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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*) in U.S. waters (Fig. 1).

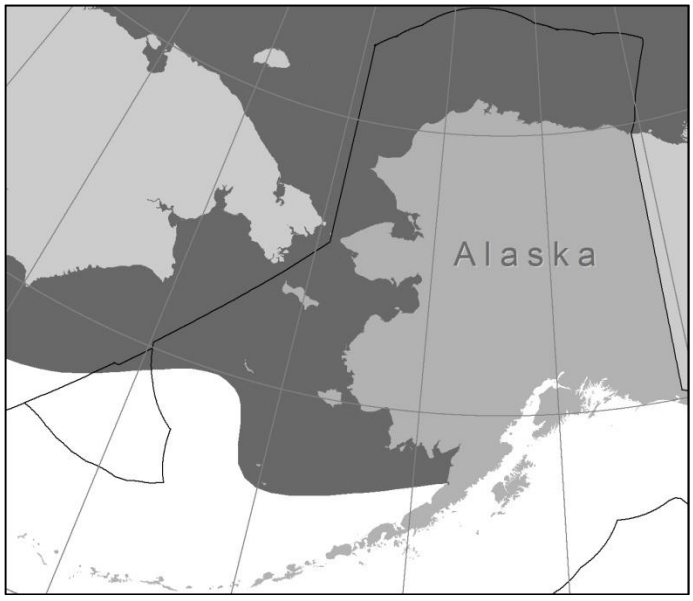

Figure 1. The Alaska stock of ringed seals is defined as the portion of the Arctic subspecies (*P. h. hispida*) in U.S. waters. The dark shaded area shows their approximate winter distribution. The U.S. Exclusive Economic Zone is delineated by a black line.

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 sites on land for molting and resting (Härkönen et al. 1998, Trukhin 2000, Kunnasranta 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 on 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 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

Although a reliable population estimate for the entire stock is not available, research programs have developed survey methods that have been used to determine abundance estimates for part of the range of the stock. In spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys over the entire Bering Sea and Sea of Okhotsk (Moreland et al. 2013). 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 171,418 ringed seals (95% CI: 141,588-201,090). 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 track-line design that will require a separate analysis. Thus, the actual number of ringed seals in the U.S. portion of the Bering Sea is likely much higher, perhaps by a factor of two or more. Researchers expect to provide a population estimate, corrected for availability bias, for the entire Alaska stock of ringed seals once the final Bering Sea results are combined with the results from spring surveys of the Chukchi Sea (conducted in 2016) and Beaufort Sea (planned for 2020).

Minimum Population Estimate

A minimum population estimate (N_{MIN}) for the entire stock cannot be determined because reliable abundance estimates are not available for the Chukchi and Beaufort seas. Using the 2012 Bering Sea abundance estimate by Conn et al. (2014), however, we are able to calculate an N_{MIN} of 158,507 ringed seals in the U.S. Bering Sea. The N_{MIN} for a stock is usually calculated using Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. The (minimal population) abundance estimate by Conn et al. (2014) was calculated using a Bayesian hierarchical framework, however, so we used the 20th percentile of the posterior distribution of abundance estimates in place of the CV in Equation 1.

Current Population Trend

Reliable data on trends in population abundance for the Alaska stock of ringed seals are not available.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is unavailable for the Alaska stock of ringed seals. Until additional data become available, the pinniped maximum theoretical net productivity rate of 12% will be used for this stock (NMFS 2016).

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: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for pinniped stocks listed as threatened under the Endangered Species Act (ESA) (NMFS 2016). Using the N_{MIN} for ringed seals in the U.S. portion of the Bering Sea, a PBR for ringed seals in this area = 4,755 seals (158,507 × 0.06 × 0.5). However, this is not an estimate of PBR for the entire stock because a reliable estimate of N_{MIN} is 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

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between 2013 and 2017 is listed, by marine mammal stock, in Delean et al. (2020); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for Alaska ringed seals between 2013 and 2017 is 700 seals: 2.4 in U.S. commercial fisheries, 697 in the Alaska Native subsistence harvest, 0.2 in marine debris, and 0.4 due to other causes (incidental to Marine Mammal Protection Act (MMPA)-authorized research). This is a minimum estimate of the Alaska Native subsistence harvest because only a small proportion of the communities that harvest ice seals are surveyed each year. Additional potential threats most likely to result in direct human-caused mortality or serious injury of this stock include the increased potential for oil spills due to an increase in vessel traffic in Alaska waters (with changes in sea-ice coverage).

Fisheries Information

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.

Between 2013 and 2017, incidental mortality and serious injury of ringed seals was reported in one of the federally-managed U.S. commercial fisheries in Alaska monitored for incidental mortality and serious injury by fisheries observers: the Bering Sea/Aleutian Islands flatfish trawl fishery (Table 1; Breiwick 2013; MML, unpubl. data). Based on observer data from 2013 to 2017, the average annual rate of mortality and serious injury incidental to U.S. commercial fishing operations is 2.4 ringed seals.

Table 1. Summary of incidental mortality and serious injury of Alaska ringed seals due to U.S. commercial fisheries between 2013 and 2017 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	2013	obs data	100	3	3	2.4 (CV = 0.01)
	2014		100	0	0	
	2015		100	1	1	
	2016		99	0	0	
	2017		100	8	8.0	
Minimum total estimated annual mortality						2.4 (CV = 0.01)

Alaska Native Subsistence/Harvest Information

Ringed seals are an important resource for Alaska Native subsistence hunters. Approximately 64 coastal communities in Alaska, from Bristol Bay to the Beaufort Sea, regularly harvest ice seals (Ice Seal Committee 2019). The Ice Seal Committee, as co-managers with NMFS, recognizes the importance of harvest information and has collected it since 2008. Annual household survey results compiled in a statewide harvest report include historical ice seal harvest information from 1960 to 2017 (Quakenbush et al. 2011, Ice Seal Committee 2019). Ringed seal harvest information for 2013 to 2017 is available for 12 communities (see Table 2). However, a number of other communities harvest ice seals and were not surveyed between 2013 and 2017, including a few communities that have never been surveyed.

Household harvest surveys are designed to estimate the harvest within each surveyed community, but because of differences in ringed seal availability, cultural hunting practices, and environmental conditions, it is not appropriate to extrapolate harvest numbers beyond that community. The number of communities surveyed and successive annual surveys in the same communities have also been limited. For example, between 2013 and 2017, only 12 of a possible 64 (19%) coastal communities were surveyed for ice seal harvest; and, of the 12 communities, only 2 were surveyed for two or more consecutive years (Ice Seal Committee 2019). Thus, annual community-level harvest estimates totaled across communities provide a partial (i.e., minimum) estimate of annual statewide harvest. The geographic distribution of communities with annual harvest estimates also varies among years, so total annual estimates across communities may be geographically or otherwise biased. Between 2013 and 2017, the minimum annual ringed seal harvest estimates totaled across surveyed communities ranged from 185 (in a year that only one community was surveyed) to 1,306 ringed seals (in a year that seven communities were surveyed) (Table 2). Based on the available harvest data from these 12 communities (Table 2), a minimum estimate of the average annual ringed seal harvest between 2013 and 2017 is 697 seals. The Ice Seal Committee is working for a better understanding of ice seal harvest by conducting more consecutive surveys in more communities and one of their goals is to report a statewide ice seal harvest estimate.

Table 2. Alaska ringed seal minimum harvest estimates between 2013 and 2017 (Ice Seal Committee 2019). Empty cells represent the years in which the communities were not surveyed for harvest information.

Community	Ringed seal minimum harvest estimates				
	2013	2014	2015	2016	2017
Nuiqsut		58			
Utqiaġvik (formerly Barrow)		428			
Point Hope		246			
Kotzebue		69			
Deering	7				
Shishmaref		296			
Scammon Bay	189				
Hooper Bay	667	158	185	546	193
Tununak				117	
Tuntutuliak	75				
Eek	13				
Quinhagak	160	51		26	
Minimum total	1,111	1,306	185	689	193

Other Mortality

Reports from the NMFS Alaska Region stranding network of ringed seals entangled in marine debris or with injuries caused by other types of human interaction are another source of mortality and serious injury data. These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined. From 2013 to 2017, reports to the NMFS Alaska Region stranding network resulted in a mean annual mortality and serious injury rate of 0.2 ringed seals observed entangled in marine debris (Table 3; Delean et al. 2020).

In 2016, a ringed seal mortality, due to a gunshot wound to the head, was reported to the NMFS Alaska Region stranding network (Delean et al. 2020). This seal was presumed to be a struck and lost animal from the Alaska Native subsistence hunt and, therefore, it is not included in the mean annual mortality and serious injury rate for 2013 to 2017.

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. Between 2013 and 2017, there were two reports (one each in 2013 and 2016) of mortality incidental to research on the Alaska stock of ringed seals (Table 3; Delean et al. 2020), resulting in a mean annual mortality and serious injury rate of 0.4 ringed seals from this stock.

In 2011, NMFS and the U.S. Fish and Wildlife Service declared an Unusual Mortality Event (UME) for pinnipeds in the Bering and Chukchi seas, due to the unusual number of sick or dead seals and walruses discovered with skin lesions, bald patches, and other symptoms. The UME occurred from 1 May 2011 to 31 December 2016 and primarily affected ice seals, including ringed seals, bearded seals, ribbon seals, and spotted seals. The investigation concluded that the skin and hair symptoms were signs of a molt abnormality; however, no infectious disease agent or environmental cause for the UME symptoms and mortality was identified (https://www.fisheries.noaa.gov/alaska/marine-life-distress/diseased-ice-seals, accessed December 2019). Patchy baldness and delayed molt, however, continue to be observed in limited numbers (<20 per year) of harvested and beachcast ringed seals, bearded seals, ribbon seals, and spotted seals in Alaska.

Table 3. Summary of Alaska ringed seal mortality and serious injury, by year and type, reported to the NMFS Alaska Region marine mammal stranding network and NMFS Office of Protected Resources between 2013 and 2017 (Delean et al. 2020). Animals that were disentangled and released with non-serious injuries have been excluded from this table.

Cause of injury	2013	2014	2015	2016	2017	Mean annual mortality
Entangled in marine debris	0	0	0	0	1	0.2
Incidental to MMPA-authorized research	1	0	0	1	0	0.4
Total in marine debris						0.2
Total due to other causes (incidental to MMPA-authorized research)						0.4

STATUS OF STOCK

On 28 December 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 is designated as depleted under the MMPA and is classified as a strategic stock. A minimum estimate of the mean annual level of human-caused mortality and serious injury is 700 ringed seals, which is less than the PBR of 4,755 seals calculated for only those ringed seals in the U.S. portion of the Bering Sea. The minimum estimated mean annual rate of U.S. commercial fishery-related mortality and serious injury (2.4 seals) is less than 10% of the PBR (10% of PBR = 475) calculated for the Bering Sea and, therefore, can be considered insignificant and approaching a zero mortality and serious injury rate. Population trends and status of this stock relative to its Optimum Sustainable Population are unknown.

There are key uncertainties in the assessment of the Alaska stock of ringed seals. Abundance estimates are not available for the Beaufort and Chukchi seas and the 2012 Bering Sea abundance estimate by Conn et al. (2014) was calculated using only a limited sub-sample of the data and may be an underestimate because of availability bias. Similarly, counts of harvest by Alaska Natives are taken from surveys conducted in a few recent years for a fraction of the communities known to harvest marine mammals and so are considered minimum estimates. Based on the best available information, ringed seals are likely to be highly sensitive to climate change.

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 loses. 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 (Kelly et al. 2010a). 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 (CO_2) 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 CO_2 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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