CHAPTER 15
Exploitation and Conservation

15.1 INTRODUCTION

In this final chapter we consider both exploitation and other threats to marine mammals as well as progress with respect to conservation. Repeatedly over a period of hundreds of years marine mammal populations were decimated by uncontrolled human harvests, which stand as textbook examples of poor resource management. Overexploitation is in part responsible for the extinction of the Steller’s sea cow (*Hydrodamalis gigas*), the Caribbean monk seal (*Neomonachus tropicalis*), and the Atlantic gray whale (*Eschrichtius robustus*), and for the endangered status of several other species including the northern right whale (*Eubalaena glacialis*), Atlantic bowhead (*Balaena mysticetus*) populations, and nearly all populations of manatees (*Trichechus* spp.) (Hofman, 1995), dugongs (*Dugon dugon*), and river dolphins (Reeves, 2009). But, recognition of marine mammals as crucial natural resources and valued ecosystem components that require protection has resulted in the establishment of many international legal frameworks for their conservation and management, as well as national and local initiatives, all of which are important. These initiatives monitor many human-induced marine mammal mortalities, including commercial harvests as well as deaths due to net entanglements, bycatch in fisheries, environmental contaminants, and other factors causing habitat degradation.

Marine mammals are still disproportionately classified as data deficient and at risk by the International Union for the Conservation of Nature (IUCN), compared to their terrestrial counterparts, and some species currently face the risk of extinction (Schipper et al. 2008). But, it is noteworthy that some populations of cetaceans, sirenians, otters, polar bears (*Ursus maritimus*), and pinnipeds have shown strong recoveries from earlier periods of overexploitation under various protection regimes (Magera et al. 2013; see below). Although some marine mammal populations are still at risk, it is undeniable that marine mammals have benefitted greatly from a general shift toward conservation and away from resource exploitation of these animals in many countries in recent decades. However, climate change is likely to put many marine mammal species at risk in the coming decades; with ice-associated arctic species being particularly vulnerable to the rapid changes taking place currently in the North.

So, in this final chapter, we reflect on historical and current consumptive and nonconsumptive use and briefly describe other threats before evaluating our progress at conserving and protecting marine mammals and possible goals and conservation challenges for the future.
15.2 EXPLOITATION OF MARINE MAMMALS

Marine mammals have been exploited for centuries for subsistence purposes by coastal peoples on all inhabited continents. Pinnipeds at rookery or haul-out sites were especially vulnerable to early hunters foraging for food, clothing, and materials to build shelters. Midden remains of seals, sea lions, and near-shore cetaceans date back many thousands of years (Krupnik, 1984; O’Leary, 1984; Beland, 1996; Rich and Erlandson, 2008). Even large cetaceans attracted the attention of early hunters. Historical evidence indicates that right whales and perhaps also gray whales were hunted regularly in the North Sea and the English Channel from around the ninth century onward (Smet and Gordon, 1981). But, the impact of these early hunting pressures on marine mammal populations was localized and small in scale compared to later industrialized commercial hunting.

15.2.1 Historical Practices

The history of commercial exploitation of marine mammal populations, including whaling, sealing, and ottering, represent tragic examples of how not to manage renewable living resources. Beginning with the Basques in the twelfth century, who took North Atlantic right whales, and late sixteenth century Japanese whalers, who took coastal gray whales (Omura, 1984), the story of “commercial” exploitation of marine mammals has been one of repeated overharvesting and serious reductions in population sizes. A particularly well-documented early chapter in whaling history occurred in Svalbard, Norway, where whaling for bowheads commenced shortly after the discovery of the Archipelago by Willem Barentsz in 1596. The historical traces including work sites, where blubber was boiled down to create transportable oil, and the bones of both whales and people, attest to the large-scale slaughter of whales (and other marine mammals) that took place. The Svalbard bowhead whale stock is estimated to have consisted of 25,000–100,000 whales before exploitation (Allen and Keay, 2006). But, within a century it was taken to the brink of extinction by whalers from Holland, England, and Denmark (with the help of Basque whaling expertise; Figure 15.1). To this day, this population remains critically endangered (Wiig et al. 2010).

“Yankee” whalers from New England extended their reach across the Atlantic and into the Pacific and Indian Oceans in the early nineteenth century in a widening search for sperm (Physeter macrocephalus), right, bowhead, and gray whales that swam slowly and could be killed with hand harpoons and lances (Figure 15.1). By the end of the nineteenth century, right whales in both hemispheres, as well as bowhead and gray whales, had been severely depleted throughout their ranges (Donovan, 1995). The North Atlantic right whale remains the most endangered species among the great whales, numbering fewer than 400 animals, despite almost complete protection for over 100 years. In 1851 Herman Melville (the author of “Moby Dick”) questioned the future that all whales faced “…the thousand harpoons and lances darting along all the continental coasts; the moot point is, whether Leviathan can long endure so wide a chase, and so remorseless a havoc” (Melville, 1851). But this was just the beginning.
The era of modern commercial whaling was initiated in the 1860s with the invention of the cannon-fired, explosive-head harpoon. In combination with the development of faster steam-powered catcher boats, whalers could for the first time take large numbers of the faster swimming rorqual whales (initially blue whales, *Balaenoptera musculus*, and fin whales, *Balaenoptera physalus*). These whales had previously been ignored by whalers because they were too fast to be overtaken by sail- or oar-powered boats.

At first, whaling for rorquals was conducted from land stations, and the number that could be exploited was limited. The first Antarctic whaling station was established in 1904 on South Georgia; 195 whales were taken that year. The invention of the stern slipway in 1925 allowed pelagic factory ships to haul harpooned whales aboard for processing at sea (Figure 15.2) rather than depending on shore stations, and the numbers of whales taken rose dramatically. By 1913, there were six land stations and 21 floating factories, and the total catch was 10,760 whales (Donovan, 1995). The annual take climbed to over 37,000 whales (mostly blues) by 1931, when 41 factory ships were working in Antarctic waters (Figure 15.3). After this peak year, blue whales became increasingly scarce, and catches declined steadily until the catch was commercially insignificant by the mid-1950s. In 1966, only 70 blue whales were killed in the world’s oceans. When searching for blue whales was no longer profitable pelagic whalers switched to the somewhat smaller, more numerous fin whales,
FIGURE 15.2
Stern view of an Antarctic whaling factory ship (Southern Venturer) showing slipway for pulling whales to the processing deck. Photo courtesy of Southampton Oceanography Center.

FIGURE 15.3
catches of which skyrocketed to over 25,000 whales each year for most of the 1950s (Figure 15.3) (Laws, 1962). By 1960, the fin whale catch began to plummet, and whaling pressure was diverted to the even smaller sei whale. The total southern hemisphere sei whale (Balaenoptera borealis) population probably never exceeded 60,000; one-third of that population was killed in 1965 alone. By the late 1960s, sei whales had followed their larger relatives into commercial extinction, and the whaling effort shifted to the even smaller minke whale (Balaenoptera acutorostrata). Minke whales remained the principal target species of pelagic whalers until pelagic harvesting of baleen whales ceased during a moratorium initiated in 1986 (discussed below).

But whales were not the only marine mammals to experience overexploitation. Sea otters (Enhydra lutris), most species of otariids, harp (Pagophilus groenlandicus), and hooded seals (Cystophora cristata), both species of elephant seals (Mirounga angustirostris, M. leonina) and walruses (Odobenus rosmarus) were all heavily harvested for skins, oil, or both, beginning in the early eighteenth century (Scammon, 1874; Busch, 1985; Figure 15.4), but these hunters left few records of the numbers of animals taken. By the late nineteenth century, California sea otters and northern elephant seals were thought to be extinct. Other species, including most of the southern hemisphere fur seals and sea lions were also severely depleted (Shaughnessy, 1982; Riedman, 1990).

15.2.2 Current Exploitation of Marine Mammals

Marine mammals are still used for human food in many parts of the world. Some of the fisheries that target marine mammal species are commercial operations, whereas others are subsistence harvests. Nonconsumptive commercial exploitation of some marine mammal populations also occurs, primarily as objects of ecotourism operations. Small numbers of marine mammals are also taken into human care, though most zoos and aquariums now share breeding stocks and trade among facilities, minimizing the numbers of animals taken in the wild.
15.2.2.1 MARINE MAMMAL HARVESTS

Some harvests of cetaceans continue at present, including the Faroe Island drive fisheries of close to 1000 long-finned pilot whales (*Globicephala melas*) annually, Japanese harvests of small coastal odontocetes, and sperm whales, as well as several species of mysticetes (*Clapham et al. 2003*). Norway and Iceland undertake commercial harvests of minke whales, in which some few hundreds of animals are taken annually. The Norwegian minke whale harvest is the largest commercial take of cetaceans in the northern hemisphere. The annual quota is approximately 1200 animals, which is set in a five-year floating average to allow the uncaught quota to move between years to accommodate variable annual ice and sea conditions. But the catch is only about half of the quota, because relatively few boats are active in the fishery, and the market is restricted to domestic sales. Iceland initially followed the 1982 IWC moratorium against whaling, which took force in 1986 (see below), but it resumed whaling in 2006. Initially, the quota was set at 30 minke whales, but this has increased to over 200 animals during the last few years, though the take is usually well under 100 animals. The Icelanders also hunt a few fin whales (*Balaenoptera physalus*) in some years; the quota for this species in Icelandic waters is set at nine animals. Population numbers are well documented for the stocks that are harvested by these Nordic countries, and the harvests are well within sustainable limits. Japanese minke whaling in the Southern Ocean is somewhat more controversial, because it takes place in international waters and population size and stock structure of the harvested animals is not known. The average annual take in this harvest has been about 700 whales over the last decade (also see below). Aboriginal communities in Canada, the US, Russia, Greenland, and the Caribbean nation of Saint Vincent and the Grenadines also harvest cetaceans for subsistence use. For example, Greenland has an IWC-approved quota for 176 minke, 19 fin, 10 humpback whales, and two bowhead annually for the period 2015–2018 (*IWC, 2014*).

Other examples of IWC-sanctioned subsistence cetacean takes include up to 140 gray whales allotted to the Chukotka Autonomous Okrun in Russia and a six-year block catch limit of 336 bowhead whales from the Bering–Chukchi–Beaufort Seas stock. Similar to Norwegian minke whale hunting, the unused quota from one year can be transferred to subsequent years within the block; the actual quota for 2014 was thus 82 whales (*Federal Register, 2014*). Greenland and Canada also harvest relatively large numbers of narwhal (*Monodon monoceros*) and belugas (*Delphinapterus leucas*), with much larger takes of these species compared to those governed by the IWC. These harvests were likely not sustainable prior to recently implemented quota systems that are attempting to reduce the takes and the creation of a Joint Commission between Canada and Greenland to deal with populations that are harvested by both countries (e.g., see *Witting et al. 2008; Jefferson et al. 2012a*). Belugas are also harvested in Russia and Alaska, and these harvests have also exceeded sustainable limits in the recent past for some stocks, but efforts are being made to stabilize stocks and allow depleted populations to recover (e.g., *Mahoney and Shelden, 2000*). Hunting of small stocks of unknown status is seen as one of the major threats to white whale populations (*Jefferson et al. 2012b*).
Commercial harvests of pinnipeds also take place currently in some countries. The most notable because of the size of the quota is the hunt for harp seals in Canada. The Total Allowable Catch (TAC) for this species in Canada is currently 400,000 animals. This harvest level is set to purposefully induce decline of this population (DFO, 2010), which is not a commonly practiced marine mammal management regime. However, harp seal catches have dropped from hundreds of thousands prior to 2009 to only about 20% of the TAC in recent years, and the population of some seven million animals continues to increase (DFO, 2012). Norway also harvests harp seals in the Greenland Sea (formerly Russia also took part in the harvest). Here, the TAC currently is 25,000 yearling+older animals (two pups can replace one). But the catches have ranged from 5000 to 16,000 in this harvest in recent years (Norwegian Ministry of Fisheries and Coastal Affairs, 2013). A Barents Sea–White Sea harp seal population has also been harvested jointly by Russia and Norway; the current TAC for this population is approximately 15,000, but relatively few animals are actually taken (Norwegian-Russian Joint Commission Report, 2013). Hooded seals are also still commercially harvested in Canada; the TAC has been 8200 in the period 2007–2014. Whether this is sustainable is unknown given that the last status update is quite dated. This species became protected in Norway in 2008 because the population had declined by in excess of 70% in recent decades in part because of overexploitation (Øigård et al. 2014; also see climate change section). These two species are also taken in large numbers in Greenlandic hunts; 78,000 harp seals and approximately 6000 hooded seals are killed annually in Greenlandic waters in subsistence harvests, without quotas (Government of Greenland Fact Sheet, 2012). Gray seals (Halichoerus grypus) are also harvested in Canada. The TAC of 60,000 is approximately two times the sustainable estimate. This management strategy is again intended to reduce the population (DFO, 2014). But, the harvest is normally only some few 1000 animals each year. This species is also harvested in small numbers in Norway in a sport-based hunt as opposed to commercial hunting; similar but smaller sport-hunting quotas are also issued for harp and ringed seals (Pusa hispida) in coastal Norway. The only otariid species that is currently subjected to large-scale commercial harvesting is the Cape fur seal (Arctocephalus pusillus), which is harvested in Namibia. The TAC is 92,000 animals, with 90% of this quota being set for pups, whereas the remainder of the allowed take is bulls. Although the harvest is currently approximately half of the TAC, two of the three colonies that are harvested are in decline (Kirkman et al. 2013). TACs defined under the Convention for the Conservation of Antarctic Seals allow for catches of crabeater seals (Lobodon carcinophaga) (175,000), leopard seals (Hydrurga leptonyx) (12,000), and Weddell seals (Leptonychotes weddellii) (5000), though no harvests are conducted currently.

Some substantial hunts of pinnipeds occur for subsistence purposes, largely in the Arctic. Greenland alone takes over 78,000 ringed seals annually. This species is actually hunted throughout the circumpolar Arctic, but most countries do not record catches. Bearded seal (Erignathus barbatus), ribbon seal (Histriophoca fasciata), and spotted seal (Phoca largha) catches can also surpass 10,000 animals across the Arctic in individual years (see Trukhin, 2009; Allen and Angliss, 2011; Marine Mammal Commission, 2012). Northern fur
Walruses are also taken in subsistence harvests in Alaska, Russia, Canada, and Greenland. In the Pacific, catches are approximately 1000 per year (Marine Mammal Commission, 2009), whereas in the Atlantic some few hundred are taken annually. But some of this hunting in the Atlantic has caused population declines; Greenland introduced quotas in 2006 for west Greenland stocks in an attempt to stop population declines (Stewart et al. in press).

Polar bears are hunted in Alaska, Canada, and Greenland by native people; Russian and Norwegian populations are protected, although there might be a small illegal harvest in Russia (see Obbard et al. 2009). About 800 bears are taken legally on an annual basis across the Arctic from a global population of about 20,000 bears. The majority are taken in the Canadian Arctic, whereas small numbers are hunted elsewhere (see IUCN polar bear specialist group—online, Marine Mammal Commission, 2012). In a few areas, where hunting takes place without quotas, overharvesting might be taking place (Schliebe et al. 2008). Sea otters are also hunted by Alaskan natives; set season or bag limit, and permits are not required. In recent years, about 1000 animals have been taken annually based on hunter-reported kills (Fish and Wildlife Service Alaska, 2013). Manatees are protected throughout their range, but illegal harvesting is a concern for both South American (Trichechus inunguis) and West African (Trichechus senegalensis) manatees (Marmontel, 2008; Powell and Kouadio, 2008). Dugongs are subject to subsistence harvests throughout all range states within their distribution, and in some areas harvesting is causing population declines (Marsh et al. 2002; Marsh, 2008; see conservation section).

Some marine mammal populations are also subjected to various forms of “culling,” which involves killing animals specifically to reduce population sizes. Coastal pinnipeds are the most common target for culling programs, but dolphins and other whales have also been culled (Bowen and Lidgard, 2013). Such programs are conducted as a fisheries management measure, with the expectation of reducing predation on fish species that are the object of human harvests. Culling programs typically involve large proportional reductions in the predator populations (>50%). The effects of culling are generally short term because, in the absence of ongoing control, predator populations usually return rapidly to preculling densities. Sometimes such programs are stimulated by local bounties being paid for confirmed kills (based on a jaw or some other body part) (e.g., De Vooys et al. 2012). Marine mammal culling programs have rarely produced measurable objectives with respect to prey populations, and the scientific evidence justifying these actions is usually highly uncertain (see Bowen and Lidgard, 2013, for a review). In fact, it is often suggested that culling marine mammals is likely counterproductive when done in an attempt to improve returns on fisheries, because the removal of these natural predators produces systemic effects through the release of fish predators that can be negative for the target species of...
the fishery (e.g., such as in the well-studied Benguela Current System—see van der Lingen et al. 2006; Kirkman, 2010; Travis et al. 2014).

15.2.2.2 NONCONSUMPTIVE USE OF MARINE MAMMALS—ECOTOURISM

Marine mammals are charismatic megafauna that attract considerable public attention. They are favorite subjects for viewing in a host of ecotourist programs in the wild, almost everywhere they can be made accessible. They are also major draws for aquaria and other facilities in which they are kept in human care. Opinions are, of course, mixed about the use of these animals in commercial contexts, but for many people such organized visits or captive situations are the only potential to see living marine mammals. The conservation value of some public exposure should not be underestimated as most potential ecotourists are very conservation-oriented (Luksenburg et al. 2014), though, of course, the footprint of these activities should be minimized (e.g., Ortega et al. 2013), particularly taking care not to disturb animals at breeding sites. According to Barstow (1986), nonconsumptive use also includes benign research using remote sensing, or noninvasive techniques, habitat protection in the form of sanctuaries or refuges, cultural valuation involving aesthetic appreciation of cetaceans through the arts, and emphasizing whales as a unique educational resource. Herein, we focus on the ecotourism involving wild animals.

Whale watching is an ancient pastime, but a relatively young industry. Only in the past few decades has there been a defined and growing market for large numbers of people to gain close contact with whales for educational or ecotourist pursuits. These activities range from casual observations of migrating, feeding, or courting whales to intensive and prolonged observations or viewing interactions from boats or aircraft. In 1991, an estimated four million people worldwide went whale watching. By 1994, this had increased to 5.4 million, with total revenues estimated at more than 500 million US dollars (Hoyt, 1995), and over 50 countries and territories offered whale watching tours (IFAW, 1995). Some of the better known whale-watching sites are listed in Table 15.1. In the Canary Islands alone, whale-watching activities target 16 species of odontocetes, are conducted from large ferry-like vessels often carrying over 1000 passengers/day, and generate 12 million euros annually. Results of analysis of the global potential of whale watching in 2010 (Cisneros-Montemayor et al. 2010) suggested that the total potential for this industry was over $2.5 billion in yearly revenue and about 19,000 jobs worldwide, though the actual revenues in the same year (2010) were estimated as one billion US dollars worldwide (Lambert et al. 2010). The economic value of whales and other marine mammals to ecotourism activities creates positive pressure on regional governments to ensure viability of the populations, particularly in economically underdeveloped areas where conservation might otherwise not be prioritized against, for example, fisheries (see Edgar et al. 2008). For some small, oceanic nations such as the Kingdom of Tonga, whale watching is a significant source of income for the country (Kessler and Harcourt, 2012). But with the expansion of whale watching in many locations, management agencies confront new responsibilities in overseeing the
A particular type of whale tourism involves swimming with, or feeding programs for, either captive or wild dolphins. The bottlenose dolphin (*Tursiops truncatus*) is the species typically involved in these human–dolphin interactions. Several facilities in the US and elsewhere conduct swim-with-dolphin programs in captivity. Quantitative behavioral studies of bottlenose dolphins in these programs revealed that human swimmers and dolphins both have risky encounters in some cases (*Samuels and Spradlin, 1995; Samuels et al. 2000*). These negative interactions (e.g., aggressive, submissive, or sexual behavior) occurred at higher rates when encounters between dolphins and swimmers were not directly controlled by staff. In controlled situations, trainers diminished the potential for dolphin distress and swimmer injury. The long-term effects of swim programs on dolphin behavior in the wild are unknown, and assessing them would require tracking the behavior of individual dolphins over extended periods and analyzing comparative quantitative behavioral data (i.e., *Samuels and Spradlin, 1995; Samuels et al. 2000*) with that from non-swim dolphins in the wild from similar habitats. Study of the responses of wild bottlenose dolphins to the presence of swimmers in the Bay of Islands, New Zealand, revealed that dolphins changed their behavior one-third to one half of the time that they were approached by the operator’s boat. Dolphin response varied with swimmer placement. The “line abreast” strategy for placing swimmers in the water resulted in the lowest rate of avoidance by the dolphins, but some data suggest that dolphins may modify their responses with time (*Constantine and Baker, 1997; Constantine, 2001*). It is possible to swim with whales other than dolphins in a few countries (e.g., humpback whales, *Megaptera novaeangliae*, in Tonga, sperm whales in the Galapagos and Azores islands, and pilot whales, *Globicephala* spp., and beaked whales off the Canary Islands;
The adoption of government regulations, operator guidelines, and visitor educational activities for swimming with humpbacks in Tonga was recommended by Kessler and Harcourt (2010) to ensure the sustainability of the swim-with-whales industry in this small country.

Few countries allow the feeding of wild dolphins. One such country is Australia, where this practice has been the subject of scientific study. Monkey Mia in Western Australia is one of the best known areas with a history of human and dolphin interactions (Conner and Smolker, 1985). Significant differences in the behavior of wild and provisioned dolphins have been reported, including an increased mortality rate for calves born to provisioned mothers (references cited in Constantine, 1999). At another feeding program in Australia at Tangalooma, Moreton Bay Island, Queensland, forceful contact (e.g., pushy behavior) between humans and wild dolphins has been reported during feeding sessions; the number of dolphins attending a particular feeding area significantly increased the pushiness as did the presence of adult males in feeding groups (Orams et al. 1996); feeding guidelines have been developed to attempt to minimize negative impacts on people or dolphins.

A basic question facing local management agencies (and other management bodies such as the International Whaling Commission (IWC)—see following) of individual cetacean stocks exposed to whale tourism activities of various types and intensities, in general, is what are the potential impacts of these activities on the normal behavior of the target animals? Do whale watching activities constitute harassment? No doubt some whale or seal watching, as well as some benign research activities (Figure 15.5), result in obvious low-level disturbance. Various studies have examined the effects of the presence of boat traffic and noise on baleen whales (reviewed by Richardson et al. 1995b; also see Patenaude et al. 2002), and a few have studied influences on smaller odontocetes (reviewed in Buckstaff, 2004). The dominant behavioral reactions of cetaceans reported in these studies were short-term effects, such as less resting behavior, increased swimming speed, spatial avoidance, increased breathing synchrony, and changes in diving behavior (Janik and Thompson, 1996; Nowacek et al. 2001; Hastie et al. 2003; Buckstaff, 2004; Constantine et al. 2004; Lusseau, 2006). Such short-term disruptions could cause longer-term changes in the behavior of a population. Salden (1988) noted that Hawaiian humpback (Megaptera novaeangliae) cows and calves may be deserting traditional winter resting areas near the shores of Maui in favor of waters 3–4 km offshore, presumably in response to increased whale watching activities. Similarly, Cartwright et al. (2012) also report that maternal female humpbacks alter their use of habitat according to locally varying pressures in the Hawaiian Islands. However, no evidence has been found of a decline in the relative encounter rate of individual humpbacks or humpback pods. In the Southern California Bight, where whale watching of migrating gray whales is an important winter component of the sportfishing industry, Sumich and Show (1999) demonstrated a definite shift of migratory routes from coastal to offshore locations, even though this population continued to increase in size. Thus, for humpback whales in Hawaii and gray whales in California, their normal (or at least historical) behavior has changed,
perhaps as a consequence of whale watching activities. One study in New England revealed that whale watching did not correlate with either calving rate or calf production in humpbacks (Weinrich and Corbelli, 2009). These results suggest that the subtle negative effects of whale watching exposure do not necessarily indicate long-term detrimental effects on either individuals or populations in this location. Similarly, Richter et al. (2006) found that sperm whales showed only minor responses to commercial whale-watching activities in Kaikoura, New Zealand, and suggested that the induced changes were most likely not biologically important. But, a study in Fiordland, also in New Zealand, strongly suggested that the levels of dolphin–boat interactions in this region were not sustainable by the three small bottle nose dolphin populations in the region. The interactions between boats and dolphins have been shown to have both short- and long-term effects on both individuals and the populations to which they belong (Lusseau et al. 2006). These authors suggested that a multilevel marine mammal sanctuary should be created to minimize dolphin–boat interactions.

Much less information is available on the effects of tourism on pinnipeds, although they are ecotourism target species in many areas (Figure 15.6) (reviewed by Richardson et al. 1995b; Constantine, 1999). One study that explored the impact of tourism on harp seals in the Gulf of St. Lawrence reported significant reduction in female attendance of their pups during visitation and increased
pup activity levels and less resting. Both pup age and tourist behavior affected the degree of disturbance. But, behavior of mother harp seals and their young returned to that characteristic of an undisturbed situation within an hour of the departure of tourists (Kovacs and Innes, 1990).

Manatees are also the subject of considerable tourist attention in some areas. Nearly 100,000 people visit Crystal River, Florida, annually to observe and swim with Florida manatees (Trichechus manatus), which are classified as endangered, making the use-versus-preservation balance a challenge (Sorice et al. 2006). The visitors bring millions of US dollars into the coastal Florida communities, and these revenues are certainly important to countering pressure to develop the wetland areas occupied by the manatees (Solomon et al. 2004). Experimental boat approaches resulted in variable responses by manatees (Miksis-Olds et al. 2007a), but it has been shown that the use of foraging areas is correlated with noise levels (Miksis-Olds et al. 2007b). Some people have called for “best practice” to be established within the tourist industry itself, to ensure future conservation of this species along with enhancement of the visitor experience, in preference to a top-down enforcement regime by management authorities, which in this case would be the US Fish and Wildlife Service. Polar bears also receive considerable tourist attention in a few areas (e.g., Churchill Manitoba, Svalbard). There are no studies of the potential impact of these activities on the bears.
15.2.3 Other Risks Faced by Marine Mammals

Although directed marine mammal fisheries are largely under control and conducted within sustainable limits (with notable exceptions), other fisheries interactions are thought a primary threat to some marine mammal populations (Fertl, 2009; Northridge, 2009). These interactions involve trophic interactions in which marine mammals are consumers of prey populations that are also consumed by human (so are perceived as competitors) and alternatively, that overfishing by humans may be limiting the size or recovery of some marine mammal populations (Goldsworthy et al. 2003) and also operational conflicts. The latter interactions include marine mammals directly preying upon (or damaging) line, or trap, or net-caught fish, crabs, etc., or become accidently entangled in fishing gear. Additionally, contaminants in the world’s oceans and other forms of habitat degradation, such as increasing levels of ocean noise, pose escalating risks to marine mammals. Ship strikes are a threat to small populations, such as North Atlantic right whales, in which every mortality is a conservation issue (Kraus et al. 2005). Global warming is already an acute threat to Arctic species, and the changes that will take place in the world’s oceans due climate change will likely be one of the most profound impact sources in coming decades (e.g., Kovacs et al. 2011, 2012). Some of these threats are discussed below in greater detail.

15.2.3.1 FISHERIES INTERACTIONS
15.2.3.1.1 Incidental Take of Marine Mammals

The incidental, unintentional capture or bycatch of marine mammals in pelagic gill nets (both set and drift types) and pelagic long-lines is a global problem (e.g., Lewison et al. 2014; Mangel et al. 2013). Entanglement in traps, pot lines, or trawls is also a problem for some species (e.g., Goldsworthy et al. 2003; Hamer and Goldsworthy, 2006; Adimey et al. 2014). Global estimates for the early 1990s for minimum bycatch of marine mammals in gill nets alone was between 500,000 and 800,000 animals per year (Read et al. 2006). Mendez et al. (2010) suggest that the social nature of odontocetes could result in the impacts of bycatch being even more detrimental than the numbers of deaths alone would suggest. The joint entanglement of mother–offspring pairs or male–female reproductive pairs could exacerbate the demographic consequences of bycatch; the simultaneous loss of groups of relatives means that significant components of genetic diversity could be lost together, which is particularly problematic in small populations.

Available evidence indicates that several stocks of small cetaceans likely cannot sustain the mortality rates occurring due to trap and passive net entanglement. These include the vaquita (Phocoena sinus) in the Gulf of California, the Indo-Pacific humpbacked dolphin (Sousa chinensis), bottlenose dolphins of the South African Natal coast, humpbacked dolphins (Sousa spp.) in KwaZulu–Natal South Africa, Mediterranean Sea striped dolphins (Stenella coeruleoalba) (5000–10,000), harbor porpoises (Phocoena phocoena) of the western North Atlantic
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(5000–8600), eastern South Pacific dusky dolphins (*Lagenorhynchus obscurus*) (1800–1900), North Pacific northern right whale dolphins (*Lissodelphis borealis*) (19,000), Mediterranean Sea sperm whales (20–30), and various species of small odontocetes such as Risso’s dolphin (*Grampus griseus*) in the Mediterranean Sea (e.g., Perrin et al. 1994; Lopez and Barcelona, 2012, Atkins et al. 2013). The recent extinction of the baiji (*Lipotes vexillifer*) in the Yangtze River was due to a combination of habitat degradation and bycatch in nets (Turvey et al. 2010); and it is feared that a similar fate will befall the Yangtze finless porpoise (*Neophocaena asiaeorientalis asiaeorientalis*) (Mei et al. 2012). Each year during the 1990s, over 3000 cetaceans and 300 pinnipeds were incidentally caught or entangled in US fisheries alone (Read, 2008). Almost all cetacean bycatch in the US involves harbor porpoises, and dolphins with gill-net fisheries accounting for most of the serious injuries and death. But baleen whales are also at risk in some regions because of bycatch in fishing gear (e.g., Finley, 2001; Song, 2011).

Bycatch in fishing gear of various types is also a conservation concern for some pinniped species. For example, both New Zealand sea lions (*Phocarctos hookeri*) and Australian sea lions (*Neophoca cinerea*) are threatened species that are being impacted heavily by mortality in gill nets or other fishing gear (Chilvers and Wilkenson, 2008; Hamer et al. 2013). Both of these otariids have limited distributions and show strong site fidelity, so site protection would likely be a useful conservation tool (see Auge et al. 2014, and also see below). Sirenians also become entangled in some forms of fishing gear (e.g., Adimey et al. 2014).

Major efforts are being made through gear adaptation (Senko et al. 2014), various deterrents, and simply greater knowledge about marine mammal distribution to reduce bycatch mortality of marine mammals (Schakner and Blumstein, 2013; Hamer et al. 2013; Mangel et al. 2013; Lauriano et al. 2014). But, compliance by fishing vessels with bycatch mitigation measures is of course an essential element in success (see Geijer and Read, 2013). Marine mammal deterrents include tactile, visual, chemosensory, and acoustic deterrents. Acoustic deterrents, also termed acoustic harassment devices (AHDs), include *pingers* that use low acoustic output to warn animals about the presence of nets. Results have indicated that acoustic alarms can reduce the incidental catch of harbor porpoises (e.g., Kraus et al. 1997; Larsen and Krog, 2007), fransicanas (*Pontoporia blainvillei*) (Bordino et al. 2002), and short-beaked dolphins (*Delphinus delphis*) (Barlow and Cameron, 2003). However, acoustic deterrents have been found to have little to no effect on some other species (e.g., Dall’s porpoises, *Phocoenoides dalli*, and common dolphins), and pingers have induced subtle behavioral changes in bottlenose dolphins and snubfinned and humpbacked dolphins (*Sousa* spp.) (see references cited in Soto et al. 2013). It is clear that the effectiveness of pingers needs to be measured on a case-specific basis; it has been suggested that they should only be used to reduce entanglements of species of conservation concern (Hodgson et al. 2007), because the level of noise pollution associated with these devices may negatively impact nontarget marine mammal populations (Johnston and Woodley, 1998; Gotz and Janik, 2013), and some target species habituate quickly to acoustic scaring devices and may
actually use them to locate potential food sources. Global patterns of marine mammal bycatch reveal that the eastern Pacific is a hot spot of occurrence (Lewison et al. 2014).

In addition to entanglement in actively tended nets, an unknown (and probably unknowable) number of marine mammals are also killed by discarded or lost fishing gear (Figure 15.7). The shift since 1940 from the use of natural to synthetic fibers for nets, lines, and other fishing gear has led to a large increase in the quantity of lost and discarded fishing gear because these materials are so resistant to degradation. Gill-net fisheries for squid in the central North Pacific Ocean, with over one million kilometers of nets set annually, constituted a large potential source of derelict gear. These nets, if lost, often drifted for years, taking a continuing toll on populations of marine mammals and birds (also see below).

Even after nets and lines drift ashore, these derelict materials can continue to kill marine mammals. A survey of Antarctic fur seals (Arctocephalus gazella) on Bird Island, South Georgia, indicated that even on that remote island, nearly 1% of the seals were entangled in synthetic debris (Croxall et al. 1990). Most of the entangled seals were wearing “neck collars” made of plastic fish case strapping (59%), or fishing line and net material (29%) (Figure 15.8). A large proportion of these seals exhibited signs of physical injury, and most of these animals presumably die after such entanglement. Between 1985 and 1996, the Marine

**FIGURE 15.7**
Net-entangled gray whale beached on the Oregon coast.
Entanglement Research Program in the US supported work to assess marine debris, including ways to monitor debris levels, inform the public about problems and solutions, reduce derelict fishing gear, and encourage international efforts to address marine debris pollution (Walsh, 1998). In 2005, the US Congress appropriated funding to reestablish a centralized marine debris capability within the National Oceanic and Atmospheric Administration (NOAA) aimed at organizing, strengthening, and increasing the visibility of marine debris efforts within the agency and its partners (also see below under Conservation Programs). A global moratorium on all large-scale drift-net fishing on the high seas became effective at the end of 1992 (Hofman, 1995).

15.2.3.1.2 Tuna–Dolphin Interactions

Tuna fisheries present a special case for marine mammal fisheries interactions because some species of dolphins and tuna travel together, with the dolphins on the surface alerting fisherman to the presence of the fish below (Hall and Donovan, 2002; Jenkins, 2007). For example, yellowfin tuna tend to associate with several particular species of dolphins (especially Pantropical spotted dolphin, *Stenella attenuata*, *S. longirostris*, spinner dolphin and short-beaked dolphins, *Delphinus delphis*) in the eastern tropical Pacific (ETP). For decades, purse-seine nets have been deployed around dolphin schools to catch the tuna swimming below. Dolphins killed in these sets are easily counted; however, an additional unobserved mortality of dependent calves separated from their mothers is estimated about 10% of observed deaths (Archer et al. 2004). But, the minimal estimates of mortalities number in the millions (Wade, 1995).

By 1970, 200,000–300,000 dolphins were being killed each year in tuna purse-seine operations. Throughout the 1960s and into the early 1970s,
the US fleet dominated this fishery and was responsible for more than 80% of the dolphin mortality (Young et al. 1993). In 1977, the US limited the annual kill of dolphins in this fishery to 52,000 with a further reduction to 31,000 demanded by 1980. This quota was accompanied by requirements for onboard observers and several fishing gear modifications and procedural restrictions such as the use of fine-mesh net panels and new back-down procedures (Figure 15.9) to release dolphins captured within nets (National

**FIGURE 15.9**
Modern tuna purse seiner, with dolphins escaping (bottom of image) during a back-down procedure. Photo courtesy of W. Perryman.
Research Council, 1992). These management actions were very successful, and during these years, dolphin mortality dropped to less than 50% of the quota allotment. By 1984, the US tuna purse-seine fleet had declined from 94 vessels in 1980 to only two vessels in 2009 (IATTC, 1981; Marine Mammal Commission, 2009). This decline was due, in part, to US vessels fishing under the flags of other nations to evade national regulations and to avoid the high operating and labor costs in the US. The international tuna fleet remained a major source of dolphin mortality for several decades. In 1986, for example, 133,174 dolphins were killed in the tuna fishery (Young et al. 1993).

These numbers have dropped considerably in the last 25 years with an estimated kill of 1239 dolphins in 2009; the most recent mortality by a US vessel occurred in 2002 (Marine Mammal Commission, 2009). Part of this reduction has been due to consumer demands for “dolphin-safe” products. Tuna marketed in North America can be labeled as dolphin safe only if no dolphins were killed or seriously injured during the harvest of the fish (Marine Mammal Commission, 2009 and previous Annual Reports). The various management actions and marketplace demands have reduced ETP dolphin mortality in domestic and foreign tuna purse-seining operations (Figures 15.9 and 15.10), and reduced relative annual mortality of all dolphin stocks involved in this fishery. However, these fisheries left both the eastern Pacific spinner dolphin and northeastern Pacific spotted dolphin population sizes depleted. Gerrodette and Forcada (2005) concluded that, despite reductions in fishing mortality that spans two orders of magnitude, neither the stock of

![Figure 15.10](image)

**FIGURE 15.10**
Annual dolphin mortality in the tropical Pacific Ocean tuna purse-seine fishery, excluding numbers of calves separated from their mothers and presumed lost. Redrawn from National Research Council (1992).
northeastern offshore spotted dolphins nor that of eastern spinner dolphins had increased in abundance by the year 2000. Recovery is not taking place as expected for these depleted stocks, but it is uncertain whether this is due to the fishery or environmental change (Wade et al. 2007). Eastern spinner dolphins now number approximately 1.06 million and offshore spotted dolphins number some 439,000 (offshore spotted dolphin), whereas inshore spotted dolphins number 278,000 animals (Gerrodette et al. 2008).

It is noteworthy that marine mammal fisheries interactions also go the “other” direction, wherein marine mammals cause damage and losses to fisheries, beyond gear damage and lost fishing time due to entanglements. Some cetaceans and some pinnipeds actively take caught fish from lines, nets, and other gear. This is particularly economically costly when high-price fish, such as various salmonids in northern waters and toothfish (Dissostichus eleginoides) in the Southern Ocean, are the targets of predation by marine mammals (e.g., Clark and Agnew, 2010; Tixier et al. 2010; Holma et al. 2014). Recovering populations of sea lions (e.g., Zalophus californianus) in California target recreational fisheries and small commercial passenger fishing vessel operations, creating significant conflicts with anglers (Cook et al. 2014). Targeted removals of seals and sea lions have been used as a management tool to reduce these types of conflict (Oksanen et al. 2014) and also to protect threatened salmonid populations such as those in near the Bonneville Dam on the Columbia River in Oregon (Marine Mammal Commission, 2010–2011). But, sperm whales and killer whales (Orcinus orca) remain a serious problem for toothfish fisheries in some areas in the subantarctic. Ecological interactions involving parasites also make pinnipeds and cetaceans unpopular with fisheries in some parts of the world. For example, gray seals are a final host to a nematode parasite (Pseudoterranova decipiens), the intermediate host for which is Atlantic cod (Gadus morhua); gray seals are definitively linked to the prevalence of this parasite, which markedly lowers the value of catches (e.g., Buchmann and Kania, 2012).

15.2.3.2 ENVIRONMENTAL CONTAMINANTS

The fact that environmental contaminants pose risks to marine mammal populations is widely accepted. The high trophic position occupied by many marine mammal species and the tendency for all marine mammals to maintain a significant blubber layer for their thermoregulatory and energetic needs leaves them particularly vulnerable to toxic compounds that are persistent in the environment and tend to bioaccumulate through food webs (biomagnification)—particularly lipophilic (“fat-loving”) substances. Persistent organic pollutants (POPs), hydrocarbons, metals, and other compounds have been found in high concentrations in the tissues of various marine mammal species and have been associated with organ and skeletal anomalies, impaired reproduction, and immune function, various disease outbreaks, and a single incidence of acute poisoning of a small harbor seal colony (Kannan et al. 1997; Cowan, 2002). Marine mammal populations worldwide are exposed to contaminants including in Arctic and Antarctic regions, far from the sources of contamination because these compounds are
transported over long distances by atmospheric and ocean currents (Letcher et al. 2010; Trumble et al. 2012). However, despite numerous studies suggesting that exposure to pollutants has impacts on marine mammal populations, mainly on reproduction and mortality, few have demonstrated a direct relationship (see Rejinders et al. 2009 for a review). But, perhaps this is not surprising given the complex nature of marine ecosystems and the logistical and ethical difficulties in performing effects studies on marine mammals.

Two “case studies” (and numerous laboratory investigations carried out on laboratory animals) do, however, suggest strongly that exposure to high levels of contaminants could have negative impacts on marine mammal health and reproduction. A host of studies conducted over a 20+ year period on belugas in the St. Lawrence River Estuary has documented heavy contamination of the whales with mercury, lead, polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethylene (DDT), Mirex, and other pesticides, and unusually high incidences of lesions, tumors, ulcers, and conditions that are often associated with impaired immunity in other mammals (e.g., LeBeuf et al. 2014). Although inherent problems arise when comparing contaminant levels and incidents of disease between stranded animals and samples obtained in other ways (see Hobbs et al. 2003; Kingsley, 2002), the suggestion that St. Lawrence beluga have been compromised by industrial pollutants is compelling. Major efforts to limit environmental release of toxins along the river in recent decades, as well as contaminant cleanup efforts look as though they are having positive effects on this population. Some studies indicate that the St. Lawrence beluga population is showing signs of recovery (Kingsley, 1999; but also see Martineau, 2002), despite heavy ship traffic and some suspected food limitation issues (See McQuinn et al. 2011; Truchon et al. 2013). A second case occurred in the Baltic Sea, where heavy pollution loads over a period of decades were thought to be the cause of pathological impairments, including reproductive disturbances, which resulted in depressed reproductive capacity and immune disruption in ringed seals and gray seals living in the region (e.g., Helle et al. 1983; Mattson et al. 1998; Nyman et al. 2002, 2003). Declining levels of DDT and PCB in marine mammal tissues in the Baltic (and in other areas) have occurred following marked reductions in their global use, achieved through legislated bans on their production and release into the environment (AMAP, 1998; Nyman et al. 2002), and evidence exists that both gray seal and ringed seal stocks in the Baltic have shown signs of recovery (Harding and Härkönen, 1999). Dramatic declines in “legacy” organochlorine compounds have been noted in marine mammal populations in the Arctic (e.g., Wolkers et al. 2008) and elsewhere following bans on their use, though concentrations remain at toxicologically significant levels that might present a risk to marine mammals at lower latitudes where human populations and industrial development are concentrated (see Law, 2014).

Plastic debris is an increasing problem in marine environments. Sea birds and marine mammals ingest plastic objects, which can produce toxic byproducts if digested or impair digestion, or even cause gastric rupture, if they do not break down (e.g., De Stephais et al. 2013).
Catastrophic oil spills are a very visible pollution source that clearly affects marine mammal populations. Events such as *Exxon Valdez* (1989), *Brear* (1993), *Prestige* (2002), and *Deepwater Horizon* (2010) are the most recent in a long series of such events. Spilled oil floats on seawater, providing a constant reminder of its presence until it is washed ashore, sinks, or evaporates. Large volumes of oil suffocate benthic organisms by clogging their gills and filtering structures or fouling their digestive tracts. Marine birds and mammals suffer heavily as their feathers or fur become oil soaked and matted, and they lose insulation and buoyancy. Detrimental effects result from inhalation of hydrocarbon vapors in the first hours and days following the spill and longer-term impacts continue when animals ingest oil while grooming or feeding.

On March 22, 1989, the supertanker *Exxon Valdez* ran aground on Bligh Reef in Alaska’s Prince William Sound (Figure 15.11). The grounding punched holes in eight of the 11 cargo tanks and three of the seven segregated ballast tanks. The result was the third largest oil spill to date in US waters (242,000 barrels or nearly 40,000,000 l). The spill occurred in an area noted for its rich assemblages of seabirds, marine mammals, fish, and other wildlife. The area of the spill, because of its gravel and cobble beaches, was particularly sensitive to oil. In places, the thick, tarry crude oil penetrated over a meter below the beach surface. High winds, waves, and currents in the days following the accident quickly spread oil over 26,000 km². The toll on wildlife was devastating. Among marine
mammals many sea otters, seals, and sea lions were killed. More details on the biological impact of the Exxon Valdez oil spill on marine mammal populations can be found in Loughlin (1994).

In November 2002, the even larger supertanker Prestige split apart about 200 km off the northwest coast of Spain and lost much of its cargo of oil. The volume of oil released from the Prestige was greater than that from the Exxon Valdez and, because of higher water temperatures along the Spanish coast, the oil was also more toxic. Local fisheries were destroyed, and the environmental damage, the clean-up, and remediation costs were substantially greater than those incurred in the Exxon Valdez spill.

In April 2010, British Petroleum’s mobile offshore drilling unit Deepwater Horizon exploded, burned, and subsequently sank, and over nearly three months an estimated 206 million gallons (4.9 million barrels) of oil spilled into the Gulf of Mexico. This was the largest accidental oil spill ever reported. Preliminary assessments of marine mammals in the Gulf revealed increased mortalities (with strandings) of several species (mostly bottlenose dolphins) decreased reproductive success, and increased health issues resulting from the toxic effects of oil exposure (Marine Mammal Commission, 2012).

15.2.3.3 OCEAN NOISE

Sound is an important factor in the lives of many marine mammal species (Tyack, 2008). Acoustic signals are energetically inexpensive and physiologically easy to produce by most mammals so are a great communication mode. The fact that sound travels so fast and far in saltwater enables some marine mammal species to communicate over vast distances. Additionally, all odontocetes depend on sound (echolocation, see Chapter 11) to find their prey and to navigate. But, theory and increasing amounts of data suggest that anthropogenically produced sound (ocean noise or sound pollution) is already having negative effects on marine mammal behavior, energetics, and physiology (Laiola, 2010; Williams et al. 2014a); worst case scenarios involve direct mortality of marine mammals due to loud sounds, such as sonar blasts through physical damage, or initiation of stranding events (see mass strandings below). But chronic and increasing levels of noise due to industrialization of the oceans are perhaps an even greater concern at the level of populations for marine mammals (Boyd et al. 2011). Anthropogenically generated noise comes from many sources, including commercial and other ship traffic, seismic and oil exploration, establishment of infrastructure for windfarms, oil rigs, or other marine-based industry, underwater explosions, and sonar testing (Weilgart, 2007; Ellison et al. 2012; Thompson et al. 2013; Nabe-Nielsen et al. 2014).

Low-frequency military sonars have proven a major problem for some marine mammals. The US Navy deployed an active sonar system the Surveillance Towed Array Sensor System, Low Frequency Active sonar (SURTASS LFA) in the mid-1990s. This system projected high-intensity (source levels up to 235 dB), low-frequency (100–500 Hz) sound from underwater arrays of acoustic projectors towed below
a surface ship to detect and track quiet submarines at distances greater than 200 km. Many concerns about potential impacts on cetaceans, in particular, were expressed beginning in 1996 when a series of stranding events occurred involving mostly beaked whales in the Bahamas, Canary Islands, Madeira, and Greece after exposure to sound from Navy sonar (e.g., Cox et al. 2006; Filadelfo et al. 2009; Tyack et al. 2011). Most of the stranded animals that were examined while fresh presented symptoms of acoustic trauma. Postmortem conditions of examined animals included hemorrhage, edema, and major-organ blood vessels congested with small gas bubbles. This type of bubble formation within blood vessels is characteristic of decompression sickness in humans. These symptoms were new to marine mammal pathologists and were consistent with exposure to intense acoustical activity characteristic of military sonar or seismic blasting (Jepson et al. 2003). The damage patterns suggest that beaked whales may have a particular sensitivity to these sounds, either because they have airspace and tissue resonance frequencies that are sensitive to sonar frequencies or because their deep-foraging habits make them particularly vulnerable to in vivo gas-bubble formation in the presence of intense sound pressures (see DeRuiter et al. 2013). Although further research on the physical and behavioral effects of exposure to military sonar is needed, it is clear that the 180 dB threshold for protecting marine mammals from sound-induced trauma is much too high, and immediate efforts should be made to make these human-generated underwater noises less harmful without waiting until the mechanisms of acoustically induced trauma on marine mammals are fully understood (see Antunes et al. 2014). Although baleen whales seem to be impacted less by these types of sounds, in that no lethalities have been documented, it has been shown that these types of sounds do cause avoidance behavior and do have negative impacts on baleen whale feeding behavior (e.g., Goldbogen et al. 2013).

The need to monitor the impacts of both intense, acute ocean noise and lower-level but increasing sources of chronic noise is being recognized; even regular ship noise is a stressor to some marine mammals (e.g., Roland et al. 2012). Some countries are now including sound levels as a criterion to be measured in the determination of critical habitats and habitat quality for some marine mammal species (e.g., Williams et al. 2014b). Many positive steps toward understanding the effects of undersea sound on marine mammals are currently taking place. One study, occurring at Stellwagen National Marine Sanctuary, at the mouth of Massachusetts Bay, is monitoring how human activities are increasing the undersea noise (Figure 15.12) and how this in turn is impacting whales. The implications of this study are that larger ships produce sounds in the same frequency used by some marine mammals and fish suggesting that their communication with one another may be seriously compromised by noise from shipping traffic (e.g., Hatch et al. 2012). Another program is attempting to establish a circumpolar network of Passive Acoustic Monitoring (PAM) devices to study both the distribution of marine mammals and the impacts of changing environments, especially ocean noise (e.g., Moore et al. 2012; Stafford et al. 2012). This technology has great potential for cost-effective monitoring in the decades ahead (Marques et al. 2013).
15.2.3.4 CLIMATE CHANGE

The earliest signs of global warming gave rise to concern for potential impacts on marine mammals (e.g., Tynan and DeMaster, 1997; Carmack and McLaughlin, 2001; Kelly, 2001), and particular concern has been raised repeatedly for ice-associated species (see Laidre et al. 2008; Kovacs et al. 2011, 2012 for reviews). Warmer water temperatures, rising sea levels, and increasing acidity in the world’s oceans are already inducing changes in the distribution of marine animals and major shifts in marine food webs (Gilg et al. 2012). Such changes in the marine environment will cause reductions in habitat availability in many marine mammal species, while increasing available habitat for some few (e.g., Salvadeo et al. 2013). Generally speaking, specialist feeders are likely more heavily impacted by changes in food webs compared to generalist feeders, and widely distributed species will have greater chances of shifting to favorable regions than species with restricted ranges (e.g., Laidre et al. 2008; Williams et al. 2014b). Several recent marine mammal population collapses in the North Pacific, including northern fur seals Steller sea lions (Eumetopias jubatus), harbor seals (Phoca vitulina), and sea otters appear to be linked to a large-scale regime shift that is a result of large-scale, long-term weather patterns (see Maschner et al. 2014 for a review, particularly focused on Steller sea lions); the severity of the declines in the recent past are likely due to global warming trends (IPCC, 2014).

Some ice-associated species, such as polar bears, ringed seals, and hooded seals are already being challenged by reductions in the geographic extent, seasonal duration, and quality (stability) of sea ice (Meier et al. 2014; Øigård et al. 2014). Ice-associated seals are dependent on sea (and, in some cases, inland lake) ice habitats for giving birth, molting, resting, and predator avoidance; some also use ice as a mating platform or staging area, and some forage on ice-associated prey. Their ability to adapt to the current rates at which environmental changes

![Graph of sound frequency produced by marine mammals and ships in Stellwagen Marine Sanctuary, Massachusetts. Modified from Malakoff (2010).]
are taking place is highly questionable (e.g., Stenson and Hammill, 2014). Polar bears depend on ice seals for most of their diet and also use sea ice as a transport platform between foraging areas, which is particularly important to mothers with small cubs that cannot swim long distances. Prognosis for the future include a marked reduction in the global range of polar bears, including extirpation from many regions they currently occupy (Durner et al. 2009). Ice-associated whales depend on sea ice for shelter from storms and predators, including killer whales (see Higdon and Ferguson, 2009; Higdon et al. 2014), and ice edges and polynya areas are hot spots for foraging. These cetacean species are also likely to be negatively impacted by increasing human activity in previously ice-free regions in addition to the direct impacts of habitat losses and food web changes that will reduce the availability of lipid-rich traditional prey species; the three endemic arctic whales’ distributions are heavily overlapped by petroleum provinces, and pressure will undoubtedly increase for access by industry to these resources in the North (Reeves et al. 2014). Sea ice declines are expected to continue, and a seasonally ice-free Arctic is predicted to occur well before the end of this century (IPCC, 2014). Predicted implications for the organisms, including the many marine mammal species that have become residents of the unique arctic sea ice habitat have been described as “transformative” (see Johannessen and Miles, 2010; Post et al. 2013).

Southern ice-associated seals are also likely to be impacted by future changes in sea ice, though at somewhat longer and more variable time frames than those in the Arctic (Siniff et al. 2008). Crabeater and Weddell seals will likely be most affected because decreases in sea ice are likely to simultaneously increase predation rates and decrease food availability for these species. Leopard and Ross seals will be more slowly and more modestly affected because their food is somewhat removed from direct linkage to sea ice distribution. But like many of the arctic seals, sea ice is the breeding habitat for all of these species. Land-locked seals that have retained their biological ties to ice as a platform for birthing and caring of their pups are perhaps of greatest immediate concern because they cannot undertake range shifts to move to more favorable areas as conditions change. Saimaa seals, for example, are already at perilously low numbers, and recent years that lack snow and ice are intensifying conservation challenges.

Marine mammal species outside the polar regions will also be impacted by climate change. For monk seals, which are both listed as Critically Endangered, increasing sea levels are likely to submerge low atolls and beaches in small caves that are currently used by Mediterranean monk seals (Monachus monachus) for giving birth, whereas warmer temperatures and ocean acidification are likely to reduce viability of the coral reefs where Hawaiian monk seals (Neomonachus schauinslandi) forage. Land-breeding species will also be affected by sea-level rise (e.g., Funayama et al. 2013) and changing food availability. In a very general sense, areas with tropical conditions will expand with global warming, and therefore cooler, seasonally high productivity areas within the world’s oceans suitable for supporting large, thriving marine mammal populations will be reduced. Highly mobile large and small cetaceans will respond by shifting their foraging locations, but might face
match–mismatch issues with the timing of their migrations and availability of seasonal peaks of prey at high latitudes or other barriers to their distribution (Learmonth et al. 2006; Lambert et al. 2014). All marine top predators will likely be exposed to increased risk due to diseases and parasites in warmer oceans (Harvell et al. 1999, Burek et al. 2008), and it is expected that enhanced toxicity of contaminants will also accompany global warming (Noyes et al. 2009).

15.2.4 Intrinsic and Extrinsic Risks Faced by Marine Mammals

In a study that quantified extinction risk for marine mammals, the primary predictors of risk were two life-history factors: body mass at weaning and number of births/year (Davidson et al. 2012). Other factors were taxonomic group, geographic range, and degree of sociality. Marine mammals with the slowest rates of production are the sirenians. Although many odontocetes have low production rates, they have large geographic ranges and form large social groups, which reduce their extinction risk. Pinnipeds have relatively high rates of production, but walruses and otariid seals have slower rates than phocid seals, which can make them more vulnerable to extinction (Davidson et al. 2012; Plate 18). This study predicted that about one-third of all data deficient marine mammal species might actually be at risk of extinction. Using the at-risk species identified by their model, these scientists created a map showing the global distribution and hot spots of risk. When marine mammal species richness, marine productivity, and human impacts were mapped on marine mammal global distributions, it was found that 74% of marine mammal species experience high levels of human impact (e.g., fishing, shipping, pollution, ocean acidification, invasive species, oil rigs, human population density) (Plate 18). Overfishing and bycatch were among the leading human threats to marine mammals. An analysis of global threats specific to pinnipeds concurs with these findings, but also notes that climate change is recognized as a major and increasing threat (Kovacs et al. 2012).

15.3 Marine Mammal Conservation and Protection

Efforts to conserve marine mammal populations began in the early twentieth century (Reeves, 2009). The necessity for conservation action in the early days generally arose directly from overexploitation of valued resource populations and cross-border management has often been motivated by the desire to sustain exploited stocks for future use by all parties. But, more recently the recognition of the maintenance of healthy populations of top trophic predators as valued ecosystem components of marine systems is becoming more prominent, independent of harvesting or the lack of it. In part, this is being driven by nonconsumptive use, but it also reflects a shifting ethic toward increased concern regarding the conservation of global biodiversity. The clear lack of good management regimes in the past has brought many marine mammal species into public focus and has led to many bilateral and international agreements and conventions being
established to conserve marine mammal populations or their habitats and the engagement of nongovernmental organizations (NGOs) in marine mammal conservation campaigns. Some of the most important actors and actions are outlined below (and summarized in Table 15.2).

<table>
<thead>
<tr>
<th>Entity</th>
<th>Operative Year</th>
<th>Primary Mandate/Action—in Relation to Marine Mammal Conservation</th>
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</thead>
<tbody>
<tr>
<td>International Convention on Pribilof Fur Seals</td>
<td>1911</td>
<td>Banned the pelagic harvesting of northern fur seals in an attempt to slow population declines due to overexploitation.</td>
</tr>
<tr>
<td>International Union for the Conservation of Nature</td>
<td>1948</td>
<td>Specialist groups provide scientific expertise and promote coordinated conservation research. The IUCN maintains a Red List, which includes all marine mammal species; this important list provides advice to both CITES, IWC, etc.</td>
</tr>
<tr>
<td>International Convention for the Regulation of Whaling (ICRW) – IWC</td>
<td>1948/1951</td>
<td>Initially managing harvests to slow the decline in populations of the great whales, followed by a period (beginning in 1982) of more general conservation issues concerning whale stocks (baleen, sperm, and bottlenose whales), but also facilitation of quota setting and information exchange on other cetacean species.</td>
</tr>
<tr>
<td>Inter-American Tropical Tuna Commission (IATTC)</td>
<td>1949</td>
<td>Operates observer programs to observe, mitigate, and regulate dolphin mortality that is incidental to fishing operations for tuna in the eastern tropical Pacific.</td>
</tr>
<tr>
<td>World Wide Fund for Nature (WWF)</td>
<td>1961</td>
<td>NGO conservation lobby group that supports conservation and research. WWF conducts or supports many marine mammal conservation programs.</td>
</tr>
<tr>
<td>Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)</td>
<td>1975</td>
<td>Regulation and monitoring of international trade in products from species and populations classified as threatened.</td>
</tr>
<tr>
<td>International Agreement on the Conservation of Polar Bears and their Habitat</td>
<td>1976</td>
<td>Prevention of endangerment of polar bear populations due to overharvesting or other human impacts. Serves as a communication and cooperation platform but also as a legally binding document in that signatories (circumpolar range states) have agreed to “enact and enforce ….legislation and other measures as may be necessary to give effect to the agreement,” i.e., prevent polar bear populations from being endangered.</td>
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Table 15.2 Important Bodies/Conventions Relevant to the Conservation of Marine Mammals continued

<table>
<thead>
<tr>
<th>Entity</th>
<th>Operative Year</th>
<th>Primary Mandate/Action—in Relation to Marine Mammal Conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convention for the Conservation of Antarctic Seals</td>
<td>1978</td>
<td>Protected some Antarctic pinnipeds (Ross, southern elephant seal, and seals in the genus <em>Arctocephalus</em>), the latter two of which had been heavily overharvested and set quotas for other Antarctic ice-breeding seals (Weddell, crabeater, and leopard seals).</td>
</tr>
<tr>
<td>Convention for the Conservation of Antarctic Living Marine Resources</td>
<td>1982</td>
<td>Manages all fisheries catches within the CCAMLR region to prevent adverse effects on stocks or the ecosystems in which they live. CCAMLR has a strong base in science and conservation.</td>
</tr>
<tr>
<td>Convention on the Conservation of Migratory Species of Wild Animals</td>
<td>1983</td>
<td>Participates in the conservation of species (or populations) that routinely migrate across one or more national boundaries. CMS recognizes cetaceans and polar bears, but not pinnipeds or sirenians as being migratory.</td>
</tr>
<tr>
<td>United Nations General Assembly Resolution 46/215 on Drift-net Fishing</td>
<td>1992</td>
<td>Banned large-scale (&gt;2.5 km long) drift-net usage on the high seas, thus eliminating a large-scale mortality source for marine mammals.</td>
</tr>
<tr>
<td>North Atlantic Marine Mammal Commission (NAMMCO)</td>
<td>1992</td>
<td>Promotes sustainable use of marine mammal populations and serves as a forum for promoting scientific information exchange.</td>
</tr>
<tr>
<td>Agreement on the Conservation of Small Cetaceans of the Baltic and</td>
<td>1994</td>
<td>Attempts to maintain a “favorable status” for small cetaceans in this region. This agreement has stimulated abundance estimates and works to reduce fisheries bycatch of harbor porpoises and dolphins.</td>
</tr>
<tr>
<td>North Sea (ASCOBANS – concluded under CMS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Areas (ACCOBANMS—concluded under CMS)</td>
<td>2001</td>
<td>Completely prohibits intentional killing of cetaceans in the region and established a network of specially protected areas to conserve cetaceans. Extends ASCOBANS to all whales, and includes other threats such as boat strikes, prey depletion, etc.</td>
</tr>
</tbody>
</table>

Adapted from Reeves (2009).

### 15.3.1 International Conservation Efforts

One of the first protective measures specific to a marine mammal species was the 1911 International Convention on Pribilof fur seals, which banned the pelagic harvesting of northern fur seals in an attempt to slow population declines, although harvesting of young bachelor males continued on land for much of the...
twentieth century (Gentry and Kooymen, 1986). After the fur seal Convention lapsed in 1984, commercial levels of harvesting of northern fur seals had effectively ceased, and only subsistence hunting continues today (Bonner, 1994).

The next major international convention with respect to marine mammals was the International Whaling Commission (IWC). The post-World War II history of modern whaling is essentially that of the history of the IWC. In 1946, the International Convention for the Regulation of Whaling was signed and in 1948 was ratified, formally establishing the IWC (Gambell, 1999). This convention set a precedent for international regulation of natural resources by giving conservation equal billing with the economics of whaling. Its stated aim was “to provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry.” The IWC was established to regulate Antarctic whaling, basically to make recommendations on quotas, but it also regulated other aspects of the harvest to ensure sustainability, such as dictating minimum sizes and banning the taking of females with calves. Although it was created to manage the “great whales” (which are customarily defined as the baleen whales plus the sperm whale), it was extended to cover all commercial pelagic whaling activities of member nations globally, and it now also serves as a venue for discussions of coastal whaling issues and occasionally small cetacean conservation practices as well. The IWC recognized the need for scientific advice and established an advisory Scientific Committee whose members are nominated by member governments. The IWC was intended to “encourage, recommend, and organize” studies and to “collect, analyze, study, appraise, and disseminate” information (Article IV); however, it lacked both inspection and enforcement powers (Wallace, 1994). Any member government could object to any decision with which it did not agree and excuse itself from the limitations of that decision. This, along with the right of member nations to unilaterally issue permits to catch whales for scientific purposes, has limited the authority of the IWC to enforce its own recommendations and regulations.

Early IWC management procedures were based on the use of the Blue Whale Unit (BWU) as a means of setting catch quotas. Based upon oil yield, it was considered that one blue whale was equal to two fin, 2.5 humpback, or six sei whales (Figure 15.13) (Andresen, 1993), with no distinction given to the actual species being harvested. In 1962–1963, a call from the Scientific Committee for quotas by species was rejected, but the total quota was reduced from 15,000 to 10,000 BWUs, and humpback whales were protected throughout the southern hemisphere. In 1964–1965, blue and humpback whales were given complete protection, and Norway, the Netherlands, and the UK ceased their Antarctic whaling operations, leaving only Japan and the Soviet Union actively engaged in the pelagic harvesting of baleen and sperm whales in the Southern Ocean (Tonnessen and Johnsen, 1982).

Reductions in target population sizes, new national and international regulations, changing market demands, and availability of synthetic substitutes for
Exploitation and Conservation

CHAPTER 15

marine mammal oil, as well as changing attitudes in many nations concerning the ethics of killing large whales for profit, all contributed to the demise of large-scale pelagic whaling. A new IWC management procedure was instituted in 1974, based on the recognition that management procedures should apply to geographically localized stocks rather than to species. This new procedure also recognized a protected-stock category, which allowed for zero quotas on individual stocks, that is, no harvesting. In 1979, a proposal to end pelagic whaling for all species except minke whales was adopted, and a sanctuary was declared for the Indian Ocean (outside the Antarctic). By 1982, the IWC had agreed to a deferred pause (a “moratorium”) in all commercial whaling to begin in 1986, with a responsibility for conducting a comprehensive assessment of large whale stocks by 1990. In 1994, the IWC accepted a revised procedure for estimating the number of whales that could be taken without causing the affected population to be reduced below its maximum net productivity. This revised management procedure (RMP; see Hofman, 1995) has been used to calculate TACs for various subsistence hunts of cetaceans.

The recommendations of the IWC have been challenged in many cases. After several years of taking small minke whale catches for scientific study, Norway tabled its objection to the moratorium on whaling, and resumed hunting minke whales commercially, within sustainable limits. A national monitoring program was established to ensure good management practice in terms of stock viability, and a national system of inspection was established to improve killing practices and monitoring of the hunt. Iceland has also recently engaged in hunting some few minke whales and also fin whales in the Northeast Atlantic. Japan is the only nation that resumed Southern Ocean whaling following the moratorium; they did so under the auspices of scientific whaling, which has continued for decades. But, in 2014, this issue was brought to the International Court of Justice, which ruled against Japan, saying the harvest level was not justified by the scientific results produced by the program and deemed further harvesting illegal. Ongoing controversy exists regarding the IWC’s authority to manage small cetacean species, which means the toothed whales except sperm whales and bottlenose

FIGURE 15.13

BWU equivalents for four species of baleen whales: one BWU = one blue whale = two fin whales = 2.6 humpback whales = six sei whales.
whales (*Hyperoodon* spp.) (see Reeves, 2009 for details). Some member nations
have insisted that these cetaceans are solely national or regional concerns with
respect to exploitation and conservation, which is reflected in various national
and regional plans (see below).

The International Union for the Conservation of Nature (IUCN) was estab-
lished in 1948. It provides regular updates of the best available information
about the global conservation status of animals. The IUCN maintains a Red List
of Threatened and Endangered Species, which places species (and sometimes
lower taxa) in categories of risk, ranging from Critically Endangered to Least
Concern, by using criteria that focus on the size and structure of wild popu-
lations, habitat quality, and the trends in these parameters over the last three
generations for individual species (IUCN, 2014). According to this classification
system, marine mammals are disproportionately threatened and disproportio-
nately data poor compared to their terrestrial counterparts (Schipper et al. 2008).
In the 2014 version of the IUCN Red List, approximately 25% of marine mam-
mal species fall in a threatened category, and about 40% of marine mammal
taxa are considered to be Data Deficient. IUCN is a highly respected conserva-
tion organization, and many countries take its designations very seriously in
terms of conservation prioritization.

The Inter-American Tropical Tuna Commission (IATTC) was created in 1949
as a treaty between the US and Costa Rica, but has expanded over the years to
include France, Japan, Mexico, and Vanuatu as well as a number of other Central
and South American countries. This commission has in recent decades managed
the incidental mortality of dolphins in purse seines, although not without its
challenges. Over the period 1960–1972, more than four million dolphins were
killed by purse-seine vessels fishing for yellowfin tuna (*Thunnus albacares*) in
the ETP (Figure 15.9) (Wade, 1995). Regulation of the fishery resulted in major
reductions in dolphin mortality.

Large-scale commercial harvests for harp and hooded seals took place with-
out meaningful regulation until the late 1950s (Reeves, 2009). But, after that
time bilateral agreements between Norway and Russia (formerly the Soviet
Union) established quotas for the Northeast Atlantic stocks and between
Canada and Norway for the Northwest Atlantic stock. Starting in the 1960s,
a Sealing Panel under NAFO (Northwest Atlantic Fisheries Organization) set
quotas and other conservation measures. More recently, the International
Council for the Exploration of the Seas (ICES) and NAFO have been coor-
dinated via the establishment of a Working Group on harp and hooded
seals that discusses and reports on all stocks. Since 1992, the North Atlantic
Marine Mammal Commission (NAMMCO) takes this advice to its members
(Iceland, Norway, Greenland, and the Faroe Islands). This latter regional
Commission was established to promote responsible, sustainable harvesting
of marine mammals in this ocean sector and to serve as a facilitator in shar-
ing scientific findings about marine mammal population in the Northeast
Atlantic.
The International Polar Bear Agreement was signed in 1973 and took effect in 1976. This agreement among the polar bear range states (Canada, US, Denmark (on behalf of Greenland), Norway, and the Soviet Union (now Russia)) was established to control harvesting, protect polar bear habitat and to ensure that research needed for management purposes took place in a coordinated manner. The polar bear specialist group of the IUCN serves as the de facto scientific committee, whereas policy decisions are taken at meetings of the Parties (i.e., Government Representatives of the Range States).

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) came into force in 1975, creating a mechanism to regulate the international trade of endangered plant and animal species, including numerous species of marine mammals. Species listed in CITES Appendix I include all species deemed threatened with extinction that are, or may be, affected by international trade policies or activities. All commercially valuable baleen whales, and some odontocete whales including the sperm whale became listed under CITES Appendix I in 2007. Species listed in CITES Appendix II include species that, although not currently threatened with extinction, may become so unless international trade is restricted or regulated by participating governments (Wallace, 1994). Despite cooperation that has resulted from resolutions adopted by CITES and the IWC, incidents of illegal trade in whale products (i.e., meat and blubber) occasionally take place. However, genetic techniques now recognize source species, stock identities, and even trace-harvested individuals in the case of the Norwegian minke whales hunt, for which a data-bank is kept that records every legally harvested animal (see Ukishima et al. 1995; Glover et al. 2012). Molecular genetic analyses of whale products found in retail market places in Japan and Korea has revealed a surprising diversity of whale and dolphin species (Baker and Palumbi, 1994; Baker et al. 1996, 2002). These same molecular techniques have been used to make species identifications of beaked whales incidentally taken in the California drift gill-net fishery (Henshaw et al. 1997).

Several marine mammal management–conservation bodies operate within, or have stemmed from, the Antarctic Treaty that came into force in 1961 (signed in 1959). The first concrete marine mammal action was the Convention for the Protection of Antarctic Seals, which forbade the kill or capture of Ross seals (Ommatophoca rossii), southern elephant seals, all fur seals within the genus Arctocephalus, and formulated quotas for the harvestable species (see above). This convention was developed in 1972 and came into force in 1978. Several protected areas have also been created that include at least small amounts of marine mammal habitat. But, perhaps the most notable advance was the creation of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), which was ratified in 1980; it was the first international agreement to approach the management of marine resources from an ecosystem perspective. Commercial ventures in the Antarctic, including all fisheries (e.g., crabs, krill, fish, ice seals, etc.) harvesting must be consistent with the goals of the Convention, namely the “maintenance of the ecological relationships between harvested,
dependent and related populations of Antarctic marine living resources and the restoration of depleted populations” (Beddington and May 1982). In practice, this means that fishing for krill, for example, cannot put krill predators, such as fur seals and baleen whales at risk. This convention was the first in a slowly growing trend of national and international efforts to recognize the integrity of large marine ecosystems (LMEs). UNEP (United Nations Environment Program) now recognizes 64 distinct LMEs around the coastal margins of the Atlantic, Pacific, and Indian Oceans (see Alexander, 1993; Sherman and Hempel, 2009).

In 1982, the United Nations Conference on the Law of the Sea III adopted a draft “Law of the Sea (UNCLOS) Treaty” that was to go into effect 12 months after ratification (Craven and Schneiden, 1989; Hedley, 2000). But, it was not until 1994 that the treaty was actually agreed upon, when the sixtieth nation became a signatory. As of August 2013, 165 countries and the European Union have joined in the Convention. The UNCLOS treaty includes many of the key features found in the US Fisheries Conservation and Management Act. In particular, it internationalized the concept of the 200-mile-wide (324 km) exclusive economic zones (EEZs), granting coastal nations sovereign rights with respect to natural resources (including fishing and marine mammal harvests), scientific research, and environmental preservation. The imposition of 200-mile-wide EEZs by essentially all coastal nations of the world has dramatically changed the assumption of responsibility for management and conservation of marine mammals, because most species of marine mammals spend all, or at least a critical portion, of their life cycles (either for feeding or for reproduction) within 200 miles of some nation’s shoreline. In some cases, this has created challenges for appropriate management of stocks that can be placed under bilateral management agreements, which have not always provided sufficient conservation focus (see Reeves, 2009). The UNCLOS Treaty obliges nations to prevent or control marine pollution, to promote the development and transfer of marine technology to developing nations, and to peacefully settle disputes arising from the exploitation of marine resources. It was notably silent regarding the Antarctic upwelling area, because national claims to territory on the Antarctic continent are not recognized. Consequently, CCAMLR provides the fundamental legal framework for management issues regarding Antarctic marine mammal species other than whales, which fall under the IWC.

Implementation of the United National ban on pelagic drift-net usage in 1992 was of major importance for marine mammal conservation, particularly in the North Pacific region. This fishing modality, which targeted squid, salmon, tuna, and billfish killed vast numbers of pinnipeds, dolphins, and porpoises each year, in addition to many other animals including seabirds and turtles. The ban effectively stopped pelagic drift netting, but unfortunately the UN decree cannot control the use of these nets inside 200-mile limits of coastal states, so drift nets remain a significant mortality source for some marine mammal populations. Additionally, pelagic long-line fisheries that have replaced the drift-net fisheries do have some marine mammal bycatch issues (Read, 2005).
The Convention for Migratory Species (CMS), which is often referred to as the Bonn Convention, has stimulated several important conservation actions for marine mammals. The first of these was the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS), which entered into force in 1994. This agreement has stimulated large-scale cetacean surveys in the Baltic, North Sea, and contiguous northeastern Atlantic areas. The CMS is also responsible for the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea, and Contiguous Atlantic Area (ACCOBAMS), which addresses a wide range of threats to whales including underwater noise, pollution, and fisheries mortality. The CMS’s influence also extends into the Pacific region via a memorandum of understanding for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region, which is in the process of developing conservation priorities and plans.

Several additional general marine conventions also benefit marine mammals, such as the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the London Dumping Convention) and the 1973–1978 Convention for the Prevention of Pollution from Ships (the MARPOL Convention). Anything that maintains global ocean quality is, of course, a benefit to all marine species, and ocean debris (fish box strapping ties, etc.) have been repeatedly shown to be a problem for marine mammals.

### 15.3.2 Bilateral, National, and Local Conservation Efforts

Some marine mammal populations benefit from bilateral agreements for populations that extend across an international boundary. An example of such an agreement is the Joint Commission on the Conservation and Management of Narwhal and Beluga, between Canada and Greenland. The commission’s Scientific Working Group plans and conducts collaborative research on these two species, and generates input used to create management advice that takes into account harvesting on both sides of the border, which when not considered resulted in declines in these populations.

Many individual nations have legislation protecting all or some marine mammals within their waters, but the Marine Mammal Protection Act (MMPA) of the US is noteworthy in the extent of its domestic commitment to conservation. The MMPA was established in 1972. It placed a moratorium on the taking of marine mammals in US waters and on importing marine mammals and marine mammal products into the US. A historical account of the establishment of the Marine Mammal Protection Act can be found in Ray and Potter (2011). The Act applies to the activities of US citizens and US flagged vessels in US territorial seas or its EEZ. The moratorium does not apply to Indians, Aleuts, or Inuits in coastal Alaska who hunt marine mammals for subsistence or for making and selling handicrafts. Under a permit system, the act also allows the taking and importing of marine mammals for scientific research, education, public display, and incidental catches occurring in the course of commercial fishing operations, such as the purse-seine tuna fishery (see above, Hofman, 1989). In addition to
its regulatory aspects, the MMPA established the US Marine Mammal Commission (consisting of three scientists appointed by the President), a Committee of Scientific Advisors on Marine Mammals (appointed by the Commission), and a Marine Mammal Health and Stranding Response Program, which includes the American marine mammal stranding networks discussed later. The success of the MMPA in protecting marine mammals was recently reviewed (Roman et al. 2013). The major conclusion of this review is that the current status of many marine mammal populations is considerably better than in 1972, which suggests that current management practices are having a positive influence on these populations. However, ship strikes and fishery bycatches remain high, and the status of 71% of marine mammal stock trends remain unknown in the US, despite the MMPA.

The US Endangered Species Act (ESA) of 1973 is also a powerful piece of legislation that has a strong influence in marine mammal conservation issues within the borders of the US. Notably, the ESA and the MMPA were the first legislative acts to recognize the values of nonconsumptive uses of protected species in the US. Under the ESA, species deemed in need of protection are listed as either endangered (in danger of becoming extinct over a significant portion of its range) or threatened (likely to become endangered). A threatened population is automatically considered depleted under the MMPA. A depleted population is defined as one that contains fewer individuals than its **optimum sustainable population (OSP)** level, in which OSP has subsequently been interpreted as a population level between 60 and 100% of carrying capacity (Gerrodette and DeMaster, 1990). Criteria were established by the ESA for protection of threatened and endangered species, which included the effects of overutilization, habitat modification, or destruction, disease, or predation, inadequate regulations, or other natural or anthropogenic factors. All large commercially hunted whale species were initially assigned endangered status (Braham, 1992). Only one, the Northeast Pacific gray whale population, has been removed from the list because of subsequent population recovery (Federal Register, 1994). Ringed seals and bearded seals have recently (2012) been listed as threatened under the ESA. These decisions were taken on the basis of declines in habitat quality and extent, which are expected to continue to deteriorate for these ice-associated seals in the coming decades (see Cameron et al. 2010; Kelly et al. 2010 for complete background details).

The impact of local recognition of conservation needs of marine mammals should not be underestimated in describing the larger scale and legislative agreements described above. Local people, particularly fishermen and members of traditional marine mammal harvesting cultures (both native and nonnative), but also other users of marine environments must be “on-board” for sustainable harvest, or recovery programs to be successful, or for suitable protection of marine mammal habitats to take place. Basically, local engagement is essential for conservation to succeed (see Reeves, 2009 for further discussion and examples).
15.3.3 Marine Mammal Conservation Actions

15.3.3.1 Marine Protected Areas and National Marine Sanctuaries

Designation of protected areas has been a long-standing conservation tool in terrestrial environments, but Marine Protected Areas (MPAs) are much less common than their land-based counterparts. MPAs often face opposition from fishing interests, such as has recently been demonstrated in a CCAMLR context in which attempts to establish a network of marine protected areas in the Southern Ocean continues to be very contentious. In addition, many areas currently classified as marine parks or reserves do not actually influence fishing activities, which can negate the basic rationale for having them. The International Committee on Marine Mammal Protected Areas (ICMMPA) is an informal group of international experts dedicated to the conservation of marine mammals and their habitats (via creation of Marine Sanctuaries Worldwide). Members of the ICMMPA represent various geographic regions, as well as a wide range of expertise within the fields of marine mammal biology, ecology, and the design and management of marine protected areas and other marine planning initiatives. A good example of the potential for MPA to protect marine mammal species is the Banks Peninsula Marine Sanctuary in New Zealand that was established to protect the rare Hector’s and Maui dolphins (Cephalorhynchus hectori hectori, C. h. maui) among other species. Evidence of the effectiveness of this sanctuary in allowing for the recovery of marine mammal populations has been demonstrated by the increase in the survival rate and population growth of Hector’s dolphin (Gormley et al. 2012).

15.3.3.2 Captive Breeding Programs

Captive breeding programs are another very traditional conservation tool for terrestrial mammals and birds, but one that is not easily employed in the case of most marine mammal species. Keeping marine mammals in human care, even for breeding purposes, is controversial. Captive facilities that display marine mammals argue that they provide a means of generating interest and education in marine mammals and conservation. The training regimens for captive marine mammals often include behaviors designed to assist veterinarians in examining animals, which allows facilities to make more extensive use of preventive medical protocols. Arguments against keeping marine mammals in captivity point to confinement of marine mammals in small pools or tanks that are not their natural habitat, and display of behaviors in captivity that are very different than those in the wild (e.g., Mason, 2010; Marino and Frohoff, 2011).

But, in some few situations, the threat to a species has been so dire and immediate that the only alternative to watching the species become extinct has been to establish a captive breeding program. Unfortunately, the most recent example, for the baiji, that attempted to maintain this species in “semi natural reserves” was ultimately unsuccessful. However, other species of marine mammals, are being successfully bred in captivity (e.g., harbor seal, California sea lion, bottlenose dolphin, and the killer whale), which at very least reduces the need for taking additional animals...
from the wild for zoos and aquariums and offers the potential for reintroductions if this became necessary, following outbreaks of disease for example.

15.3.3.3 RELLOCATION

Reestablishing populations of endangered or threatened species, termed relocation or translocation, is another established conservation strategy for a host of terrestrial animals. However, projects of this type that have involved marine mammals have been relatively few. One marine mammal attempt took place in the late 1980s, when the US Fish and Wildlife Service relocated 140 southern sea otters (*Enhydra lutris nereis*) from the mainland population near Monterey Bay, California, to San Nicholas Island, one of the Channel Islands approximately 65 miles offshore. The goal was to establish a colony of sea otters that would not be affected by a nearshore catastrophic oil spill and would not deplete the commercial shellfish fishery off southern California. Most of the otters vanished and fewer than 20 remain today. Although this translocation experiment failed, valuable lessons were learned. For example, the homing behavior of sea otters was not adequately considered, nearly one-quarter of the otters simply returned to the capture site, nor was the high mortality rate following releases of the animals predicted (*Marine Mammal Commission, 2010–2011*). But other relocation programs have succeeded. For example, a recovery plan for the Hawaiian monk seals involved moving several female seals from Midway Island, rehabilitating them at a facility in the Hawaiian Islands and releasing them. This pilot study provided important information that has become part of a broader strategy to conserve the species (*Baker et al. 2011*).

15.3.3.4 STRANDING NETWORKS

Stranding networks around the world attempt to respond to stranded marine mammals that either swim onto shore or are trapped ashore by waves or receding tides. Although this is more a question of animal welfare rather than conservation per se, significant numbers of animals can be involved and for some species that strand frequently, population consequences are not impossible (*Hofman, 1991*). Strandings can occur singly (*Figure 15.14*), or as a group or a mass stranding event (*Figure 15.15*), is defined by *Klinowska (1985)* as three or more individuals of the same species stranded in the same general area at approximately the same time. Mass stranding events usually involve social odontocetes and are especially common among pilot whales and Atlantic white-sided dolphins (*Lagenorhynchus* spp.). Stranding frequency varies geographically, but long-term data from worldwide stranding records collated by *Pyenson (2011)* demonstrated that stranding records faithfully reflect the number of species and the relative abundance found in live surveys on a regional basis.

In the US, amendments to MMPA established a Marine Mammal Health and Stranding Response Program in 1992. The MMPA provided six national
FIGURE 15.14
Beached minke whale on the Oregon coast.

FIGURE 15.15
networks with appropriate authority and resources to respond to beachings and strandings of marine mammals for the purposes of necropsy and tissue salvage of beached animals and of rescue and/or rehabilitation of live stranded animals (Dierauf, 1990; Hofman, 1991). These networks have become valuable (and sometimes the only) sources of tissues from rare or legally protected marine mammal species. The program was largely in response to the stranding of hundreds of bottlenose dolphins along the US Atlantic coast in 1987 and 1988. In the 20 years since the program was established, personnel have responded to 50,000 stranded marine mammals, rehabilitated and released more than 10,000 animals, and led to investigation of 56 unusual mortality events (Marine Mammal Commission, 2012). These and other nations’ networks and their activities are summarized in Wilkinson and Worthy (1999) and Gulland et al. (2001).

Explanations for odontocete mass strandings include the presence of parasitic infestations of the respiratory tracts, brain, or middle ear; bacterial or viral infections (e.g., morbillivirus discussed in Chapter 14); harmful algal blooms (see Chapter 14); predator evasion; and near-shore disorientation of echolocation or geomagnetic signals used for navigation (see Geraci et al. 1999; Walsh et al. 2001 for reviews). The latter explanation is based on an assumption that odontocetes are capable of detecting and responding to the Earth’s magnetic field direction or intensity, or both. Biological magnetic detectors (small crystals of a magnetic form of iron oxide, magnetite) have been found in the brains, bone, blubber, and muscle of the bottlenose dolphin, Cuvier’s beaked whale (Ziphius cavirostris), Dall’s porpoise, fin whale, and the humpback whale (Bauer et al. 1985). By sensing changes in the orientation of these crystals, the host animal is thought to be able to determine the direction in which it is traveling, a useful ability during extended open-ocean migrations. Because high frequencies of live strandings of whales seem to occur in areas where geomagnetic anomalies (geological formations that distort the earth’s magnetic field) are present, it has been suggested (Klinowska, 1985, 1986, 1988) that these strandings may result from navigational errors. This hypothesis, however, has been questioned. Hui (1994) evaluated sightings of free-ranging common dolphins and demonstrated only an association with bottom topography patterns. He found no support for the hypothesis that free-ranging dolphins use magnetic intensity gradients as navigational pathways. An analysis of a comparably sized sample of New Zealand single and mass strandings by Brabyn and Frew (1994) found no apparent relationship between mass stranding locations and either geomagnetic contours or magnetic minima, and no evidence exists that whales appeared to be avoiding magnetic gradients.

The occurrences of several recent mass strandings of beaked whales have been correlated with military use of sonar systems (see Anthropogenic Sound). Indirect and experimental evidence for this explanation of mass strandings comes from analyses of cetacean stranding patterns in the UK (Klinowska, 1985, 1986, 1988) and eastern US coastlines (Kirschvink et al. 1986; Kirschvink, 1990; Walker et al. 1992).
15.4 PROGRESS AND THE FUTURE

In the twenty-first century, we can look back on some successes in our attempts to manage and conserve populations of marine mammals. Northern elephant seals, Pacific humpbacks, and Eastern Pacific gray whales have all made dramatic recoveries in the past century. Populations of several large baleen whales in the southern hemisphere and also in the Northeast Atlantic are also increasing (e.g., Branch et al. 2004; Lockyer and Pike, 2009). Baltic Sea harbor and gray seal numbers have increased after protection was introduced for them in the 1960 and 1970s and pollution levels were brought under control (Heide-Jørgensen and Härkönen, 1988; Svensson et al. 2011); and recoveries have taken place in some walrus stocks (e.g., Kovacs et al. 2014). Some sea otter populations have been rescued from the brink of extinction. Large-scale commercial harvests of marine mammals are few in number today, and marine mammals currently enjoy substantial empathy from the public.

But, despite the widespread awareness of and concern for the welfare of marine mammals, some marine mammal populations (and even species) are still at risk, some as a result of direct interactions with humans or as a result of the impacts humans have on the world’s oceans. Marine mammal species listed by the MMPA as depleted, or by the ESA as endangered, or in CITES Appendix I or II (see Table 15.3) or within the IUCN Red List of threatened categories include: species of baleen whales, the population of which has been reduced by direct harvesting; small odontocetes, such as the vaquita, whose small population continues to decline due to incidental mortality in fishing nets; manatees in Florida, which experience high mortality because of recreational boat activity; pinnipeds, which are threatened by fisheries bycatches; and species whose habitat is at risk (e.g., polar bears). Some marine mammal populations are harvested without records being kept, for populations the abundances of which are not even roughly known. Climate change is a serious threat to ice-associated marine mammal species already and is likely to put other marine mammal species at risk in the future. The recent extinction of the baiji confirms that marine mammal conservation actions are sometimes still too little and too late.

With the human population of the world expected to increase by about 1.3% per year, so does the pressure on the oceans of the world as source of protein and place for recreation, at the same time that the industrial intrusions multiply. Thus, conservation concerns for marine mammals must continue to be a priority. The history of our involvement with marine mammal populations has repeatedly demonstrated a lack of practical awareness of the fundamental effects our interventions cause in these natural systems. As we move on through the twenty-first century, we can hopefully increase our sense of stewardship toward the world’s oceans and their inhabitants that is reflected in our personal as well as our political decisions.
15.5 SUMMARY AND CONCLUSIONS

Overexploitation has resulted in the extinction of three marine mammal species: Steller’s sea cow, the Atlantic gray whale, and the Caribbean monk seal. Despite establishment of a host of legal frameworks to address exploitation, some species continue to be affected by harvesting, and others are being impacted by various other human activities, such as bycatch in commercial fisheries, net entanglements, and environmental contaminants. Information about mortality patterns, disease, and levels of environmental contaminants have been obtained from beached and stranded marine mammals as well as studies

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Abundance</th>
<th>Principal Threats</th>
</tr>
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<tbody>
<tr>
<td>Vaquita</td>
<td>&lt;100</td>
<td>Fisheries bycatch.</td>
</tr>
<tr>
<td>Mauii’s dolphin</td>
<td>~100</td>
<td>Fisheries bycatch.</td>
</tr>
<tr>
<td>Ungava harbor seal</td>
<td>Low 100s</td>
<td>Loss and fragmentation of habitat due to water management and also hunting.</td>
</tr>
<tr>
<td>Saimaa ringed seal</td>
<td>&lt;300</td>
<td>Reduction in suitable breeding habitat due to ice and snow reductions due to warming and fisheries bycatch.</td>
</tr>
<tr>
<td>North Atlantic right whale</td>
<td>300–350</td>
<td>Poorly known both in terms of abundance and specific threats, but ship strikes are one issue.</td>
</tr>
<tr>
<td>Mediterranean monk seal</td>
<td>&lt;500</td>
<td>Loss of pup-rearing and resting habitat, fisheries bycatch, and intentional shooting by fishermen.</td>
</tr>
<tr>
<td>Hawaiian monk seal</td>
<td>~1000</td>
<td>Possible prey depletion, debris entanglement, disturbance of pupping and resting habitat, climate warming impacts on reef communities.</td>
</tr>
<tr>
<td>Red Sea dugong</td>
<td>Low hundreds up to low 1000s</td>
<td>Hunting and fisheries bycatch.</td>
</tr>
<tr>
<td>Indus river dolphin</td>
<td>~1000</td>
<td>Loss and fragmentation of habitat due to water management practices, fisheries bycatch, and pollution.</td>
</tr>
<tr>
<td>Yangtze river finless porpoise</td>
<td>&lt;2000</td>
<td>Loss and fragmentation of habitat due to water management practices, fisheries bycatch.</td>
</tr>
<tr>
<td>Southern sea otter</td>
<td>~3000</td>
<td>Fisheries bycatch and possibly human-mediated diseases.</td>
</tr>
</tbody>
</table>
designed to address these issues in wild populations or via laboratory studies. It is clear that the presence of boat traffic, as well as swimming and feeding activities with whales and dolphins, alters, at least in the short term, their normal behavior patterns, although the long-term effects of these ecotourism activities in a broader perspective are unknown. The recovery of the northern elephant seal, the Pacific humpback, and the California sea otter indicates that some of our conservation efforts have been successful. But future marine mammal conservation requires better information on the population status and ecological relationships of marine mammals within their ecosystems as well as greater understanding of the effects of human-induced activities, especially perhaps climate change-induced impacts.

15.6 FURTHER READING AND RESOURCES

Marine mammal conservation is the subject of multi-authored volumes by Simmonds and Hutchinson (1996), Reeves and Twiss (1999), Clapham et al. (1999); see also Annual Reports of the Marine Mammal Commission especially for US legislation affecting marine mammal conservation. The Journal of Cetacean Research and Management publishes papers about the conservation and management of whales, dolphins, and porpoises, especially topics taken up by the IWC Scientific Committee and Marine Mammal Science and Conservation Biology feature marine mammal conservation research. For a review of aboriginal subsistence whaling, see Reeves (2002). The effects of the Exxon Valdez oil spill on marine mammals are reviewed in Loughlin (1994). See Richardson et al. (1995a) for a summary of the effects of noise (i.e., boat traffic, offshore drilling, seismic profiling) on marine mammals and Reijnders et al. (1999) and Vos et al. (2003) for a summary of the effects of persistent contaminants on marine mammals. General reviews of topics relevant to marine mammal conservation can be found in Evans and Raga (2001) and Reynolds et al. (2005). Reeves (2009) provides an overview of marine mammal conservation according to international, national, and local conservation actions.

Among marine mammal conservation groups/agencies with Internet addresses are the following:

http://www.nmfs.gov—headquarters of National Marine Fisheries Service (NMFS), the office primarily responsible for marine mammal conservation with links to other NMFS offices.


http://www.iucn.org—World Conservation Union (IUCN), environmental biologists active in global cetacean conservation.

References


IAITC (Inter-American Tropical Tuna Commission), 1981. Annual Report, La Jolla, CA.


Exploitation and Conservation


