proboscidea), the flying bats (Order Chiroptera), to the fully marine manatees and dugongs (Order Sirenia) and whales and dolphins (Order Cetacea), and to monkeys, apes, and humans (Order Primates) (**Figure 1.4**).

Domain Eukarya
Kingdom Animalia
Phylum Chordata
Subphylum Vertebrata
Superclass Tetrapoda
Class Mammalia

Defining a Marine Mammal

What is the definition of a marine mammal? In *Marine Mammals of the World, Systematics and Distribution* (1998), Dale Rice lists marine mammals as sirenians (manatees and dugongs), pinnipeds (seals, sea lions, and walruses), and cetaceans (whales, dolphins, and porpoises). He also notes several species of bats and carnivores that inhabit marine waters and are sometimes considered to be marine mammals, although he does not specifically define what a marine mammal is. These groups include the bulldog (*Noctilio leporinus*) and fishing bats (*Myotis vivesi*), the polar bear (*Ursus maritimus*), the Arctic fox (*Vulpes lagopus*), and several otters, including the sea otter (*Enhydra lutris*), marine otter (*Lutra felina*), and Eurasian otter (*Lutra lutra*). Reynolds et al. (1999, p.1) describe marine mammals as follows:

- (a) “occupy or rely on aquatic, if not strictly marine, habitats”;
- (b) “have evolved similar anatomical features, including large body size, streamlined shape (compared to terrestrial relatives), insulation in the form of blubber and dense fur, and in most

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A



B



C



D



E

FIGURE 1.4 Examples of the diverse range of animals contained in Class Mammalia. (A) Etruscan shrew; (B) hippopotamus; (C) giraffe; (D) elephant; (E) orangutan.

cases, a modified appendicular skeleton resulting in reduction in the size of appendages”; and (c) “possess some similar physiological adaptations (e.g., for diving, thermoregulation, osmoregulation, communication, and orientation).”

They consider sirenians, pinnipeds, cetaceans, polar bears, and also marine otters and sea otters to be marine mammals but do not include species such as the North American river otter (*Lontra canadensis*) or the bulldog or fishing bats. They do note, however, that these animals can be dependent, at least in part, on the marine ecosystem. They then go on to say that this classification is influenced by the species listed under the U.S. Marine Mammal Protection Act (MMPA) of 1972, which states, “The term ‘marine mammal’ means any mammal which (a) is morphologically adapted to the marine environment (including sea



FIGURE 1.5 The polar bear, a species that is considered to be a marine mammal under the U.S. Marine Mammal Protection Act.



FIGURE 1.6 A sea otter eating crustaceans.

otters and members of the orders Sirenia, Pinnipedia and Cetacea), or (b) primarily inhabits the marine environment (such as the polar bear)” (Section 3 [6]). However, this legally based definition of a marine mammal does not specifically exclude bats or the Arctic fox, which may indeed primarily inhabit the marine environment.

Many marine mammal field guides use similar classifications, typically including polar bears and the sea and marine otters. Therefore, for the purposes of this textbook pinnipeds, sirenians, and cetaceans are the main marine mammal groups described, but we also consider that sea otters, marine otters (see Chapter 7), and polar bears (see Chapter 6) should be treated as marine mammals and devote entire chapters to them (**Figures 1.5** and **1.6**). However, we briefly discuss some of the quasi-marine mammals here.

Quasi-Marine Mammals

■ Greater Bulldog Bat (*Noctilio leporinus*)

Bulldog bats have large cheek pouches, in which they store food, giving them their name (**Figures 1.7A**). They are about 7 to 14 cm long and weigh up to 75 g, with reddish brown fur on their bodies. They have relatively large wings and

unusually long feet and claws, which aid them in their fishing behavior. The species is found in forests and mangrove swamps in Central and South America from Mexico to Argentina, but they are also found in Trinidad and the Antilles.

They hunt both freshwater and saltwater fish (as many as 30 a night) using echolocation. The bat’s large wings enable it to glide over the water when hunting for fish. They fly close to the water surface and trail their claws into the water. The claws and toes are laterally flattened, which reduces drag and allows them to slice through the water. After catching a fish with their feet, the bulldog bat transfers the fish up into its mouth. When the bat lands it chews up the fish, breaking it into large pieces. The pieces are stored in cheek pouches and chewed again before being swallowed.

Their diet exposes them to the threat of water pollution and makes them vulnerable to variations in water quality on prey abundance and distribution due to the changing climate, the alteration of freshwater influx as a result of human water usage, or increased turbidity (i.e., reduced clarity) associated with deforestation and other coastal and inshore activities. There are also reports that fish farmers in Guatemala kill this species, presumably due to their perceived impact on profits, but their population status is not known at this time.

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A



B

FIGURE 1.7 Quasi-marine mammals. (A) a greater bulldog bat; (B) a fish-eating bat.

■ Fishing (or Fish-Eating) Bat (*Myotis vivesi*)

Like the greater bulldog bat above, the fishing bat (**Figure 1.7B**) has relatively large wings and long, laterally compressed claws that it uses to fish for crustaceans and small fish, in a similar method to that used by the bulldog bat. It has brown fur, with a paler underside, and weighs about 25 g. It has a very limited distribution, being found only on the islands and coastal areas on either side of the Sea of Cortez and on the central western coast of the Baja California peninsula (**Figure 1.8**). Because both the terrestrial and marine environments it inhabits are effectively arid, the bat has a modified urinary system, which is an adaptation to low water availability. This makes the fishing bat somewhat more adapted to a marine environment than the greater bulldog bat. The fishing bat has also been seen up to 8 km from the shore.



FIGURE 1.8 Map showing the current, known distribution of the fishing bat. Data from: IUCN Red List.

Because of its limited distribution, small population size, and risks of habitat destruction and degradation, the fishing bat is listed by the International Union for Conservation of Nature (IUCN) as “vulnerable” (see Chapter 17). Invasive species, such as rats and cats, are also thought to be a concern for this species.

■ Arctic Fox (*Vulpes lagopus*)

As its name suggests, this species of fox is found in the northern polar regions, from northern Scandinavia and Russia to northern Canada, Alaska, and even the islands of Svalbard, Iceland, and Greenland.

Exploring the Depths: International Union for Conservation of Nature

The IUCN includes governments as well as environmental and animal welfare nongovernmental organizations. A major activity of the IUCN is the collation of the Red List of Threatened Species. This list categorizes species of animals and plants according to their conservation status based on scientific information on species abundance trends, distribution, and threats. The IUCN Red List categories include, in order of species threat, “vulnerable,” “endangered,” and “critically endangered” (see Chapter 17).



FIGURE 1.9 An Arctic fox.

The Arctic fox is about 85 cm long and weighs 3 to 3.5 kg, with males being slightly larger (**Figure 1.9**). They are famous for their thick white coats of dense hair that provide camouflage in the Arctic snow and ice and insulation in one of the coldest regions on earth. During the summer their coat changes color to brown, blending in with the tundra. Pups are likewise born with a brown coat.

Further adaptations to a polar environment include fur on the pads of their paws to insulate against heat loss; a substantive fat layer, a typical feature of marine mammals; a countercurrent system (see Chapter 4) that reduces heat loss from their extremities; and rounded and small extremities (ears and muzzle), reducing the surface area through which they can lose heat to the environment (see Chapter 4 for an explanation of adaptations to cold temperatures). Indeed, many of their adaptations are similar to those of polar bears (see Chapter 6). Also similar to polar bears, the Arctic fox will walk on ice to find prey and may jump on ice and snow to break the crust and gain access to prey hiding beneath the snow. They may even eat seals and cetaceans by scavenging from carcasses of stranded animals or animals killed by polar bears.

Their main prey are lemmings (*Dicrostonyx richardsoni*), but when these are scarce up to two-thirds of their

food can come from marine sources, such as scavenged seal carcasses. Changes in marine productivity can therefore greatly affect Arctic fox populations when lemming numbers are low.

The IUCN categorizes the Arctic fox as “Least Concern,” meaning their survival as a species is reasonably secure. However, several populations are severely depleted and threatened, including the Scandinavian (Norway, Sweden, and Finland) population comprising an estimated 140 adult Arctic foxes. This is primarily the result of a long history of being hunted for their fur, despite the legal protections the species has in these countries. The population on and around Medny Island (Commander Islands, Russia) has also been severely depleted as the result of an outbreak of mange that stemmed from the introduction of ticks from dogs brought to the island by humans. The current population is only approximately 90 animals.

Historically, the Arctic fox faced competition from wolves (*Canis lupus*), but as wolf populations were depleted by humans this competition has decreased. Instead, they now compete with red foxes (*Vulpes vulpes*), whose ranges are expanding, perhaps also due to the decline in wolf populations. Climate change as well as reduced available

Exploring the Depths: Sea Wolves and Sea Sheep?

Although gray wolves (*Canis lupus*) are terrestrial mammals, there is a population of wolves on the coast of British Columbia, Canada and Alaska that occupy coastal habitats, with subpopulations inhabiting the outer islands of this region. These wolves have been found to have a diet that is predominantly (75%) marine based, consisting mainly of salmon and marine mammal carcasses (**Figure B1.1**). Their dependence on a marine diet makes them vulnerable to impact from marine threats such as oil spills and over-fishing of marine species. Should this population of “sea wolves” be considered marine mammals for conservation and management purposes?



FIGURE B1.1 A marine environment-inhabiting gray wolf from British Columbia.

An analogous case could be made for a breed of sheep (*Ovis aries*) that live on the remote island of North Ronaldsay in the Orkney Islands, Scotland (**Figure B1.2**). This semiferall flock lives almost entirely on seaweed for most of the year (except for the lambing period). They have been kept this way for almost 180 years when a dry-stone wall was built to exclude sheep from the center of the island. During this time the digestive physiology of this breed evolved to efficiently extract nutrients and sugars from *Laminaria* species. The behavior of the sheep has also adapted to the availability of seaweed with grazing linked to the tidal cycle and rumination generally occurring at high tide rather than at night as in other sheep.



FIGURE B1.2 A marine environment-inhabiting sheep from North Ronaldsay, Scotland.

Exploring the Depths: Eurasian Otters: A Marine Mammal?

The Eurasian otter (*Lutra lutra*) is widespread along Scotland's north and west coast (**Figure B1.3**). Its distribution is closely associated with coastal freshwater pools and streams because otters use fresh water to wash salt from their fur to maintain its insulation. For this reason coastal Eurasian otters are generally considered to be terrestrial rather than marine mammals. Based on their diet and behavior we should probably recognize these populations as marine ecotypes because they feed on small bottom-dwelling fish and crustaceans within the littoral and sublittoral zones. Their feeding behavior is mainly diurnal (in contrast to otters in fresh water, which are crepuscular (active during twilight) and nocturnal), which is an adaptation to optimize foraging success when prey are least active and easier to catch. Furthermore, DNA analysis of otters has revealed that some island populations such as those in the Orkney and Shetland Isles are genetically distinct from Scottish mainland populations.

Whether a species is marine or terrestrial has relevance for conservation and management. Scottish marine-dwelling otters have been excluded in discussions on marine biodiversity conservation and have not been included in national marine stranding recording schemes. Factors such as fisheries

bycatch and marine pollution (i.e., threats in common with other marine species such as cetaceans and pinnipeds) do influence these populations, and therefore national agencies should include these mammals for conservation and management purposes.



FIGURE B1.3 A marine environment-inhabiting European otter in a Scottish sea loch.

Exploring the Depths: Steller's Sea Monkey: Were There More Species of Marine Mammals Historically?

Two species of marine mammal were discovered and first described to science in the 18th century by the naturalist Georg Wilhelm Steller: Steller's sea cow (*Hydrodamalis gigas*) and the Steller sea lion (*Eumetopias jubatus*) (see Chapters 8 and 16, respectively). However, two other marine animals that Steller describes in his writings remain a mystery to science. The first is the sea wolf, and Steller describes it as follows:

There is another large marine mammal which resembles the whale but is smaller, with a proportionately much thinner circumference. The Russians call it "sea wolf"; the Itelmen call it plebun; on the Kamchatka River this animal is called tsheshshak. I have not been fortunate enough to see it during my stay here. Only its meat, cheeks [jaws], tongue, and intestines are used for food. The fat is used only as fuel in lamps and not eaten because, like mercury, as soon as it is ingested, it comes out again at the other end, and so the Itelmen only eat it when they are badly constipated or, just for fun, give it to others who do not know about it (Steller 2003, pp. 79–80).

The second is the sea monkey or sea ape. The famous 19th century biologist, Leonhard Stejneger, who conducted ground-breaking research on marine mammals and who also wrote a book on Georg Steller, assumed the animal Steller sighted was a sea lion (Stejneger 1936, p. 280). Steller describes the animal meticulously:

"On August 10, we saw a very unusual and new animal, about which I shall write a short description since I watched it for two whole hours. The animal was about 2 ells long (1 ell = 1.378 ft). The head was like a dog's head, the ears pointed and erect, and on the upper and lower lips on both sides whiskers hung down which made him look like a Chinaman. The eyes were large. The body was longish, round, and fat, but gradually became thinner towards the tail; the skin was covered thickly with hair, gray on the back, russet white on the belly, but in the water it seemed to be entirely red and cow-colored. The tail, which was equipped with fins, was divided equally into two parts, the upper fin being two times as long as the lower one, just like on the sharks" (Steller 1988, p. 82).

Steller had his "cossack" shoot at it several times. The first shot missed. The second shot may have wounded the animal and it disappeared. "However, it was seen at various times in different parts of the sea" (Steller 1988, p. 83).

The naturalist Stejneger details an account by Tilesius that describes an animal which sounds remarkably like Steller's sea ape. Tilesius named it *Phoca mimica*, which is an older name for the Northern fur seal. Steller was an excellent observer, but it is very difficult to observe animals in the sea when one is really a land-trained naturalist. Stejneger also states that Steller had not seen a fur seal, either living or dead, when he made the detailed observation of the sea ape. It is, however, interesting to note that Steller makes no mention of the sea ape and the resemblance it had to a fur seal in his book *De Bestiis Marinis*. It seems as though an observer of Steller's caliber would have made that connection. Most scientists agree that Steller saw something but what it was remains a mystery.

Perhaps science will never know what Steller described in these few lines. It is important to note that Steller was a great observer, an extremely accomplished naturalist and wildlife expert, who recorded biological information with great precision and detail. Perhaps what he saw was a previously unknown species of marine mammal that did not survive until today and is now extinct!



—Contributing author, Lorelei Crerar, George Mason University.

habitat and prey species are expected to further increase competition between Arctic and red foxes.

Why Are Marine Mammals Special?

The question of why marine mammals are special has become an important one in recent years. Why are they often singled out for protection over, say, marine turtles? And why should commercial whaling not be allowed to resume in species that seem to have recovered in number?

First, marine mammals are unusual because air-breathing animals in the ocean are a rarity. They are also (for the most part) unique within mammals due to their different appearance and morphology. This is particularly true for cetaceans, which were considered to be fish throughout the world even late into the 19th century. In fact, an 1818 trial over taxation of fish oil in New York State (vs. the lack of taxation on whale oil) explored the taxonomy of the whale. Ultimately, the jury declared the whale to be a fish in line with popular (and biblically seated)

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opinion. Similarly, whales (like sturgeon) were declared to be royal fish in England in the early 14th century, a legal status that is still maintained today. They thus enjoy the various protections of being the property of the monarch (other European monarchies have also, at one time or another, made similar claims).

Marine mammals are also culturally important to humans. Any visitor to western Canada or the northwestern coast of the United States will see the images of killer whales made famous by the Nootkan peoples. In New Zealand marine mammals have an important cultural role, most famously perhaps (thanks to the movie *Whale Rider*) the Whangara people of eastern New Zealand, who tell of their legendary ancestor Paikea who rode on the back of a whale to New Zealand after his canoe sunk. Even in Europe marine mammals feature as important components of traditional cultures, for example, stories and songs of Selkies (shape-shifting seals who can turn into people) in Scotland. These are just a few examples of the place of marine mammals in the history, traditions, and cultures of humans.

Some species of marine mammals, particularly the bottlenose dolphin, have been shown to be highly intelligent. Common bottlenose dolphins are part of the small, but growing, number of animals that demonstrate a degree of self-awareness (see Chapter 12). They appear to have “names” or signature whistles (see Chapter 4), understand the linguistic rules of word order or syntax (see Chapter 12), and maximize the efficiency of their communication in a similar way to humans, with their most often used communicative elements being the shortest in their vocabulary. In fact, they are the first species demonstrated to follow this law of brevity, which is one of the basic rules that define all human languages.

Marine mammals are “keystone” species, meaning they are species that are essential for the proper functioning of an ecosystem and which if depleted or removed lead to a significant alteration, or even collapse, of that ecosystem. Top predators such as sharks and many marine mammals are known to be keystone species, with one of the best

known examples being sea otters. When sea otters are removed from the kelp forest ecosystem, their sea urchin prey multiply, consuming kelp and denuding and destroying this marine “forest” ecosystem (see Chapter 7).

Finally, marine mammals are special because we believe them to be. Societies around the world have always been in awe of the whale or have depended on seals and sea lions, earning these animals a unique place in our collective hearts. The fact that tours specifically to see marine mammals, especially cetaceans, is a global industry worth over a billion dollars (see Chapter 18 on marine mammal tourism) indicates the extent of public interest and fascination for these animals. This is one reason marine mammals are treated as conservation “flagship” or “umbrella” species. A “flagship” species is a charismatic or iconic species with which people can identify, or be motivated by, to promote conservation in general (i.e., a rallying image). The Worldwide Fund for Nature (called the World Wildlife Fund [WWF] in the U.S.) uses the image of a panda as its conservation flagship species, but many other groups use marine mammals (e.g., the International Fund for Animal Welfare uses a seal pup in their logo).

The use of marine mammals as an “umbrella” species is a subtly different use of a charismatic or iconic animal. People may not be so motivated to conserve a rare benthic (seabed) habitat but may be more willing to support the conservation of marine mammals that use or rely on that habitat. Therefore, by conserving the umbrella species, collaterally other (less charismatic but no less important) species and habitats are protected.

Returning to the MMPA as our guide for what constitutes a marine mammal, we can see that the U.S. Congress subscribed to the view that marine mammals are special, stating, “marine mammals have proven themselves to be resources of great international significance, esthetic and recreational as well as economic, and it is the sense of the Congress that they should be protected and encouraged to develop to the greatest extent feasible.”

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