

RINGED SEAL (*Pusa hispida hispida*): Alaska Stock**STOCK DEFINITION AND GEOGRAPHIC RANGE**

Ringed seals (*Pusa hispida*) have a circumpolar distribution and are found in all seasonally ice-covered seas of the Northern Hemisphere as well as in certain freshwater lakes (King 1983). Most taxonomists currently recognize five subspecies of ringed seals: *P. h. hispida* in the Arctic Ocean and Bering Sea; *P. h. ochotensis* in the Sea of Okhotsk and northern Sea of Japan; *P. h. botnica* in the northern Baltic Sea; *P. h. lagodensis* in Lake Ladoga, Russia; and *P. h. saimensis* in Lake Saimaa, Finland. Morphologically, the Baltic and Okhotsk subspecies are fairly well differentiated from the Arctic subspecies (Ognev 1935, Müller-Wille 1969, Rice 1998) and the Ladoga and Saimaa subspecies differ significantly from each other and from the Baltic subspecies (Müller-Wille 1969, Hyvärinen and Nieminen 1990, Amano et al. 2002). Genetic analyses support isolation of the lake-inhabiting populations (Palo 2003, Palo et al. 2003, Valtonen et al. 2012). Lack of differentiation between the Baltic and the Arctic subspecies may reflect recurrent gene flow (Martinez-Bakker et al. 2013) but is more likely due to retention of high diversity within the relatively large effective population size of the Baltic subspecies since separation from the Arctic subspecies (Nyman et al. 2014). Widespread mixing within the Arctic subspecies is the likely explanation for its high diversity and apparent lack of population structure (Palo et al. 2001, Davis et al. 2008, Kelly et al. 2009, Martinez-Bakker et al. 2013). Differences in body size, morphology, growth rates, and/or diet between Arctic ringed seals in shorefast versus pack ice have been taken as evidence of separate breeding populations in some locations (McLaren 1958, Fedoseev 1975, Finley et al. 1983). This has not been thoroughly examined, however, and the taxonomic status of the Arctic subspecies remains unresolved (Berta and Churchill 2012). For the purposes of this stock assessment, the Alaska stock of ringed seals is considered the portion of the Arctic subspecies (*P. h. hispida*) that occurs within the U.S. Exclusive Economic Zone of the Beaufort, Chukchi, and Bering seas (Fig. 1).

Throughout their range, ringed seals have an affinity for ice-covered waters and are well adapted to occupying both shorefast and pack ice (Kelly 1988a). They remain with the ice most of the year and use it as a platform for pupping and nursing in late winter to early spring, for molting in late spring to early summer, and for resting at other times of the year. This species rarely comes ashore in the Arctic; however, in more southerly portions of its range where sea or lake ice is absent during summer and fall, ringed seals are known to use isolated haul-out sites on land for molting and resting (Härkönen et al. 1998, Trukhin 2000, Kunasranta 2001, Lukin et al. 2006). In Alaska waters, during winter and early spring when sea ice is at its maximal extent, ringed seals are abundant in the northern Bering Sea, Norton and Kotzebue Sounds, and throughout the Chukchi and Beaufort seas. They occur as far south as Bristol Bay in years of extensive ice coverage but generally are not abundant south of Norton Sound except in nearshore areas (Frost 1985). Although details of their seasonal movements have not been adequately documented, most ringed seals that winter in the Bering and Chukchi seas are thought to migrate north in spring as the seasonal ice melts and retreats (Burns 1970) and spend summers in the pack ice of the northern Chukchi and Beaufort seas, as well as in nearshore ice remnants in the Beaufort Sea (Frost 1985). During summer, ringed seals range hundreds to thousands of kilometers to forage along ice edges or in highly productive open-water areas (Harwood and Stirling 1992, Freitas et al. 2008, Kelly et al. 2010b, Harwood et al. 2015). With the onset of freeze-up in the fall, ringed seal movements become increasingly restricted. Seals that have summered in the Beaufort Sea are thought to move west and south with the advancing ice pack, with many seals dispersing



Figure 1. Approximate winter distribution of ringed seals (dark shaded area).

throughout the Chukchi and Bering seas while some remain in the Beaufort Sea (Frost and Lowry 1984, Crawford et al. 2012, Harwood et al. 2012). Some adult ringed seals return to the same small home ranges they occupied during the previous winter (Kelly et al. 2010b).

POPULATION SIZE

Ringed seal population surveys in Alaska have used various methods and assumptions, incompletely covered their habitats and range, and were conducted more than a decade ago; therefore, current, comprehensive, and reliable abundance estimates or trends for the Alaska stock are not available. Frost et al. (2004) conducted aerial surveys within 40 km of shore in the Alaska Beaufort Sea during May-June 1996-1999 and observed ringed seal densities ranging from 0.81 seals/km² in 1996 to 1.17 seals/km² in 1999. Moulton et al. (2002) conducted similar, concurrent surveys in the Alaska Beaufort Sea during 1997-1999 but reported substantially lower ringed seal densities than Frost et al. (2004). The reason for this disparity was unclear (Frost et al. 2004). Bengtson et al. (2005) conducted aerial surveys in the Alaska Chukchi Sea during May-June 1999-2000. While the surveys were focused on the coastal zone within 37 km of shore, additional survey lines were flown up to 185 km offshore. Population estimates were derived from observed densities corrected for availability bias using a haul-out model from six tagged seals. Ringed seal abundance estimates for the entire survey area were 252,488 (SE = 47,204) in 1999 and 208,857 (SE = 25,502) in 2000. Using the most recent survey estimates from surveys by Bengtson et al. (2005) and Frost et al. (2004) in the late 1990s and 2000, for the purposes of an Endangered Species Act (ESA) status review, Kelly et al. (2010a) estimated the total population in the Alaska Chukchi and Beaufort seas to be at least 300,000 ringed seals. This estimate is likely an underestimate since the Beaufort Sea surveys were limited to within 40 km from shore.

Though a reliable population estimate for the entire Alaska stock is not available, research programs have recently developed new survey methods and partial, but useful, abundance estimates. In spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys of the entire Bering Sea and Sea of Okhotsk (Moreland et al. 2013). The data from these image-based surveys are still being analyzed, but Conn et al. (2014), using a very limited sub-sample of the data collected from the U.S. portion of the Bering Sea in 2012, calculated an abundance estimate of about 170,000 ringed seals. This estimate did not account for availability bias and did not include ringed seals in the shorefast ice zone, which were surveyed using a different method. Thus, the actual number of ringed seals in the U.S. sector of the Bering Sea is likely much higher, perhaps by a factor of two or more.

Minimum Population Estimate

A minimum population estimate (N_{MIN}) for the entire stock of ringed seals cannot presently be determined because current reliable estimates of abundance are not available for the Chukchi and Beaufort seas. The 2012 Bering Sea abundance estimate by Conn et al. (2014) of 170,000, however, can be considered an N_{MIN} for only those ringed seals in the U.S. sector of the Bering Sea.

Current Population Trend

Frost et al. (2002) reported that a trend analysis based on an ANOVA comparison of observed seal densities in the central Beaufort Sea suggested marginally significant but substantial declines of 50% on shorefast ice and 31% on all ice types combined from 1985-1987 to 1996-1999. A Poisson regression model indicated highly significant density declines of 72% on shorefast ice and 43% on pack ice during the 15-year period. However, the apparent decline between the mid-1980s and the late-1990s may have been due to a difference in the timing of surveys rather than an actual decline in abundance (Frost et al. 2002, Kelly et al. 2006). As these surveys represent only a fraction of the stock's range and occurred more than a decade ago, current and reliable data on trends in population abundance for the Alaska stock of ringed seals are considered unavailable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for the Alaska stock of ringed seals. Hence, until additional data become available, it is recommended that the pinniped maximum theoretical net productivity rate (R_{MAX}) of 12% be employed for this stock (Wade and Angliss 1997).

POTENTIAL BIOLOGICAL REMOVAL

Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{\text{MIN}} \times 0.5R_{\text{MAX}} \times F_R$. The recovery factor (F_R) for this stock is 0.5,

the value for pinniped stocks with unknown population status (Wade and Angliss 1997). Using the N_{MIN} for ringed seals in the U.S. sector of the Bering Sea, a PBR for ringed seals in this area is 5,100 ($170,000 \times 0.06 \times 0.5$) seals. However, this is not an estimate of PBR for the entire stock because a reliable estimate of N_{MIN} is currently not available for the entire stock; i.e., N_{MIN} is not available for the Chukchi and Beaufort seas.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Detailed information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presented in Appendices 3-6 of the Alaska Stock Assessment Reports.

During 2010-2014, incidental mortality and serious injury of ringed seals was reported in 4 of the 22 federally-regulated commercial fisheries in Alaska monitored for incidental mortality and serious injury by fisheries observers: the Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands pollock trawl, Bering Sea/Aleutian Islands Pacific cod trawl, and Bering Sea/Aleutian Islands Pacific cod longline fisheries (Table 1; Breiwick 2013; MML, unpubl. data). An additional ringed seal mortality due to U.S. commercial fisheries was reported to the NMFS Alaska Region stranding network in 2011; however, because the seal was discovered during the offloading process, the resulting mean annual mortality and serious injury rate of 0.2 could not be assigned to a specific fishery (Table 2; Helker et al. 2016). Based on data from 2010 to 2014, the average annual rate of mortality and serious injury incidental to U.S. commercial fishing operations is 3.9 ringed seals (3.7 from observer data + 0.2 from stranding data).

In 2010, a ringed seal that was initially considered seriously injured due to entanglement in a subsistence salmon set gillnet in Nome, Alaska, was disentangled and released with non-serious injuries (Helker et al. 2016), so it was not included in the mean annual mortality and serious injury rate in this report.

Table 1. Summary of incidental mortality and serious injury of Alaska ringed seals due to U.S. commercial fisheries in 2010-2014 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl	2010	obs data	99	0	0	2.4 (+0.2) ^c (CV = 0.02)
	2011		100	6 (+1) ^a	6.0 (+1) ^b	
	2012		99	3	3.0	
	2013		99	3	3	
	2014		99	0	0	
Bering Sea/Aleutian Is. pollock trawl	2010	obs data	86	0	0	0.6 (CV = 0.03)
	2011		98	3	3.0	
	2012		98	0	0	
	2013		97	0	0	
	2014		98	0	0	
Bering Sea/Aleutian Is. Pacific cod trawl	2010	obs data	66	0	0	0.2 (CV = 0)
	2011		60	1	1	
	2012		68	0	0	
	2013		80	0	0	
	2014		80	0	0	
Bering Sea/Aleutian Is. Pacific cod longline	2010	obs data	64	0	0	0.3 (CV = 0.61)
	2011		57	1	1.6	
	2012		51	0	0	
	2013		66	0	0	
	2014		64	0	0	

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Minimum total estimated annual mortality						3.7 (CV = 0.06)

^aTotal mortality and serious injury observed in 2011: 6 seals in sampled hauls + 1 seal in an unsampled haul.

^bTotal estimate of mortality and serious injury in 2011: 6 seals (extrapolated estimate from 6 seals observed in sampled hauls) + 1 seal (1 seal observed in an unsampled haul).

^cMean annual mortality and serious injury for fishery: 2.4 seals (mean of extrapolated estimates from sampled hauls) + 0.2 seals (mean of number observed in unsampled hauls).

Table 2. Summary of mortality and serious injury of Alaska ringed seals, by year and type, reported to the NMFS Alaska Region in 2010-2014 (Helker et al. 2016). Only cases of serious injuries are reported in this table; animals that were disentangled and released with non-serious injuries have been excluded.

Cause of injury	2010	2011	2012	2013	2014	Mean annual mortality
Unidentified commercial fishery	0	1	0	0	0	0.2
Total in commercial fisheries						0.2

Alaska Native Subsistence/Harvest Information

Ringed seals are an important resource for Alaska Native subsistence hunters. Approximately 64 Alaska Native communities in western and northern Alaska, from Bristol Bay to the Beaufort Sea, regularly harvest ice seals (Ice Seal Committee 2016). The Ice Seal Committee, as co-managers with NMFS, recognizes the importance of harvest information and has collected it since 2008, when funding and personnel have allowed. Annual household survey results compiled in a statewide harvest report include historical ice seal harvest information back to 1960 (Quakenbush et al. 2011). This report is used to determine where and how often harvest information was collected and where to focus in the future (Ice Seal Committee 2016). Information for 2009-2013 is available for 12 communities (Point Lay, Kivalina, Noatak, Buckland, Deering, Emmonak, Scammon Bay, Hooper Bay, Tununak, Quinhagak, Togiak, and Twin Hills) (Table 3), but more than 50 other communities harvest ringed seals and have not been surveyed in this time period or have never been surveyed. Harvest surveys are designed to estimate harvest within the surveyed community, but because of differences in seal availability, cultural hunting practices, and environmental conditions, extrapolating harvest numbers beyond that community is not appropriate. For example, during 2009-2013, only 12 of 64 coastal communities were surveyed for ringed seals; and, of those communities, only 6 were surveyed for two or more consecutive years (Ice Seal Committee 2016). Based on the harvest data from these 12 communities (Table 3), a minimum estimate of the average annual harvest of ringed seals in 2009-2013 is 1,050 seals. The Ice Seal Committee is working toward a better understanding of ice seal harvest by conducting more consecutive surveys in more communities with a goal to report a statewide ice seal harvest estimate.

Table 3. Alaska ringed seal harvest estimates in 2009-2013 (Ice Seal Committee 2016).

Community	Estimated ringed seal harvest				
	2009	2010	2011	2012	2013
Point Lay				51	
Kivalina			16		
Noatak			3		
Buckland			26		
Deering			0		
Emmonak			56		
Scammon Bay			137	169	
Hooper Bay	889	458	674	651	667
Tununak	232	162	257	219	

Community	Estimated ringed seal harvest				
	2009	2010	2011	2012	2013
Quinhagak		163	117	140	160
Togiak	1	1	0		
Twin Hills	0	0			
Total	1,122	784	1,286	1,230	827

Other Mortality

Beginning in mid-July 2011, elevated numbers of sick or dead seals, primarily ringed seals, with skin lesions were discovered in the Arctic and Bering Strait regions. By December 2011, there were more than 100 cases of affected pinnipeds, including ringed seals, bearded seals, spotted seals, and walruses, in northern and western Alaska. Due to the unusual number of marine mammals discovered with similar symptoms across a wide geographic area, NMFS and USFWS declared a Northern Pinniped Unusual Mortality Event (UME) on December 20, 2011. Disease surveillance efforts in 2012-2013 detected few new cases similar to those observed in 2011, but the UME investigation remains open for ringed seals based on continuing reports in 2013-2014 of ice seals in the Bering Strait region with patchy hair loss (alopecia). To date, no specific cause for the disease has been identified.

In 2011, a ringed seal mortality, due to a gunshot wound to the head, was reported to the NMFS Alaska Region stranding network (Helker et al. 2016). This seal was presumed to be a struck and lost animal from the Alaska Native subsistence hunt.

Mortality and serious injury may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. In 2013, there was one report of a mortality incidental to research on the Alaska stock of ringed seals, resulting in a mean annual mortality and serious injury rate of 0.2 ringed seals from this stock in 2010-2014 (Division of Permits and Conservation, Office of Protected Resources, NMFS, 1315 East-West Highway, Silver Spring, MD 20910).

STATUS OF STOCK

On December 28, 2012, NMFS listed Arctic ringed seals (*P. h. hispida*) and, thus, the Alaska stock of ringed seals, as threatened under the ESA (77 FR 76706). The primary concern for this population is the ongoing and anticipated loss of sea ice and snow cover stemming from climate change, which is expected to pose a significant threat to the persistence of these seals in the foreseeable future (based on projections through the end of the 21st century; Kelly et al. 2010a). Because of its threatened status under the ESA, this stock was designated as depleted under the MMPA. As a result, the stock was classified as a strategic stock. On March 11, 2016, the U.S. District Court for the District of Alaska issued a memorandum decision in a lawsuit challenging the listing of ringed seals under the ESA (Alaska Oil and Gas Association et al. v. Pritzker, Case No. 4:14-cv-00029-RPB). The decision vacated NMFS' listing of Arctic ringed seals as a threatened species. Consequently, it is also no longer designated as depleted or classified as a strategic stock. Because the PBR for the entire stock is unknown, the mean annual U.S. commercial fishery-related mortality and serious injury rate that can be considered insignificant and approaching zero mortality and serious injury rate is unknown. A PBR for only those ringed seals in the U.S. portion of the Bering Sea is 5,100 ringed seals. The total estimated annual level of human-caused mortality and serious injury is 1,054 ringed seals. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknown.

HABITAT CONCERNS

The main concern about the conservation status of ringed seals stems from the likelihood that their preferred sea-ice and snow habitats are being modified by the warming climate. Future scientific projections are for continued and perhaps accelerated warming (Kelly et al. 2010a). Climate models consistently project overall diminishing ice and snow cover through the 21st century with regional variation in the timing and severity of those losses. Increasing atmospheric concentrations of greenhouse gases are driving climate warming and increasing acidification of the ringed seal's habitat. Changes in ocean temperature, acidification, and ice cover threaten prey communities on which ringed seals depend. Laidre et al. (2008) concluded that on a worldwide basis ringed seals were likely to be highly sensitive to climate change based on an analysis of various life history features that could be affected by climate.

The greatest impacts to ringed seals from diminished ice cover will be mediated through diminished snow accumulation. While winter precipitation is forecasted to increase in a warming Arctic (Walsh et al. 2005), the duration of ice cover will be substantially reduced, and the net effect will be lower snow accumulation on the ice (Hezel et al. 2012). Ringed seals excavate subnivean lairs (snow caves) in drifts over their breathing holes in the ice, in which they rest, give birth, and nurse their pups for 5-9 weeks during late winter and spring (Chapskii 1940, McLaren 1958, Smith and Stirling 1975). Snow depths of at least 50-65 cm are required for functional birth lairs (Smith and Stirling 1975, Lydersen and Gjertz 1986, Kelly 1988b, Lydersen 1998, Lukin et al. 2006). Such depths typically are found only where 20-30 cm or more of snow has accumulated on flat ice and then drifted along pressure ridges or ice hummocks (Lydersen et al. 1990, Hammill and Smith 1991, Lydersen and Ryg 1991, Smith and Lydersen 1991). According to climate model projections, snow cover is forecasted to be inadequate for the formation and occupation of birth lairs within this century over the Alaska stock's entire range (Kelly et al. 2010a). Without the protection of these lairs, ringed seals—especially newborns—are vulnerable to freezing and predation (Kumlien 1879, McLaren 1958, Lukin and Potelov 1978, Smith and Hammill 1980, Lydersen and Smith 1989, Stirling and Smith 2004). Changes in the ringed seal's habitat will be rapid relative to their generation time and, thereby, will limit adaptive responses. As ringed seal populations decline, the significance of currently lower-level threats—such as ocean acidification, increases in human activities, and changes in populations of predators, prey, competitors, and parasites—may increase.

A second major concern, driven primarily by the production of carbon dioxide (CO₂) emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem. Ocean acidification, a result of increased CO₂ in the atmosphere, may affect ringed seal survival and recruitment through disruption of trophic regimes that are dependent on calcifying organisms. The nature and timing of such impacts are extremely uncertain. Changes in ringed seal prey, anticipated in response to ocean warming and loss of sea ice, have the potential for negative impacts, but the possibilities are complex. Ecosystem responses may have very long lags as they propagate through trophic webs. Because of ringed seals' apparent dietary flexibility, this threat may be of less immediate concern than the threats from sea ice degradation.

Additional habitat concerns include the potential effects from increased shipping (particularly in the Bering Strait) and oil and gas exploration activities (particularly in the outer continental shelf leasing areas), such as disturbance from vessel traffic, seismic exploration noise, or the potential for oil spills.

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