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BEARDED SEAL (*Erignathus barbatus nauticus*): Beringia 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).

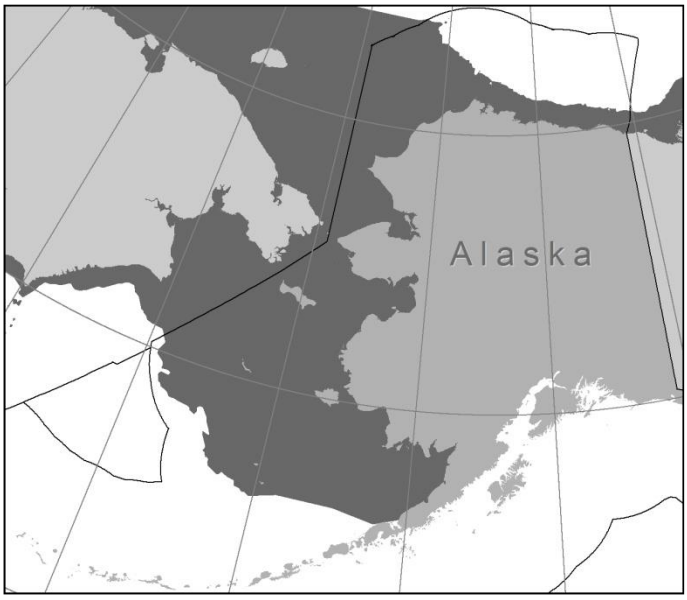

Figure 1. The Beringia bearded seal stock is defined as the Beringia DPS of the *E. B. nauticus* subspecies (dark shaded area). This stock assessment considers only the portion of the stock occurring in U.S. waters (i.e., the U.S. Exclusive Economic Zone delineated by a black line).

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. NMFS defined longitude 145°E as the Eurasian delineation between the two subspecies and 130°W in western Canada as the North American delineation between the two subspecies (Cameron et al. 2010; 77 FR 76740, 28 December 2012). Based on evidence for discreteness and ecological uniqueness of bearded seals in the Sea of Okhotsk, under the Endangered Species Act (ESA) the *E. b. nauticus* subspecies was further divided into an Okhotsk Distinct Population Segment (DPS) and a Beringia DPS (77 FR 76740), 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. This stock is defined as the Beringia DPS; however, this stock assessment considers only the portion of the Beringia stock found within U.S. waters bounded by the U.S. Exclusive Economic Zone (EEZ; Fig. 1), because the relevant stock assessment data on abundance and human-caused mortality and serious injury are generally not available for the broader range of the stock or even for waters adjacent to the U.S. EEZ.

Spring surveys conducted in 1999 and 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; Jimbo et al. 2019). 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; Breed et al. 2018; Cameron et al. 2018). 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, Citta et al. 2018). 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

Although a reliable population estimate for the entire stock is not available, survey methods have been developed and applied to substantial portions of the stock's range in U.S. waters. In the spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys over the entire ice-covered portions of the Bering Sea (Moreland et al. 2013). Conn et al. (2014), using a sub-sample of the data collected from the U.S. portion of the Bering Sea in 2012, calculated an abundance estimate of 301,836 bearded seals (95% CI: 238,195-371,147) in those waters. Researchers expect to provide a population estimate for the entire U.S. portion of the bearded seal stock 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 2021).

Minimum Population Estimate

A minimum population estimate (N_{MIN}) for the entire U.S. portion of the stock cannot be determined because reliable abundance estimates are not yet available for the Chukchi and Beaufort seas. Using the 2012 Bering Sea density 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 (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$, which approximates the 20th percentile of a distribution that is assumed to be log-normal. However, the abundance estimate based on Conn et al. (2014) was calculated using a Bayesian hierarchical framework, so we used the 20th percentile of the posterior distribution of abundance estimates as a more direct estimator of N_{MIN} than Equation 1. This N_{MIN} is negatively biased as an estimator of the Beringia bearded seal stock, and even the U.S. portion of the stock, because the estimate is based solely on the Bering Sea and, therefore, doesn't include the many bearded seals that inhabit the Chukchi and Beaufort seas (e.g., Bengtson et al. 2005, Laidre et al. 2015).

Current Population Trend

Reliable data on trends in population abundance for the Beringia stock of bearded seals or the portion of the stock within U.S. waters are not available.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not available for the Beringia stock of bearded seals or any portion of the stock within U.S. waters. Until additional data become available, the default 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 ESA (NMFS 2016). Using the negatively biased N_{MIN} for bearded seals in the U.S. portion of the Beringia stock, PBR is 8,210 seals (273,676 × 0.06 × 0.5). This PBR is negatively biased because of its dependence on the negatively biased N_{MIN} estimate.

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 2014 and 2018 is listed, by marine mammal stock, in Young 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 the portion of the Beringia bearded seal stock in U.S. waters between 2014 and 2018 is 6,709 seals: 1.8 in U.S. commercial fisheries, 6,707 in the Alaska Native subsistence harvest (average statewide harvest, including struck and lost animals, in 2015, based on a recently published analysis (Nelson et al. 2019) that is higher and likely more accurate than previous estimates but also revealed stable or decreasing trends in harvest numbers; see below), and 0.4 due to Marine Mammal Protection Act (MMPA)-authorized research-related permanent removals from the population. 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 for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is available in Appendix 3 of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed December 2020).

Between 2014 and 2018, incidental mortality and serious injury of bearded seals in U.S. waters occurred in two 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 and Bering Sea/Aleutian Islands flatfish trawl fisheries (Table 1; Breiwick 2013; MML, unpubl. data). The minimum estimated mean annual mortality and serious injury rate incidental to U.S. commercial fisheries between 2014 and 2018 is 1.8 bearded seals, based exclusively on observer data.

Table 1. Summary of incidental mortality and serious injury of Beringia bearded seals in U.S. waters due to U.S. commercial fisheries between 2014 and 2018 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 3 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
Bering Sea/Aleutian Is. pollock trawl	2014 2015 2016 2017 2018	obs data	98 99 99 99 99	1 0 0 1 0	1.0 (0.14) 0 0 1.0 (0.1) 0	0.4 (CV = 0.09)
Bering Sea/Aleutian Is. pollock trawl	2016	obs data	99	1*	N/A	0.2 (CV = N/A)
Bering Sea/Aleutian Is. flatfish trawl	2014 2015 2016 2017 2018	obs data	100 100 99 100 100	1 2 1 1 1	1 (0.05) 2 (0.03) 1 (0.05) 1 (0.04) 1 (0.05)	1.2 (CV = 0.02)
Minimum total estimated annual mortality						1.8 (CV = 0.03)

*This seal was discovered during a vessel offload. Because it could not be associated with a haul number, it was not included in the bycatch estimate for the fishery.

Alaska Native Subsistence/Harvest Information

NMFS signed an agreement with the Ice Seal Committee (ISC; 2006) to co-manage Alaska ice seal populations. This co-management agreement promotes full and equal participation by Alaska Natives in decisions affecting the subsistence management of ice seals (to the maximum extent allowed by law) as a tool for conserving ice seal populations in Alaska (https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska, accessed December 2020).

Bearded seals are an important resource for Alaska Native subsistence hunters. Approximately 64 coastal communities in Alaska, from Bristol Bay to the Beaufort Sea, harvest ice seals (ISC 2019). The ISC, 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, ISC 2019).To estimate the recent subsistence harvest of ice seals, Nelson et al. (2019) used ice seal harvest survey data collected from 1992 to 2014 for 41 of 55 communities that regularly hunt ice seals, as well as the per capita removal estimates (based on the 2015 human population) from the surveyed communities, to estimate the average regional and statewide subsistence harvest (Table 2). The best statewide estimate of the average

number of bearded seals harvested in 2015, including struck and lost animals, is 6,707 seals (Nelson et al. 2019). The authors also found stable or decreasing trends in the annual numbers of ice seals harvested (Nelson et al. 2019).

Table 2. Average regional and statewide subsistence harvest (including struck and lost animals) of Beringia bearded seals in 2015 (Nelson et al. 2019). See Figure 1 in Nelson et al. (2019) for a list of the communities in each region.

Region	Average harvest (including struck and lost animals)
North Slope Borough	1,031
Maniilaq	1,038
Kawerak	3,248
Association of Village Council Presidents	1,360
Bristol Bay Native Association	30
Statewide total	6,707

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. Between 2014 and 2018, two research-related permanent removals (one seal each in 2014 and 2015) were reported for the Beringia stock of bearded seals (Young et al. 2020; Table 3), 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://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed December 2020). 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.

Since 1 June 2018, elevated numbers of ice seal strandings have occurred in the Bering and Chukchi seas in Alaska and NMFS declared a UME for bearded seals, ringed seals, and spotted seals from 1 June 2018 to present in the Bering and Chukchi seas (https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed December 2020). As of 31 July 2020, 298 ice seal strandings of all age classes have been reported, including 88 bearded seals, 72 ringed seals, 49 spotted seals, and 89 unidentified seals. A subset of seals has been sampled for genetics and harmful algal bloom exposure and a few have had histopathology samples collected.

Table 3. Summary of mortality and serious injury of Beringia bearded seals, by year and type, reported to the NMFS Alaska Region marine mammal stranding network and NMFS Office of Protected Resources between 2014 and 2018 (Young et al. 2020).

Cause of Injury	2014	2015	2016	2017	2018	Mean annual mortality
MMPA-authorized research-related permanent removals	1	1	0	0	0	0.4
Total MMPA-authorized research-related permanent removals						0.4

STATUS OF STOCK

On 28 December 2012, NMFS listed the Beringia DPS bearded seal (*E. b. nauticus*), which corresponds to the Beringia 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 resulting 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. The best estimate of the mean annual level of human-

caused mortality and serious injury in the portion of the stock in U.S. waters is 6,709 bearded seals, which is less than the negatively biased PBR of 8,210 seals. The minimum estimated mean annual rate of U.S. commercial fishery-related mortality and serious injury (1.8 seals) is less than 10% of the PBR (10% of PBR = 821) 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 Beringia stock of bearded seals. Abundance and mortality and serious injury estimates are not available for the vast majority of the stock's range. Within U.S. waters, where abundance estimates are being developed and data are currently available on mortality and serious injury in commercial fisheries and the Alaska Native subsistence harvest, key abundance estimates for the Beaufort and Chukchi seas are not yet available. The negatively biased N_{MIN} used here, based on a 2012 Bering Sea density estimate from Conn et al. (2014), was calculated using only a sub-sample of the data and may be biased as an estimate for the U.S. waters of the Bering Sea. Also, it represents just a portion of the population of bearded seals in U.S. waters and is, therefore, not very reliable for comparison with mortality and serious injury numbers for the entire U.S. portion of the stock. 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 is long-term habitat loss and modification resulting from climate change (77 FR 76740, 28 December 2012). Laidre et al. (2008) 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. Climate models consistently project substantial reductions in both the extent and timing of sea ice within the range of bearded seals in Alaska waters (Cameron et al. 2010). Bearded seals are closely associated with sea ice, particularly during the periods of reproduction and molting. 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. 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 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. As discussed in Cameron et al. (2010), 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), such as disturbance from vessel traffic and the potential for oil spills.

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