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BEARDED SEAL (*Erignathus barbatus nauticus*): Alaska Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Bearded seals are a boreoarctic species with a circumpolar distribution (Fedoseev 1965; Johnson et al. 1966; Burns 1967, 1981; Burns and Frost 1979; Smith 1981; Kelly 1988). Their normal range extends from the Arctic Ocean (85°N) south to Sakhalin Island (45°N) in the Pacific Ocean and south to Hudson Bay (55°N) in the Atlantic Ocean (Allen 1880, Ognev 1935, King 1983). Bearded seals inhabit the seasonally ice-covered seas of the Northern Hemisphere, where they whelp and rear their pups and molt their coats on the ice in the spring and early summer. Bearded seals feed primarily on benthic organisms, including epifaunal and infaunal invertebrates, and demersal fishes and are closely linked to areas where the seafloor is shallow (less than 200 m).

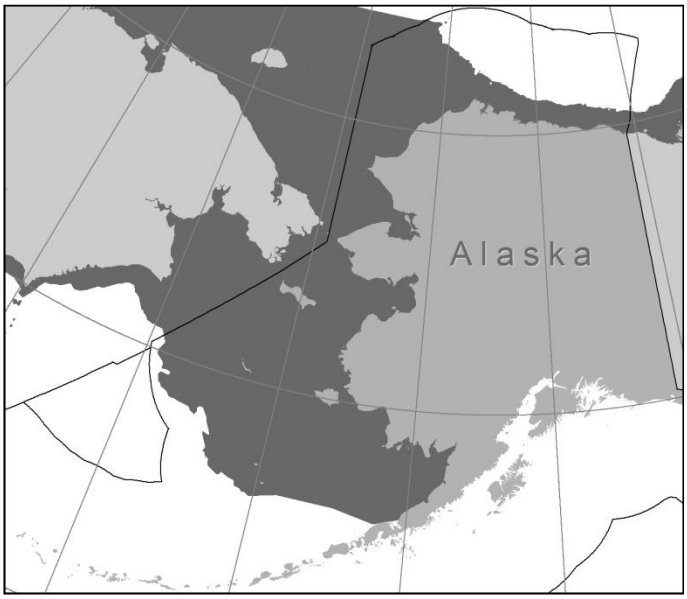

Figure 1. The Alaska stock of bearded seals is defined as the portion of the Beringia DPS (dark shaded areas) in U.S. waters. The U.S. Exclusive Economic Zone is delineated by the solid black line.

Two subspecies have been described: *Erignathus barbatus barbatus* from the Laptev Sea, Barents Sea, North Atlantic Ocean, and Hudson Bay (Rice 1998); and *E. b. nauticus* from the remaining portions of the Arctic Ocean, the Bering Sea, and the Sea of Okhotsk (Ognev 1935, Scheffer 1958, Manning 1974, Heptner et al. 1976). The geographic distributions of these subspecies are not separated by conspicuous gaps, and there are regions of intergrading generally described as somewhere along the northern Russian and central Canadian coasts. As part of a status review of the bearded seal for consideration of listing as threatened or endangered under the Endangered Species Act (ESA), Cameron et al. (2010) defined longitude 145°E as the Eurasian delineation between the two subspecies and 112°W in the Canadian Arctic Archipelago as the North American delineation between the two subspecies. Based on evidence for discreteness and ecological uniqueness of bearded seals in the Sea of Okhotsk, the *E. b. nauticus* subspecies was further divided into an Okhotsk Distinct Population Segment (DPS) and a Beringia DPS, so named because the continental shelf waters of the Bering, Chukchi, Beaufort, and East Siberian seas that are the bearded seals' range in this region overlie much of the land bridge that was exposed during the last glaciation, which has been referred to as Beringia. For the purposes of this stock assessment, we define the Alaska stock of bearded seals to be that portion of the Beringia DPS in U.S. waters (Fig. 1).

Spring surveys conducted in 1999-2000 along the Alaska coast indicate that bearded seals are typically more abundant 20-100 nautical miles (nmi) from shore than within 20 nmi from shore, except for high concentrations nearshore to the south of Kivalina (Bengtson et al. 2000, 2005; Simpkins et al. 2003). Many seals that winter in the Bering Sea move north through the Bering Strait from late April through June and spend the summer in the Chukchi Sea (Burns 1967, 1981). Bearded seal sounds (produced by adult males) have been recorded nearly year-round (peak occurrence in December-June, when sea ice concentrations were >50%) at multiple locations in the Bering, Chukchi, and Beaufort seas, and calling behavior is closely related to the presence of sea ice (MacIntyre et al. 2013, 2015). The overall summer distribution is quite broad, with seals rarely hauled out on land, and some seals, mostly juveniles, may not follow the ice northward but remain near the coasts of the Bering and Chukchi seas (Burns 1967, 1981; Heptner et al. 1976; Nelson 1981; Cameron et al. 2018). As the ice forms again in the fall and winter, most seals move south with the advancing ice edge through the Bering Strait into the Bering Sea where they spend the winter (Burns and Frost 1979; Frost et al. 2005, 2008; Cameron and Boveng 2007, 2009). This southward migration is less noticeable and predictable than the northward movements in late spring and early summer (Burns and Frost 1979, Burns 1981, Kelly 1988). During winter, the central and northern parts of the Bering Sea shelf have the highest densities of bearded seals (Fay 1974, Heptner et al. 1976, Burns and Frost 1979, Braham et al. 1981, Burns 1981, Nelson et al. 1984). In

late winter and early spring, bearded seals are widely, but not uniformly, distributed in the broken, drifting pack ice ranging from the Chukchi Sea to the ice front in the Bering Sea. In these areas, they tend to avoid the coasts and areas of fast ice (Burns 1967, Burns and Frost 1979).

POPULATION SIZE

A reliable population estimate for the entire stock is not available, but research programs have developed survey methods and partial, but useful, abundance estimates. In spring 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 approximately 301,836 bearded seals (95% CI: 238,195-371,147) in those waters. Researchers expect to provide a population estimate for the entire Alaska stock of bearded seals once the final Bering Sea results can be combined with the results from spring surveys of the Chukchi Sea (conducted in 2016) and Beaufort Sea (planned for 2020).

Minimum Population Estimate

The 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 273,676 bearded 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 (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. The 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 bearded seals are unavailable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is unavailable for the Alaska stock of bearded seals. Until additional data become available, the pinniped maximum theoretical net productivity rate of 12% will be used for this stock (Wade and Angliss 1997).

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 with unknown population status (Wade and Angliss 1997). Using the N_{MIN} calculated for bearded seals in the Bering Sea, a PBR for bearded seals that overwinter and breed in the U.S. Bering Sea = 8,210 seals ($273,676 \times 0.06 \times 0.5$). 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 in 2012-2016 is listed, by marine mammal stock, in Helker et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The total estimated annual level of human-caused mortality and serious injury for Alaska bearded seals in 2012-2016 is 557 seals: 1.6 in U.S. commercial fisheries, 555 in the Alaska Native subsistence harvest (from 2011-2015 data, which are the most recent data available), and 0.4 due to Marine Mammal Protection Act (MMPA) research-related permanent removals from the population. 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.

During 2012-2016, incidental mortality and serious injury of bearded seals occurred in three 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 pollock trawl, Bering Sea/Aleutian Islands flatfish trawl, and Bering Sea/Aleutian Islands Pacific cod trawl fisheries (Table 1; Breiwick 2013; MML, unpubl. data). The estimated minimum mean annual mortality and serious injury rate incidental to U.S. commercial fisheries in 2012-2106 is 1.6 bearded seals, based exclusively on observer data.

Table 1. Summary of incidental mortality and serious injury of Alaska bearded seals due to U.S. commercial fisheries in 2012-2016 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. pollock trawl	2012	obs data	98	1	1.0	0.4 (CV = 0.11)
	2013		97	0	0	
	2014		98	1	1.0	
	2015		99	0	0	
	2016		99	0	0	
Bering Sea/Aleutian Is. flatfish trawl	2012	obs data	99	1	1	1 (CV = 0.01)
	2013		99	0	0	
	2014		99	1	1	
	2015		99	2	2	
	2016		99	1	1	
Bering Sea/Aleutian Is. Pacific cod trawl	2012	obs data	68	0	0	0.2 (CV = 0)
	2013		80	1	1	
	2014		80	0	0	
	2015		72	0	0	
	2016		68	0	0	
Minimum total estimated annual mortality						1.6 (CV = 0.03)

Alaska Native Subsistence/Harvest Information

Bearded 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 2017). 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 2015 (Quakenbush et al. 2011, Ice Seal Committee 2017). Bearded seal harvest information for 2011-2015 is available for 16 communities (see Table 2). However, a number of other communities harvest ice seals and were not surveyed in 2011-2015, 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 bearded 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, during 2011-2015, only 16 of a possible 64 coastal communities were surveyed for ice seal harvest; and, of the 16 communities, only 4 were surveyed for two or more consecutive years (Ice Seal Committee 2017). 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. During 2011-2015, the minimum annual bearded seal harvest estimates totaled across surveyed communities ranged from 148 (in 1 community) to 1,176 bearded seals (in 4 communities) (Table 2). Based on the available harvest data from these 16 communities (Table 2), a minimum estimate of the average annual bearded seal harvest in 2011-2015 is 555 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 bearded seal minimum harvest estimates in 2011-2015 (Ice Seal Committee 2017). Empty cells represent the years in which the communities were not surveyed for harvest information.

	Bearded seal minimum harvest estimates				
Community	**2011**	**2012**	**2013**	**2014**	**2015**
Nuiqsut				26	
Utqiaġvik (formerly Barrow)				1,070	
Point Lay		55			
Kivalina	123				
Noatak	65				
Buckland	48				
Deering	49				
Golovin		11			
Emmonak	106				
Scammon Bay	82	51			
Hooper Bay	210	212	171	64	148
Tununak	42	44			
Tuntutuliak			53		
Quinhagak	26	44	49	16	
Togiak	2				
Dillingham		7			
Minimum total	753	424	273	1,176	148

Other Mortality

Permanent removals from the population may occasionally occur during marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. During 2012-2016, two research-related permanent removals were reported for the Alaska stock of bearded seals (Helker et al. in press), resulting in a mean annual rate of 0.4 bearded seals.

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://alaskafisheries.noaa.gov/pr/ice-seals, accessed December 2018). Patchy baldness and delayed molt, however, continue to be observed in limited numbers (<20 per year) of harvested and beach-cast ringed seals, bearded seals, ribbon seals, and spotted seals in Alaska.

STATUS OF STOCK

On 28 December 2012, NMFS listed the Beringia DPS bearded seal (*E. b. nauticus*) and, thus, the Alaska stock of bearded seals, as threatened under the ESA (77 FR 76740). The primary concern for this population is the ongoing and projected loss of sea-ice 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: Cameron et al. 2010). 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 total annual level of human-caused mortality and serious injury is 557 bearded seals, which is less than the PBR of 8,210 seals calculated for only those bearded seals that overwinter and breed in the U.S. portion of the Bering Sea. The minimum mean annual rate of U.S. commercial fishery-related mortality and serious injury (1.6 seals) is less than 10% of the PBR (10% of PBR = 821)

calculated for U.S. waters 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 bearded 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 biased. Similarly, counts of harvest by Alaska Natives are taken from surveys of only a fraction of the communities known to harvest marine mammals and so are considered minimum estimates. Based on the best available information, bearded seals are likely to be highly sensitive to climate change.

HABITAT CONCERNS

The main concern about the conservation status of bearded seals stems from the likelihood that a warming climate is reducing their preferred sea-ice habitats. Scientific projections are for continued and perhaps accelerated warming (Cameron et al. 2010). For bearded seals, the presence of sea ice is considered a requirement for whelping and nursing young. Similarly, the molt is believed to be promoted by elevated skin temperatures that, in polar regions, can only be achieved when seals haul out of the water. Thus, if suitable ice cover is absent from shallow feeding areas during times of peak whelping and nursing (April/May), or molting (May/June and sometimes through August), bearded seals would be forced to seek either sea-ice habitat over deeper waters (perhaps with poor access to food) or onshore haul-out sites (perhaps with increased risks of disturbance, predation, and competition). Both scenarios would require bearded seals to adapt to novel (i.e., potentially suboptimal) conditions, and to exploit habitats to which they may not be well adapted, likely compromising their reproduction and survival rates. A reliable assessment for the future conservation status of each bearded seal DPS requires a focus on projections of specific regional conditions, especially sea ice. End of century projections for the Bering Sea in April-May suggest that there will be sufficient ice only in small zones in the Gulf of Anadyr and in the area between St. Lawrence Island and the Bering Strait. Suitable ice in June in the Bering Sea is predicted to disappear as early as mid-century. To adapt to this regime, bearded seals would likely have to shift their nursing, rearing, and molting areas to the ice-covered seas north of the Bering Strait (Cameron et al. 2010). Laidre et al. (2008) also concluded that on a worldwide basis bearded 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.

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 bearded 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 bearded 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 bearded 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 and development activities, such as disturbance from vessel traffic, seismic exploration noise, and the potential for oil spills.

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