Chapter 14
Loss of Habitat: Impacts on Pinnipeds and Their Welfare

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Abstract Pinnipeds around the world have been affected by habitat loss as a result of climate change and anthropomorphic activity, such as marine and coastal development. In addition to the physical reduction of available habitat, pinnipeds are impacted by secondary effects of habitat loss, such as disease and changes in prey availability. The impacts of global climate change are thought to be the most wide reaching, with changes in the availability and stability of sea and pack ice habitat expected to be most significant for at least 11 ice-associated species. Potential impacts on pinniped welfare occur as a result of changes in distribution and migration patterns, increased pup mortality, reduced foraging success, and decrease in body condition. Reductions in survival due to increased storm activity, increased exposure to disease and parasites, and human development have also been observed.

14.1 Introduction

While overexploitation is considered to have been the most important factor affecting the abundance and welfare of marine mammals historically, habitat destruction and fragmentation have become increasingly important threats to pinnipeds around the world.

Being relatively large and highly mobile marine species, pinnipeds are often thought to be less affected by habitat loss than many terrestrial animals. However, most have specific habitat needs for breeding or feeding. Identifying and quantifying habitat loss is challenging in marine environments, and understanding the impact on individual welfare is complex. Regardless, it seems clear that diminishing and deteriorating habitat are having a negative impact on the welfare and abundance of many pinniped species (Kovacs et al. 2011).

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Of growing concern is the impact of climate change, which is resulting in a direct loss of ice habitat for many ice-associated pinniped species but may increase the availability of land-based habitats for others. Loss of ice and warming ocean temperatures occurring as a result of climate change will alter marine food webs, which will affect the distribution and availability of prey and result in changes to seals' foraging habitat and success. Ocean acidification, a result of increased carbon dioxide in the atmosphere, may also impact ice-associated seal survival and recruitment through disruption of food webs dependent on calcifying organisms (Kovacs et al. 2012). Rising sea levels are expected to result in reductions in available shoreline habitat for some pinniped species.

Other indirect impacts of climate change include induced habitat loss (Cooper et al. 2006), which will have a negative effect on pinniped welfare, increased disease and parasite risk (Karamanlidis et al. 2016), and increased impacts from human traffic and development in previously inaccessible areas (Skeate et al. 2012).

Apart from climate change, habitat loss continues to occur as a direct result of human activity, primarily coastal and marine development. Mineral, oil, and gas extraction, renewable energy development (Davis 2010; Tougaard et al. 2009), and practices such as aquaculture (Kemper et al. 2003) and the repeated use of mobile fishing gear have the potential to destroy or degrade areas of critical habitat (Skeate et al. 2012). Pinniped welfare may be compromised, and survival and reproductive rates may fall as a result of increased risk of entanglement in fishing gear (please see Chap. 13 this volume), exposure to chemicals that reduce immune system function or reproduction, and exposure to new pathogens or noise pollution (Harwood 2001). Even disturbance from tourism may pose a risk to seal welfare by forcing them to abandon preferred breeding or resting habitats (Johnson and Lavigne 1999b).

While it would be difficult to cover all sources and examples of pinniped habitat loss in this chapter, we address a few of the better known examples and species. Although little has been published on the welfare impacts of habitat loss, it is assumed that changes resulting in increased mortality, reduced pup survival, and decreased body condition will have negative welfare impacts for individual animals.

14.2 Climate-Driven Losses of Habitat

Global climate change is the most pervasive threat to pinnipeds worldwide, and climate-driven habitat losses are the most wide reaching in impact. The consequences of climate change on marine mammals have been increasingly documented in recent decades, with direct loss of sea ice habitat recognized as a prominent threat to Arctic marine mammals (Ragen et al. 2008, Tynan and DeMaster 1997; Simmonds and Isaac 2007, Laidre et al. 2008, 2015, Moore and Huntington 2008, Kovacs et al. 2011, 2012).

It is well documented that the earth's atmosphere is warming, causing regional adjustments in temperature, wind, ocean circulation, precipitation, ice cover and sea level, and pH balance, which are amplified in the polar regions (IPCC 2013). The extent of Arctic sea ice is now more than two million square kilometres less than it was in the late twentieth century (Kinnard et al. 2011). The declines in Arctic sea ice extent and thickness resulting from these changes are expected to continue

into the future at increasing rates (IPCC 2007, 2013), with predictions suggesting that we are rapidly moving toward a seasonally ice-free Arctic (Overland and Wang 2013). Climate change is also affecting Antarctic habitat and ecosystems, although patterns have been very different in various sectors, with some areas experiencing increases in ice extent while others exhibiting a decrease. Central West Antarctica is one of the most rapidly warming regions on earth (Bromwich et al. 2013).

Sea ice habitats are unique in that they are spatially extensive, have few surface predators, and are virtually free of disease vectors (Kovacs et al. 2011). For ice-associated pinnipeds, ice acts as a physical platform, a marine ecosystem foundation, and a barrier to non-ice-adapted marine mammals and human commercial activities. Sea ice (and its loss) is an important factor in marine ecological dynamics, influencing productivity, species interactions, population mixing, gene flow, and pathogen and disease transmission (Post et al. 2013). The direct loss and deterioration of sea ice is the most obvious and immediate threat to ice-associated pinnipeds, particularly those in the Arctic.

14.3 Impacts of Climate Change-Induced Habitat Loss on Pinnipeds

Both Arctic and Antarctic seal species have evolved traits that depend on the larger-scale predictability of pack ice development, movements, persistence, and extent. Although accustomed to interannual fluctuations in ice and prey availability, ice-associated pinnipeds are vulnerable to a fast-changing environment and ill equipped to respond quickly to permanent or complete habitat loss as a result of climate change (Laidre et al. 2008; Moore and Huntington 2008).

Climate-driven habitat loss is expected to be most significant for ice-breeding pinniped species that require long periods of stable ice late in the spring season and specialist feeders who rely on prey species that are sensitive to changes in ice.

In the Arctic, seven pinniped species are considered ice associated, relying on ice to at least some extent for survival: ringed (*Pusa hispida*), bearded (*Erignathus barbatus*), spotted (*Phoca largha*), ribbon (*Histriophoca fasciata*), harp (*Pagophilus groenlandicus*) and hooded seals (*Cystophora cristata*), and walrus (*Odobenus rosmarus*). Of these, the walrus, ringed seal, and bearded seal are considered to be ice dependent and restricted to spatial and temporal domains influenced by sea ice.

In the Antarctic, four species of seal are closely tied to the presence of pack ice and require certain sea ice characteristics to complete their life cycle: the crabeater seal (*Lobodon carcinophagus*), Weddell seal (*Leptonychotes weddellii*), leopard seal (*Hydrurga leptonyx*), and Ross's seal (*Ommatophoca rossii*). These species rely on sea ice for critical portions of their life history and have demonstrated sensitivity to small changes in the sea ice environment. Climate change-driven impacts on prey distribution may also impact the ice-tolerant Antarctic fur seal (*Arctocephalus gazella*) and southern elephant seal (*Mirounga leonina L.*) (Siniff et al. 2008), who winter and forage in open water and marginal ice zones but reproduce on land.

Many pinniped species have already been affected by reductions in the geographic extent, seasonal duration, and stability of sea and pack ice (Siniff et al. 2008; Kovacs et al. 2011), and these impacts are expected to intensify. Changes in

ice directly reduce the habitat available for seals that give birth and molt on sea ice, hide from predators or seek protection from inclement weather within ice fields, or eat ice-associated fish and other prey (Kovacs et al. 2011). This loss of available habitat can be expected to affect welfare through negative impacts on foraging success, breeding success, body condition, and mortality rates (Moore and Huntington 2008; Kovacs et al. 2011). Some of the impacts of ice habitat loss on pinnipeds that are likely to have welfare considerations include changes in distribution and migration patterns, increased pup mortality, decreased foraging success resulting from greater distances to food or changes to food webs, increased use of land-based haulouts, increased exposure to disease and contaminants, and increased exposure to human development and traffic (Tynan and Demaster 1997; Kovacs et al. 2011).

14.4 Changes in Distribution, Migration, and Abundance

Changes in the distribution and migration routes of some pinniped species are already occurring and are expected to continue, and this will ultimately alter population structure and genetic exchange rates. Ice habitat loss means many pinniped species will experience compression of their range concurrent with a loss of suitable breeding or foraging habitat, potentially resulting in population reductions. At the same time, subarctic and temperate pinniped species are likely to exhibit northward expansions of their ranges, which may place competitive pressure on endemic arctic species, further reducing their available habitat and putting them at greater risk of predation, disease, and parasite infections (Kovacs et al. 2011).

The manner and degree to which pinnipeds may adapt their behaviour, or relocate their breeding areas, in response to changing ice conditions, is still highly uncertain. Some species may be able to adapt; however species which are fixed in their traditional spatial and temporal cycles, and unable to shift, may be threatened with extirpation (removal or uprooting from a locality) or extinction (Kovacs et al. 2011). Major declines in abundance or pup production have already been documented for hooded seals in the Northeast Atlantic harp seals in the White Sea and ringed seals in Hudson Bay, which have largely been attributed to climate change impacts on ice conditions (Kovacs et al. 2012).

14.5 Increased Pup Mortality

In the complete absence of ice, female harps seals may move to find suitable ice outside of their historical pupping areas. However, if ice is present, females will give birth on ice insufficiently thick to persist throughout the nursing period, resulting in high levels of pup mortality (Stenson and Hammill 2014). There is no evidence that harp seal females have successfully adapted to give birth on land. In 2010 and 2011, poor ice conditions in the Gulf of St. Lawrence, Canada, resulted in mother harp seals giving birth on small, loose ice pans (Figs. 14.1 and 14.2), many barely able to hold the mother's weight. Pup mortality was extremely high, with large numbers of pups assumed to have drowned.

Fig. 14.1 Harp seal mother and pup in the Gulf of St. Lawrence, Canada, 2010. *Image credit: Sheryl Fink*

Fig. 14.2 A harp seal pup clings to a fragile pan of sea ice on March 25, 2006, in the midst of the annual commercial seal hunt. *Image credit: HSI/Frank Loftus*

Examination of dead and abandoned pups found on shore has demonstrated that causes of death included starvation, trauma from crushing by ice pans, pneumonia, and other infections that have not been observed among pups born on pack ice (Stenson and Hammill 2014). Predation by coyotes and eagles was also reported, species not present on pack ice. The type and extent of ice cover has also been found to be negatively correlated with the incidence of yearling harp seal strandings in the Northwest Atlantic (Soulen et al. 2013).

The ringed seal also depends almost exclusively on sea ice as a breeding habitat and haul-out platform. Ringed seals construct snow dens or subnivean lairs over breathing holes maintained in the ice, which are used for resting, and for females to give birth in the early spring. Both stable ice and sufficient snow to cover the lairs must be maintained long enough in the spring season to successfully complete the six-week period of nursing (Kovacs et al. 2011), in order to provide protection from predators and freezing. Spring rains or warm temperatures may cause the roofs of lairs to collapse, pushing pups out of the shelters and exposing them to predators such as polar bears, arctic fox, and ravens or gulls before they are able to survive in the open. In areas of less stable ice, pups tend to be smaller and may suffer higher mortality due to early separation from their mothers or an increased need to expend energy on thermoregulation. Ringed seals in some areas are already showing relatively long-term declines in reproductive rates and pup survival. With the disappearance of sea ice, many species such as walrus may be forced to rely on land-based haulouts. Terrestrial haul-out sites alone will not support the same number of walruses that the mixed seasonal use of sea ice and land has permitted in the past, and increasingly crowded conditions are likely to increase mortality among younger animals due to normal herd behaviours such as threat displays, fighting among bulls, manoeuvring for preferred positions within a herd, and general agonistic behaviour (Fay 1982; Jay et al. 2012; Kovacs et al. 2012).

Walruses on terrestrial haulouts are also at increased risk from polar bears, aircraft, boats, tourists/recreationists, hunters, feral dogs, etc. When threatened or disturbed, walrus stampede to the ocean which can lead to trampling and death of hundreds to thousands of animals each year, particularly young animals (Jay et al. 2011).

14.6 Nutritional Stress Due to Changes in Prey and Prey Availability

Decreases in prey abundance caused by a reduction of ice may impact pinnipeds' foraging success, body condition, reproductive rate, and pup survival. Availability of prey may also be reduced where reductions in ice habitat force pinniped species (e.g., bearded seal, walrus) to seek haul-out or whelping sites that provide poorer access to food. In the Antarctic, declines in ice extent have been correlated to

reductions in krill, squid, and fish, which have been linked to decreased pup survival for southern elephant seals and crabeater seals (McMahon and Burton 2005). Conversely, increases in sea ice are thought to be related to reductions in phytoplankton blooms, which affect fish availability and lead to decreased foraging success for pregnant Weddell seal females (Siniff et al. 2008).

Reductions in sea ice have also been associated with declines in the clam populations that are critical prey for Pacific walruses, and the overall impact of less extensive seasonal ice coverage is expected to have a long-term negative impact on food resources of both walrus subspecies (Kovacs et al. 2015). Increased use of land haulouts, particularly by mothers and calves, could result in increased distances to food and greater energy expenditures from foraging trips and reduced access to preferred feeding grounds (Jay et al. 2011; Kovacs et al. 2011). Abandoned calves of Pacific walrus have been reported at sea, suggesting that females with dependent young may be experiencing nutritional stress with the retreat of their usual sea-ice resting platform separating them from feeding areas (Cooper et al. 2006).

14.7 Rising Sea Levels and Storms

Rising sea levels can mean a loss of habitat for seals and sea lions that rely on low-lying coastal areas for rest, moulting, giving birth, and pup rearing. Rising sea levels may submerge some of the low atolls, beaches, and small caves currently being used for giving birth by Mediterranean monk seals *(Monachus monachus),* and an evaluation of potential effects on the endangered Hawaiian monk seal (*Monachus schauinslandi*) in the Northwestern Hawaiian Islands found that maximum projected habitat loss ranged from 65–75% under modelled levels of sea level rise, which could increase extinction risk for these small isolated populations (Kovacs et al. 2012).

Increased storm activity associated with climate change is also likely to increase the risk of pinniped pups being separated from their mothers in beaches or caves and swept to sea and increase mortality of pups born on ice through trauma and crushing.

14.8 Disease and Contaminants

Although the causes are often difficult to pinpoint, pinniped mortality events have been linked to habitat degradation resulting from both climate change and coastal development. Individuals that are stressed or weakened are more susceptible to pathogens such as microparasites and morbilliviruses. Phycotoxins associated with algal blooms were linked to the mass die-offs of Mediterranean monk seals that occurred in the mid-1990s (Hernández et al. 1998).

14.9 Increased Human Development and Traffic

It is expected that the opening of previously inaccessible ice-covered areas will present increased threats from shipping and development (including oil and gas extraction) and spread from other oceanic areas of disease, parasite, and contaminant risks (e.g., Tynan and Demaster 1997, Ragen et al., 2008, Kovacs et al. 2011, Kovacs et al. 2012).

14.10 Habitat Loss Through Coastal and Marine Development

Pinnipeds, particularly those which haul out and give birth on land rather than ice, are also vulnerable to habitat loss by more 'traditional' causes of habitat loss: human activities such as coastal and marine development. About 44% of the world's population lives within 150 km of the coast (UN Atlas of Oceans 2016). As human population increases in coastal areas, pinniped species will feel the impacts of habitat loss, fragmentation, and change. Even if habitat is not completely lost, human disturbance can have a negative impact on resting and breeding behaviour if not properly managed.

Boating and shipping can impact marine mammals through direct boat strike injury and mortality, disturbance, and habitat destruction. While injury and mortality may appear to pose the greatest threats to welfare, behavioural changes associated with boat disturbance may affect energy budgets and general health and the well-being of individuals. Other pinniped species may be attracted to sounds of certain types of vessels or fishing activity, which can lead to boat impacts, entanglement, and death (Marsh et al. 2003).

14.11 Coastal Development

Coastal development has resulted in the reduction of suitable breeding habitat for a number of pinniped species, the most well known of which may be the Mediterranean monk seal (*Phoca monacus)* – currently the most endangered seal species (Aguilar 1999; Karamanlidis et al. 2016). Human persecution and disturbance has driven the Mediterranean monk seal into increasingly marginal habitat over centuries, with dramatic declines in both abundance and geographical range as a result of habitat deterioration, and with negative impacts on the welfare and conservation of the species (Johnson and Lavigne 1999a; Harwood et al. 1996, Karamanlidis et al. 2016).

Historically thought to haul out in colonies on open beaches and rocks that offered habitat to relatively large colonies of seals, Mediterranean monk seals have been displaced by centuries of development and human activity into progressively smaller and inaccessible marine caves to give birth and rear their pups (Johnson and

Lavigne 1999a). As space for colony and family group formation has disappeared, individual mothers with pups became the norm, forcing reduced gregarious behaviour, limited social interactions, and probably reduced mating and breeding success. Disturbance from construction and tourism may also force females to abandon their pups before weaning, resulting in death by starvation. Storm surges entering the caves can separate newborns from their mothers and sweep pups to their death when they drown or die from starvation (Gazo et al. 1999, 2000; Karamanlidis et al. 2016). In parts of the Eastern Mediterranean, seals have been discovered inhabiting caves that are little more than water-filled crevices with no internal beach or haul-out area, forcing animals to rest and sleep while floating in the water. It is unlikely that caves of this type can meet the essential biological or welfare needs of the species (Johnson and Lavigne 1999b).

14.12 Energy Exploration and Development

Anthropogenic pulsed sounds from activities such as seismic surveys, sonar, explosives, or pile driving are common in the marine environment and likely to increase, raising concerns about potential impacts on marine mammals. Ocean energy exploration and power generation presents a wide range of potential welfare concerns for pinnipeds. These include direct disturbance from increased human and vessel activity, changes in foraging conditions (which may be positive or negative), pollution, and the presence of noise which can cause direct physical auditory damage and affect patterns of distribution and abundance through behavioral responses (Tougaard et al. 2009; Skeate et al. 2012; Hastie et al. 2016).

Even renewable energy development may pose welfare threats. Many sites for wind farms are located on offshore sandbanks, which overlap with important pinniped habitats (Hastie et al. 2016). The extreme noise generated from pile-driving turbine bases may lead to the displacement of species such as harbour seals and increased competition with other species such as grey seals, which may be more tolerant of this activity (Skeate et al. 2012). There are concerns that the low-frequency anthropogenic noise emitted during the construction and maintenance processes of energy development may mask low-frequency underwater pinniped acoustic signals used for social communication, foraging, navigation, and mating. Potential collision and entanglement in mooring cables associated with wave energy or wind-float parks may also pose a welfare concern (Davis 2010).

14.13 Aquaculture

Marine aquaculture is the fastest growing world food industry and is rapidly occupying pinniped habitat in coastal and estuarine waters. Habitat degradation is caused not only by the loss of physical space but by the noise created by constant vessel traffic, the potential for local pollution, operational maintenance, and harvesting.

These impacts on pinnipeds are less studied (Wursig and Gailey 2003). Shooting, acoustic harassment devices, underwater explosives, exclusion nets, electric fencing, chasing, bright lights, and trapping and relocation are frequently used to deter pinnipeds from aquaculture sites and mitigate damage to equipment. Death and injury due to entanglement in antipredator nets is often reported (Kemper et al. 2003). Impacts of operational interactions with pinnipeds (with their associated welfare concerns of mortality and injury) have been well studied, but the effects of aquaculture on behaviour, range, demography, and ecology are far less explored.

14.14 Conclusions

Although it is clear that many pinniped species are being affected by various forms of habitat loss, little direct information on the welfare impacts of this loss currently exists. Habitat loss may have impacts on pup mortality, foraging success, reproductive success, and health, all of which will almost certainly affect the welfare of individual animals. There are numerous reported studies which examine the effects of climate change and human development on pinnipeds and their environments, but there is still great uncertainty in predicting future impacts and how species might adapt to these changes.

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