Ecosystem-based Management for Protected Species in the North Pacific Fisheries

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ABSTRACT—In the North Pacific Ocean, an ecosystem-based fishery management approach has been adopted. A significant objective of this approach is to reduce interactions between fishery-related activities and protected species. We review management measures developed by the North Pacific Fishery Management Council and the National Marine Fisheries Service to reduce effects of the groundfish fisheries off Alaska on marine mammals and seabirds, while continuing to provide economic opportunities for fishery participants. Direct measures have been taken to mitigate known fishery impacts, and precautionary measures have been taken for species with potential (but no documented) interactions with the groundfish fisheries. Area closures limit disturbance to marine mammals at rookeries and haulouts, protect sensitive benthic habitat, and reduce potential competition for prey resources. Temporal and spatial dispersion of catches reduce the localized impact of fishery removals. Seabird avoidance measures have been implemented through collaboration with fishery participants and have been highly successful in reducing seabird bycatch. Finally, a comprehensive observer monitoring program provides data on the location and extent of bycatch of marine mammals and seabirds. These measures provide managers with the flexibility to adapt to changes in the status of protected species and evolving conditions in the fisheries. This review should be useful to fishery managers as an example of an ecosystem-based approach to protected species management that is adaptive and accounts for multiple objectives.

Introduction

In 2010, President Barack Obama signed Executive Order 13547 that established a National Policy for the Stewardship of the Ocean, Coasts, and Great Lakes. The highest priority of the National Policy is to adopt ecosystem-based management as a foundational principle for comprehensive management of the oceans, coasts, and Great Lakes (CEQ, 2010). Federal agencies are directed to take appropriate steps and to work together to implement the National Policy objectives to the fullest extent consistent with applicable law.

An ecosystem-based strategy to manage fisheries involves using the best available scientific information to promote long-term sustainability and to prevent adverse and irreversible harm to ecosystem structure and functioning by addressing how fishing activities affect biodiversity, food web interactions, and habitat (NMFS, 1999; Pikitch et al., 2004; Fluharty, 2005). Practical strategies to achieve ecosystem-based management of marine fisheries include: 1) maintaining abundant fish stocks, 2) maintaining healthy habitats, 3) maintaining biodiversity and food webs, 4) minimizing the effects of fisheries on protected species, 5) incorporating variable environmental conditions, uncertainty, and ecosystem science into decision making, and, 6) coordinating with other nongovernmental agencies and communities to address nonfishery impacts on marine ecosystems (Francis et al., 2007; Marasco et al., 2007; Witherell, 2009).

In the North Pacific, measures to protect seabirds and marine mammals arise from an overall ecosystem-based approach for managing Alaska groundfish fisheries (Witherell et al., 2000; NPFMC, 2010a; NPFMC, 2011). The stated management policy is "to apply judicious and responsible fisheries management practices, based on sound scientific research and analysis, proactively rather than reactively, to ensure the sustainability of fishery resources and associated ecosystems for the benefit of future, as well as current, generations." This policy has been implemented through a variety of measures to achieve specified goals (NPFMC, 2010a; NPFMC, 2011). Precautionary and conservative annual catch limits have been established for every target fish species (DiCosimo et al., 2010). Total removals of fish (of all species) from the ecosystem have been constrained by system level optimum yield limits, particularly in the Bering Sea (NMFS, 2004). Bycatch of nontarget species has been controlled with explicit catch limits and area closures (Witherell and Pautzke, 1997; Reuter et al., 2010) and avoided by the fleets using gear modifications and proactive real-time fishery closures (Haflinger and Gruver, 2009). Fishing for forage fish species has been prohibited. Sensitive habitats and vulnerable species have been protected from fishery impacts with marine protected areas (Witherell and Woodby, 2005). At-sea observers, combined with strict reporting requirements and tight enforcement of regulations, ensure effective implementation of these mea-

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Figure 1.—Major geographic areas referenced in the text.

sures. An Ecosystem Considerations Report containing an ecosystem assessment and ecosystem indicators is prepared annually, and provides fishery managers information to qualitatively incorporate ecosystem information into the establishment of annual catch limits for target species (NPFMC, 2010b). The ecosystem-based approach for fisheries, as applied in the North Pacific, provides both direct and indirect beneficial impacts to marine mammals, seabirds, and other components of the ecosystem. This paper reviews these measures as they apply to reducing impacts of fisheries on protected species.

The North Pacific Fishery Management Council (Council) was established by the Fishery Conservation and Management Act of 1976 and is responsible for developing Fishery Management Plans (FMP's) for fisheries that take place in Federal waters (5.6–370 km or 3–200 nmi from shore) off Alaska (Fig. 1). The process of developing FMP's involves extensive input by state and Federal agencies, industry, and public interest groups, and proposed measures also undergo formal scientific review. Management measures developed by the councils must be approved by the Secretary of Commerce, and they are implemented by NMFS if they meet the requirements of the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) of 2006. In developing FMP's, the MSFCMA requires councils to consider the impacts of fishing activities on all living marine resources, including marine mammals and seabirds.

In addition, fishery management measures are reviewed to ensure that they are consistent with several other Federal laws. The National Environmental Policy Act (NEPA) of 1973 requires that all Federal actions, including fishery management measures implemented by NMFS, be reviewed to ensure that potential environmental impacts are duly weighed and considered in decision making. And the Endangered Species Act (ESA) of 1973 requires the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) to ensure that fishing activities do not jeopardize the continued existence of any listed species or adversely modify its designated critical habitat.

Under the Marine Mammal Protection Act (MMPA) of 1972, NMFS has responsibility for the management and conservation of all marine mammal species in the North Pacific, with the exception of Pacific walrus, *Odobenus rosmarus divergens;* sea otter, *Enhydra lutris*; and polar bear, *Ursus maritimus*, which are managed by USFWS. The MMPA requires these agencies to conserve species, protect their habitat, limit mortality, and not allow them to diminish below their optimum sustainable population.

The Migratory Bird Treaty Act of 1918 requires NMFS to work cooperatively with USFWS to reduce the impacts of fishing activities on seabirds. The Protected Resources Division of NMFS coordinates management and conservation of protected species, which include marine mammals, seabirds, and sea turtles, and all marine and anadromous species (including fish and invertebrates) listed under the Endangered Species Act. Fishing activities in state waters of Alaska (0–5.6 km or 0–3 nmi from shore or the baseline) are regulated by the Alaska Board of Fisheries, and the Alaska Department of Fish and Game (ADFG) implements the Board's actions.

Fishing activities may have both direct and indirect impacts on protected species. Direct impacts of fishing activities include inflicting incidental injuries or mortalities of animals through entanglement with fishing gear or vessel strikes or disturbances to animals at rookeries and haulouts. Fishing activities may also affect protected species indirectly through competition for or disruption of access to prey resources (Lowry and Frost, 1985). The indirect effects of fishing are difficult to assess because they often cannot be isolated from other ecosystem processes, such as oceanographic regime shifts and predator-prey dynamics (Springer et al., 2003; DeMaster et al., 2006). Because these impacts are uncertain and difficult to quantify, fisheries managers in the North Pacific have adopted a precautionary approach to mitigate the effects of fishing activities on marine mammals and seabirds.

In the North Pacific, several types of management measures work in concert to reduce interactions between the groundfish fisheries and protected species. Area closures are designed to reduce the direct and indirect impacts of fishing in areas and during time periods determined to be especially important to protected species (Witherell and Woodby, 2005). Catch limits are seasonally apportioned to reduce the likelihood of localized depletion of key prey resources. Seabird avoidance measures allow the longline groundfish and Pacific halibut, *Hippoglossus stenolepis*, fisheries to be prosecuted with minimal disruption to the fisheries or economic burden on participants while minimizing seabird bycatch. Finally, observer monitoring requirements ensure that managers have access to timely and accurate data on the interactions between fisheries and protected species. The North Pacific Observer Program is unique in that the costs of deploying observers are paid for by the fishing industry, but the program is administered by NMFS to ensure that observers provide independent, scientifically valid data (NPFMC, 2010c). In addition, the Council has worked cooperatively with the fishing industry and state and Federal agencies to promote new research on the impacts of fishing on protected species.

This paper examines how the NPFMC and NMFS have developed an ecosystem-based management approach to mitigate interactions between the fisheries off Alaska and protected species. For the purposes of this review, we focus on marine mammal and seabird species which have known or likely interactions with the fisheries off Alaska, and hence have been addressed by the Council management process. We review direct measures developed by the Council and NMFS to mitigate known interactions between protected species and fisheries, and precautionary measures taken in cases where no direct fisheries actions have been identified to date, but where the potential exists for interactions to occur. Although other factors may have contributed to or may have been the primary reason for the decline of some species, such as shooting, predation, or shifts in the ecosystem, fisheries managers have focused on addressing fisheries interactions when and where practicable to assist in the recovery of protected species.

The Council process involves extensive participation by the public, fishery participants, marine scientists, and fishery managers. Protected species management measures continue to be developed and refined as new information becomes available and provide the Council with the tools to address new problems as they are identified (Witherell, 2004, 2005; NPFMC, 2010d).

Direct Measures for Species with Known Fisheries Interactions

Pacific Walrus

Pacific walrus occur in the Bering and Chukchi Seas and make seasonal movements among several areas. In winter, Pacific walrus are found in shelf waters of the Bering Sea and use pack ice as a haulout. The breeding season occurs in late winter, and during this time walrus are concentrated in the Gulf of Anadyr, southwest of St. Lawrence Island, and south of Nunivak Island (Fay, 1982; Speckman et al., 2010; Fig. 2). In summer, most Pacific walrus move north with the receding pack ice to the Chukchi Sea, but thousands of male walrus may remain in Bristol Bay in the southeastern Bering Sea throughout the summer and use terrestrial haulout sites (Fay, 1982; USFWS, 1994; Jay and Hills, 2005; Okonek et al., 2009).

The Council first addressed interactions between Pacific walrus and fishing activities in the late 1980's by establishing several area closures around terrestrial haulouts in Bristol Bay. Walrus use of coastal haulouts in Bristol Bay began increasing in the 1970's as walrus numbers recovered following restrictions on commercial hunting (Fay et al., 1997). By the 1980's, four primary haulout sites were being used by walrus in Bristol Bay, including Round Island, Cape Peirce, Cape Newenham, and

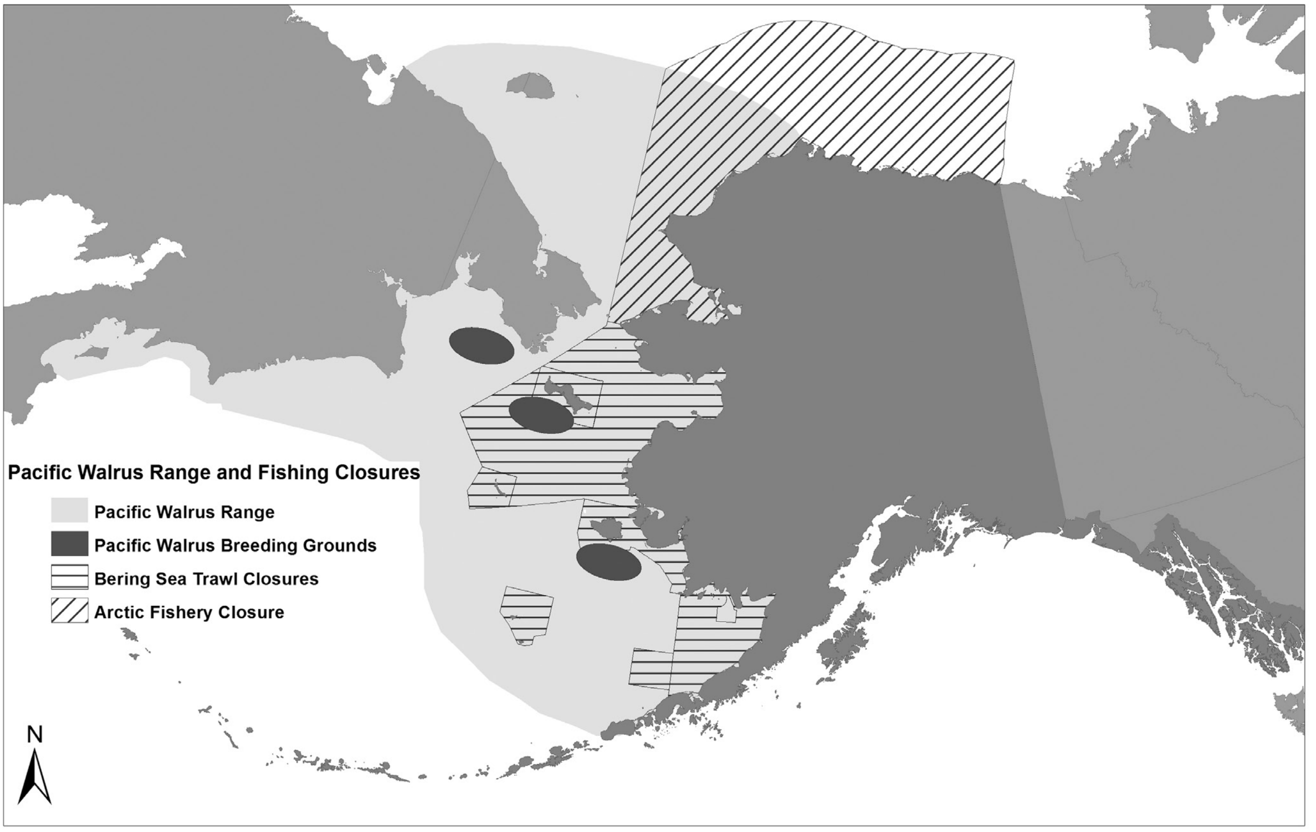

Figure 2.—Pacific walrus range and fishing closures off Alaska.

Cape Seniavin. However, peak counts at the largest haulout on Round Island declined in the 1980's by more than 50% from counts in the late 1970's (Okonek et al., 2009). Walrus in Bristol Bay may use more than one haulout during a given season, and the decrease in use of the Round Island haulout may be related to increased use of other Bristol Bay haulouts (Jay and Hills, 2005).

Shifts in haulout use within Bristol Bay are not well understood (Jay and Hills, 2005), but walrus use of haulouts may be influenced by human disturbances at haulout sites, which can cause animals to flee haulouts temporarily or abandon them permanently (Salter, 1979; Fay et al., 1989). The decline in use of the Round Island haulout in the early 1980's was coincident with the development of the Togiak Pacific herring, *Clupea pallasii*, fishery and increased aircraft traffic bringing visitors to Round Island (NPFMC, 1989). Visitor use was restricted and use of the haulout increased. However, Round Island haulout counts declined again in the late 1980's when the yellowfin sole, *Limanda aspera*, fishery was developed in northern Bristol Bay. This fishery was prosecuted by a fleet of more than 100 vessels during summer months (NPFMC, 1989). Peak annual counts at the Round Island haulout declined from more than 14,000 animals in 1978 to 4,500 in 1988 (Okonek et al., 2009).

In response to concerns expressed by residents of Bristol Bay and wildlife managers from USFWS and ADFG about fishery-related disturbances to walrus using the Bristol Bay haulouts, the Council designated several walrus protection areas in 1989 (NPFMC, 1989; Fig. 3). The closures extend from 5.6 km to 22.2 km (3–12 nmi) from haulouts on Round Island, the Twins, and Cape Peirce, and are intended to reduce fishery-related disturbances to walrus using these sites. The closures are seasonal (1 Apr. through 30 Sept.) and coincide with peak walrus use of haulouts. All vessels with Federal fisheries permits are prohibited from engaging in fishery-related activities in the closure areas. In addition, the State of Alaska created a complementary vessel closure that extends from 0 to 5.6 km (0–3 nmi) from Round Island and is in effect year round. The walrus area closures encompass approximately 3,087 km^2 (900 nmi^2).

The Council did not designate a closure around the walrus haulout at Cape Newenham, but this site is also used as a haulout by Steller sea lions, *Eumetopias jubatus,* and is encircled by a 37 km (20 nmi) radius Steller sea lion closure that prohibits directed fishing for walleye pollock, *Theragra chalcogramma*, or Pacific cod, *Gadus macrocephalus,* using trawl, hook-and-line, and pot gear (Fig. 3; NMFS, 2010a). More recently, the Council has considered establishing a new closure area around a recently established walrus haulout on Hagemeister

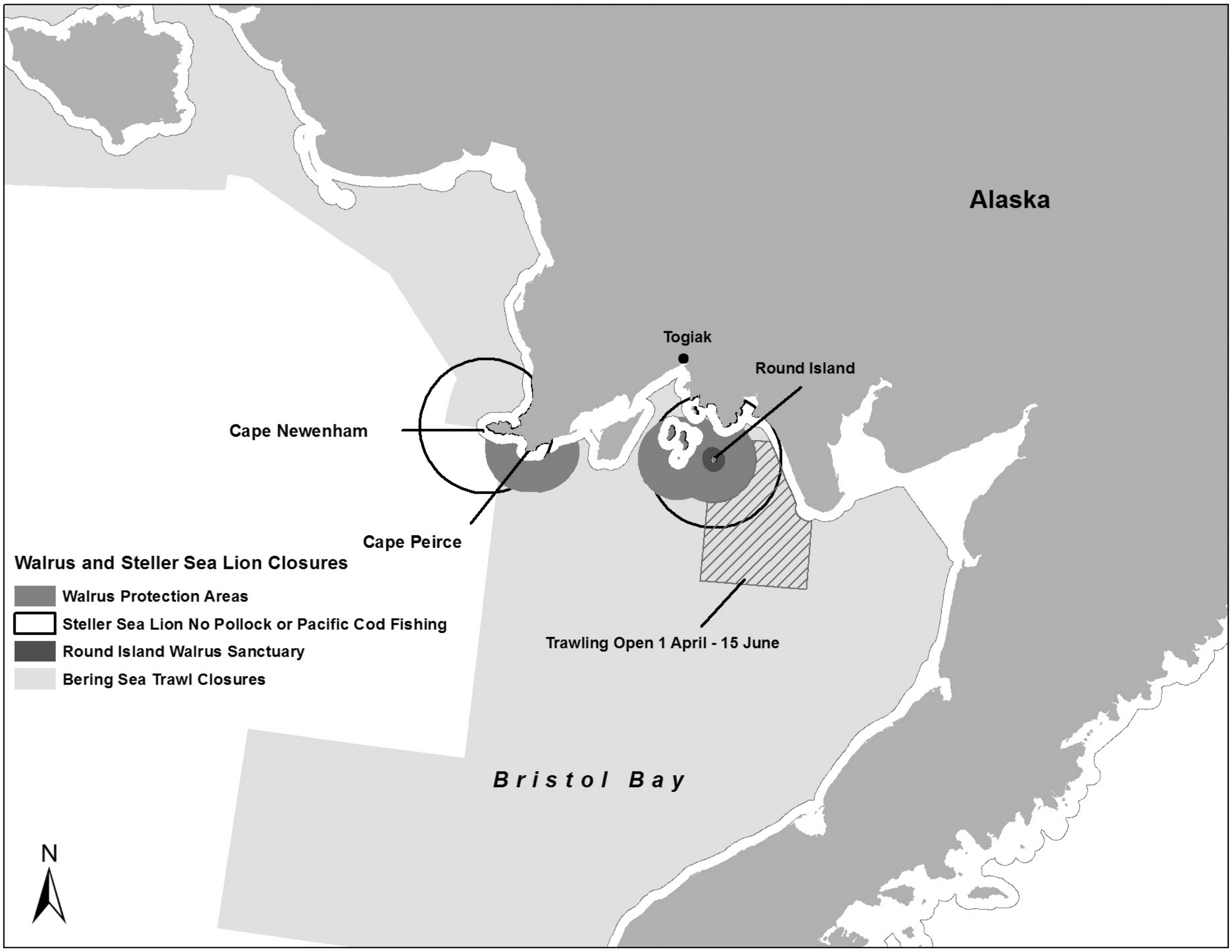

Figure 3.—Pacific walrus and Steller sea lion protection areas in Bristol Bay, Alaska.

Island, also located in northern Bristol Bay, where nearly 3,000 walrus have been counted (NPFMC, 2010e).

During 2001–10, up to 14% of the Bering Sea yellowfin sole catch was harvested in northern Bristol Bay, with harvests occurring in May and early June (NPFMC, 2010e). The yellowfin sole grounds in Bristol Bay are important to the fleet because halibut bycatch is relatively low compared with other yellowfin sole fishing grounds in the Bering Sea (NPFMC, 2010e).

Herring and Pacific salmon, *Oncorhynchus* spp., fisheries are also prosecuted in northern Bristol Bay during the time walrus are present. The intent of establishing a new closure at the Hagemeister haulout site would be to mitigate these potential fishery-related disturbances. The proposed closure would be precautionary, as the status quo fisheries have not been determined to have non-negligible adverse impacts on walrus (NPFMC, 2010e). The primary economic cost of the proposed closure to fishery participants is increased travel time and fuel costs to transit around the closure area, because little fishing activity occurs inside the proposed closure area (NPFMC, 2010e). No action was taken since other sources of walrus disturbance in this area would not be affected by a Council action.

The Council and NMFS monitor other potential impacts of fisheries on walrus in cooperation with USFWS. Bycatch of Pacific walrus in the commercial fisheries is not considered to be a significant source of mortality. Observer data indicate that fewer than three fishery-related mortalities of walrus occur per year (Allen and Angliss, 2011).

Bottom trawling may disturb benthic habitat in areas that are used by foraging walrus. Walrus generally feed in waters less than 80 m in depth (Fay, 1982; Jay et al., 2001; Jay and Hills, 2005) and forage on the seafloor for bivalve mollusks and other invertebrates (Fay, 1982). In 2007, the Council closed 458,921 km^2 (133,800 nmi^2) of the northern Bering Sea to bottom trawling year-round. A portion of the closed area is designated as the Northern Bering Sea Research Area (188,645 km^2 or 55,000 nmi^2) and a research plan is being developed for the area that may open limited areas to experimental trawling in the future.

The intent of the closures is to protect sensitive benthic habitat in areas where little fishing currently occurs. Fishing activities in the North Pacific have the potential to shift northward as climate patterns and fish distributions change (Mueter and Litzow, 2008). Areas used by Pacific walrus during the late winter breeding season overlap extensively with the newly designated bottom trawl closure areas (Fig. 2).

The USFWS recently determined that listing Pacific walrus as threatened under the ESA is warranted but precluded at this time due to higher priority listings (USFWS, 2011a). A range-wide survey conducted in 2006 estimated a minimum population of 129,000 walrus (Speckman et al., 2010). This may indicate that the population has declined from estimates of more than 200,000 animals in the 1970's and 1980's (Fay et al., 1997), but different survey methods make it difficult to compare historical and recent population estimates (Speckman et al., 2010). If Pacific walrus are listed under the ESA in the future, USFWS would prepare a Biological Opinion evaluating the status of walrus and any adverse impacts of human activities, including fishing. If non-negligible, adverse fishery-related impacts on walrus are identified, the Council and NMFS would likely need to consider additional walrus protection measures.

Steller Sea Lions

Steller sea lions overlap in distribution with commercial fisheries throughout their range off Alaska. Steller sea lions use coastal rookeries on a seasonal basis and use haulouts on a seasonal or year-round basis, and forage offshore from these sites. The diet of Steller sea lions consists of several commercially harvested species, including walleye pollock, Atka mackerel, *Pleurogrammus monopterygius*; Pacific cod, Pacific salmon, and herring, as well as noncommercially harvested species (e.g. forage fishes), and it varies seasonally and by area (Sinclair and Zeppelin, 2002).

Steller sea lion numbers declined dramatically beginning in the 1970's, and the species was initially listed as threatened in 1990. Two distinct population segments (DPS) were later identified based on genetic and demographic differences, and the western DPS was listed as endangered in 1997. The western DPS of Steller sea lions declined by about 80% from the 1970's to 2000, and then increased slightly from 2000 to 2008, although the trend is not statistically significant (NMFS, 2010a). Declines have continued in some areas, particularly in the western and central Aleutian Islands (NMFS, 2010a).

Many management measures have been implemented since 1990 when Steller sea lions were initially listed as threatened. These measures are summarized in detail in NMFS (2010a, 2010b), and an overview of the measures is provided here. Prior to 1990, shooting and incidental take in commercial fisheries were likely important causes of the decline (Loughlin and York, 2001). An estimated 6,543 Steller sea lions were incidentally taken in groundfish fisheries off Alaska from 1978 through 1988, although there was generally a declining trend in the number of animals taken per year over this time period (Perez and Loughlin, 1991). Shooting at or near a sea lion was prohibited in 1990, and the incidental take limit was reduced by 50%. In recent years, fewer than 20 sea lions per year have been taken in the groundfish fisheries off Alaska (Allen and Angliss, 2011).

Extensive area and fishing closures have been implemented around rookeries and haulouts and several larger at-sea foraging areas to reduce disturbance to animals and to reduce the potential for fisheries to cause localized depletion of prey species (NMFS, 2010a; NMFS, 2010b). In 1990, when Steller sea lions were initially listed, 5.6 km (3 nmi) radius no-entry zones were established around all rookeries.

Several consultations conducted by NMFS under Section 7 of the ESA have concluded that the groundfish fisheries may be contributing to the decline of sea lions and have resulted in additional closures. Groundfish trawling was prohibited within an 18.5 km (10 nmi) radius of all rookeries in 1992. In 1999, the western DPS of Steller sea lions was listed as endangered and this prohibition was extended to all major haulouts for the pollock trawl fishery. Some closures around rookeries and haulouts were extended to a 37 km (20 nmi) radius either on a seasonal or year-round basis. In addition, the Aleutian Islands were closed to directed pollock fishing.

In 2002, the Council, together with NMFS, developed a comprehensive suite of gear, fishery, and area closures, including no transit and fishing zones extending up to 37 km (20 nmi) from rookeries and haulouts and directed fishing closures for pollock, Pacific cod, and Atka mackerel in three important foraging areas. Altogether, these closures total approximately 198,940 km^2 (58,000 nmi^2) in waters off Alaska and encompass extensive portions of the area designated as critical habitat by NMFS in 1993 (Fig. 4). Detailed descriptions and maps of the Steller sea lion area, time, and fishery closures are available on the NMFS website (http://www.fakr.noaa.gov/sustainablefisheries/sslpm/), and are not displayed here owing to the complexity of the closures. Area closures have generally resulted in a decrease in the proportion of catch made inside Steller sea lion critical habitat in the walleye pollock, Pacific cod, and Atka mackerel fisheries (Table 1; NMFS, 2010a). The catch data in Table 1 are calculated from annual catch data provided in NMFS (2010a).

In addition to area closures, the total allowable catch (TAC) of three species that are important prey items for Steller sea lions (walleye pollock, Pacific cod, and Atka mackerel) is seasonally apportioned to distribute fishing effort over time (NMFS, 2010b). Temporal distribution of fishing effort may reduce the likelihood that fishing activities will cause localized depletion of key prey species. These measures have been implemented for the largest fisheries off Alaska, including the Bering Sea pollock, Aleutian Islands Atka mackerel,

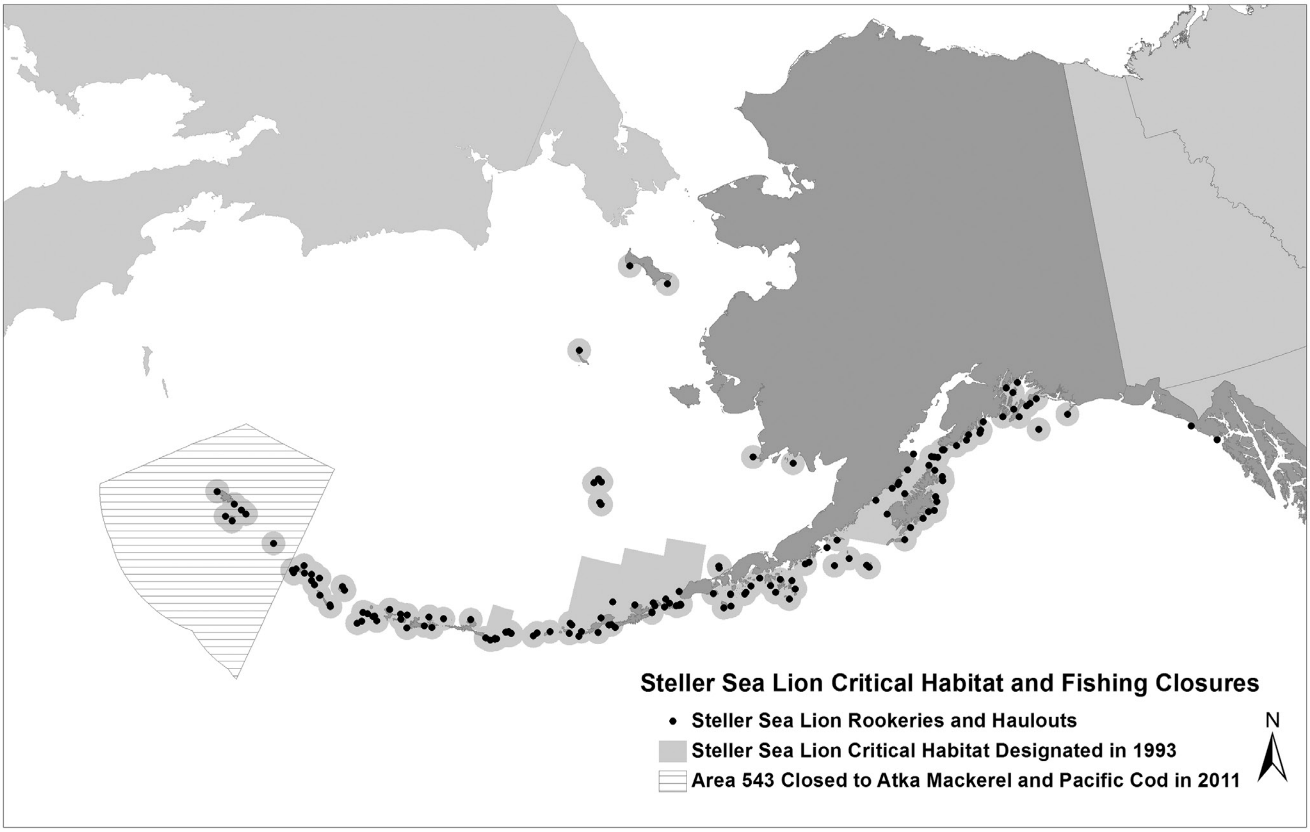

Figure 4.—Steller sea lion critical habitat, rookery and haulout locations, and recent fishery closures.

Table 1.—Total catch in metric tons (t) and percent of catch landed inside Steller sea lion critical habitat, averaged from 1991 to 1999 and 2000 to 2008.

	Average (1991–99)			Average (2000–2008)		
Fishery	Total catch (t)	Percent catch inside critical habitat	Annual range of percent catch inside critical habitat	Total catch (t)	Percent catch inside critical habitat	Annual range of percent catch inside critical habitat
Bering Sea pollock	1,248,553	52.9%	36.5%–66.1%	1,364,726	36.3%	17.3%–54.1%
Bering Sea Pacific cod	183,458	41.0%	27.0%–49.0%	159,774	33.9%	23.4%–42.7%
Aleutian Islands Atka mackerel	62,088	66.8%	27.0%–93.8%	54,113	38.6%	29.3%–47.0%
Aleutian Islands Pacific cod	26,944	82.7%	69.9%–95.2%	31,438	80.5%	69.3%–89.5%
GOA Pollock	93,493	75.5%	56.9%–85.6%	63,117	68.1%	53.8%–78.7%
GOA Pacific cod	65,778	67.9%	56.7%–74.3%	50,212	53.3%	39.5%–61.6%

Gulf of Alaska pollock, and Pacific cod fisheries. In addition, directed trawling for pollock, Pacific cod, and Atka mackerel is closed from 1 November through 19 January, and area-specific harvest limits have been established in key Steller sea lion foraging areas. Finally, directed harvests of forage fish species (with the exception of herring), some of which are regionally and temporally important prey items for many marine mammals and seabirds, have been prohibited since 1998.

In a recent biological opinion, NMFS determined that the status quo groundfish fisheries in the Aleutian Islands may be jeopardizing the continued existence of the western DPS of Steller sea lions and adversely modifying its designated critical habitat (NMFS, 2010a). In addition to fisheries, environmental changes were also identified as likely contributors to the decline, and predation by killer whales, contaminants, and interspecific competition were identified as possible contributors to the decline (NMFS, 2010a). The Steller Sea Lion Recovery Plan divides the western DPS into 7 subareas, and the Plan's recovery criteria state that if the western DPS is declining in two or more adjacent subareas, the recovery plan goals are not being met (NMFS, 2008a). Because fisheries effects, along with enviromental changes, were identified as likely contributors to the decline of Steller sea lions, the Biological Opinion recommended additional restrictions on the Atka mackerel and Pacific cod fisheries in the Aleutian Islands as precautionary measures. In the Aleutian Islands, counts of nonpups (defined as adult and juvenile sea lions, excluding pups of the year) declined substantially from 2000 to 2008 (7% annual decline in the western Aleutians; 1–4% annual decline in the central and eastern Aleutians: NMFS, 2010a). Counts of both pups and nonpups were stable or increasing in the rest of the western DPS range (0–5% annual increase from 2000 to 2008; NMFS, 2010a). Consequently, no changes were made to Steller sea lion protection measures outside of the Aleutian Islands.

Beginning in 2011, NMFS prohibited retention of Atka mackerel and Pacific cod in the western Aleutian Islands management area (Fig. 4), and most areas of critical habitat are closed to Atka mackerel and Pacific cod fishing in the central and eastern Aleutian Islands management areas (NMFS, 2010a). Overall, about half of the Aleutian Islands Atka mackerel catch limit cannot be harvested under the new measures (NMFS, 2010b). These are the first Steller sea lion measures that have directly reduced groundfish catch limits. In addition, Pacific cod harvests in the Aleutian Islands are likely to decline because of the additional spatial restrictions on harvests, but some effort may shift to the Bering Sea (NMFS, 2010b). The economic impact of the measures on gross revenues is estimated to be $50 million to $66 million per year (NMFS, 2010b).

Much remains unknown about the causes of the Steller sea lion population decline (NRC, 2003; Atkinson et al., 2008; NMFS, 2010b). Recent studies have examined the effects of the pollock and Pacific cod fisheries on the prey field (Wilson et al., 2003; Conners and Munro, 2008). Future research efforts will likely focus on the Aleutian Islands to investigate the cause of continued sea lion population declines and to monitor the effects of the recently implemented fishery closures (NMFS, 2010a).

Short-tailed Albatross and Seabird Avoidance Requirements

The Council began addressing seabird bycatch issues in the late 1990's when incidental take limits were established for the endangered short-tailed albatross, *Phoebastria albatrus*. Short-tailed albatross numbers were severely reduced by commercial feather hunting in the late 1800's and early 1900's (USFWS, 2008). Nesting sites now have protected status, and the primary threat to the recovery of the population is the potential for volcanic activity at Toroshima Island, Japan, where more than 80% of short-tailed albatross nest (USFWS, 2008). The Short-tailed Albatross Recovery Plan (USFWS, 2008) has focused recovery efforts on establishing additional nesting sites.

A secondary threat to recovery is bycatch in the commercial fisheries (USFWS, 2008). Short-tailed albatross primarily range in waters off Alaska during the post-breeding season from May until November (Suryan et al., 2007). Locations where short-tailed albatross are frequently observed include several canyons along the Bering Sea shelf edge and passes in the Aleutian Islands (Piatt et al., 2006; Suryan et al., 2007), areas where commercial fishing also occurs seasonally.

Regulations that have been developed to limit incidental takes of short-tailed albatross are described in detail in USFWS (2003) and a summary of the measures is provided here. In 1998, the USFWS issued short-tailed albatross incidental take limits of four birds during a 2-year period in the longline groundfish fisheries and two birds during a 2-year period in the longline Pacific halibut fisheries. In anticipation of the take limits being established, the fishing industry recognized a looming threat, and adopted voluntary measures to test seabird avoidance devices aboard longline fishing vessels (Wilson, 2004). This experience led the Council and NMFS to develop seabird avoidance requirements for longline vessels (Wilson, 2004), and measures were implemented in 1997 and 1998 (NMFS, 1997, 1998). All longline vessels targeting groundfish were required to adhere to specific seabird avoidance measures beginning in 1997, and the measures were extended to the longline halibut fleet in 1998.

The regulations developed by the Council required all longline vessels more than 7.9 m (26 ft) long to utilize one or more of the following seabird avoidance measures: set gear at night; tow one or more streamer lines while deploying gear; tow a buoy bag or stick while deploying gear; or deploy hooks underwater through a lining tube (NMFS, 1997, 1998). In addition, longline vessels were required to use weighted hooks that sink quickly and to follow specific offal discharge protocols. Research conducted by the University of Washington's Sea Grant Program in 1999–2000 found that the use of paired streamer lines substantially reduced seabird bycatch (Melvin et al., 2001). Consequently, seabird avoidance measures were revised by NMFS and the Council in 2001 to require all longline vessels greater than 16.7 m (55 ft) in length to use paired streamer lines (NMFS, 2002). Longline vessels from 7.9 m to 16.7 m (26–55 ft) in length are required to use either a single streamer or a buoy bag, depending on the fishing location. Streamer lines have been provided to longline vessel operators free of charge through a program administered by the Pacific States Marine Fisheries Commission in Portland, Oreg.

Overall seabird bycatch in the demersal longline fisheries declined dramatically as many vessels in the longline fleet began to use paired streamer lines (Fitzgerald et al., 2008). The regulation requiring the use of streamer lines was implemented in 2004, but many longline catcher processors began using streamer lines voluntarily in 2002 (Fitzgerald et al., 2008). Annual seabird bycatch data from 1993–2006 are provided in Fitzgerald et al. (2008).

Bycatch data for the demersal longline groundfish fisheries is summarized here for the time periods before and after streamer use was extensive in the longline fleet (1993–2000 and 2002–06, respectively: Fitzgerald et al., 2008). The average annual bycatch rate in the Alaska demersal longline groundfish fisheries declined from 0.083 birds per 1,000 hooks in 1993–2000 to 0.017 birds per 1,000 hooks in 2002–06 (Fig. 5). The average number of incidental takes in

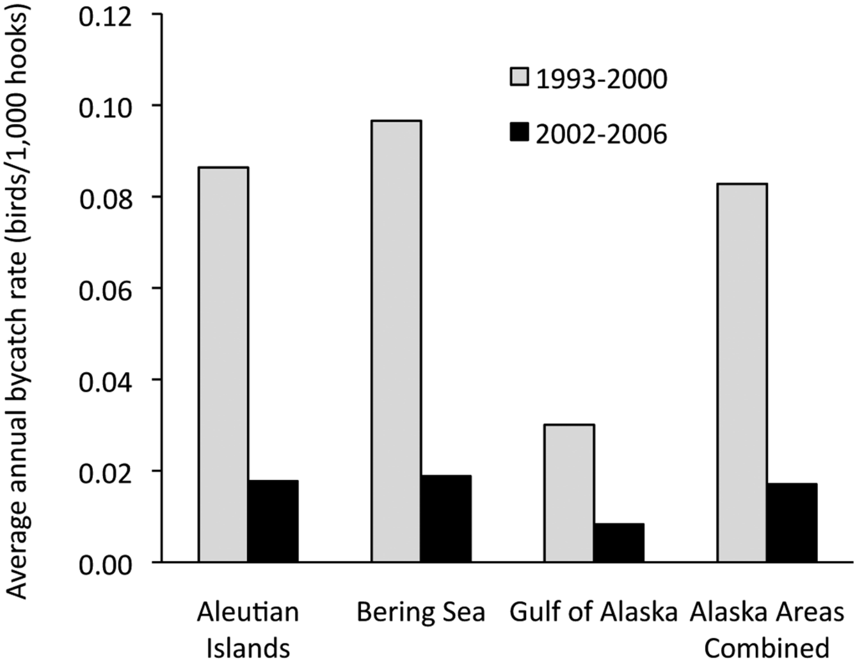

Figure 5.—Annual bycatch rate (birds per 1,000 hooks) in Alaska demersal longline groundfish fisheries, averaged for 1993–2000 and 2002–06.

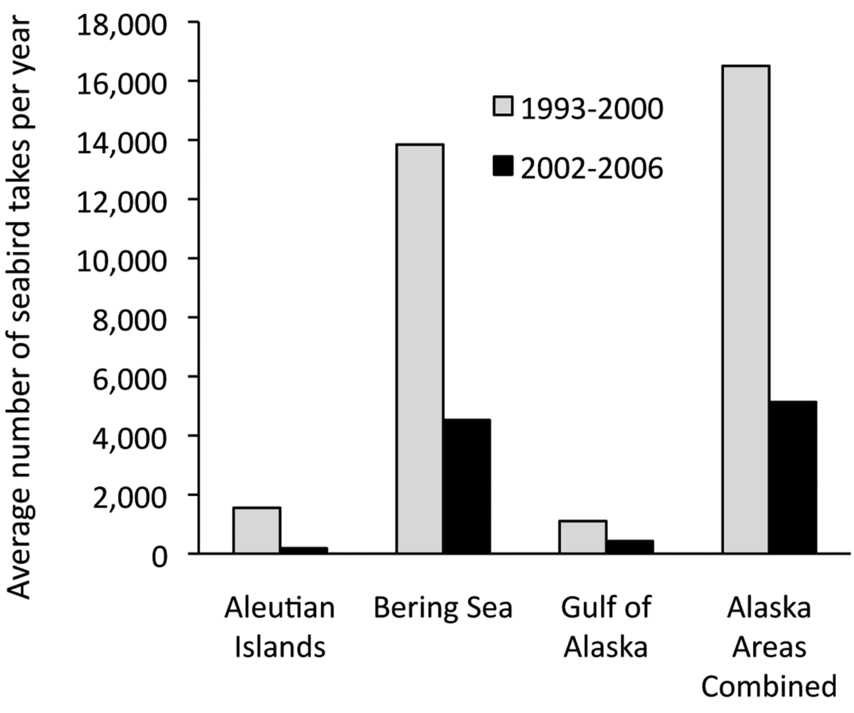

Figure 6.—Annual seabird bycatch in Alaska demersal longline groundfish fisheries, averaged for 1993–2000 and 2002–06.

the Alaska demersal longline groundfish fisheries declined from 16,507 birds per year during 1993–2000 to 5,138 birds per year during 2002–06 (Fig. 6).

Albatross takes (Laysan albatross, *Phoebastria immutabilis*; black-footed albatross, *Phoebastria nigripes*; and short-tailed albatross combined) declined from 1,051 birds per year during 1993–2000 to 185 birds per year during 2002–06 (Fig. 7). The majority of bycatch in the longline fisheries during 2002–06 consisted of northern fulmar, *Fulmarus glacialis* (39%); gulls, *Larus* spp. (39%); and shearwaters, *Puffinus* spp. (8%) (Fitzgerald et al., 2008). Total annual seabird bycatch is a relatively small proportion of the total seabird population in Alaska, which includes an estimated 48 million breeding seabirds in the Bering Sea and Gulf of Alaska and additional seabirds that visit Alaska waters (Fitzgerald et al., 2006).

Short-tailed albatross incidental take limits have not been reached since they were established in 1998. Five incidental takes of short-tailed albatross were documented in the 1990's and occurred in the Bering Sea longline Pacific cod fishery (2 takes), Bering Sea longline sablefish fishery (2 takes), and western Gulf of Alaska longline sablefish, *Anoplopoma fimbria*, fishery (1 take) (USFWS, 2008). No short-tailed albatross takes were reported from 1999 to 2009. In 2010, two short-tailed albatross were taken on observed vessels in the Bering Sea Pacific cod longline fishery. The short-tailed albatross population has increased in recent years at an annual rate of about 6–7% and currently numbers about 2,400 (USFWS, 2008). As the short-tailed albatross population increases, the likelihood of incidental takes may also increase. The take limits could be revised in the future if USFWS determines that this action is warranted.

The majority of seabird bycatch in the North Pacific during 1993–2006 occurred in the longline groundfish fisheries (92%), but bycatch also occurred in the trawl (7%) and pot (1%) fisheries (Fitzgerald et al., 2008). In the trawl fisheries, seabirds are often caught during retrieval of the trawl net.

In addition, seabirds collide with trawl cables and with transducer or "third" wires, which extend from the stern to the head of the trawl net and monitor the net's performance (Wilson et al., 2004; Melvin et al., 2011). Species with large wingspans, such as albatrosses, are particularly vulnerable to collisions with trawl cables and transducer wires (Wilson et al., 2004; Melvin et al., 2011). These mortalities are not systematically monitored by observers in the groundfish fisheries off Alaska and are likely underestimated (Fitzgerald et al., 2008).

To date, no short-tailed albatross mortalities have been observed in the trawl fisheries. However, due to the spatial and temporal overlap between short-tailed albatross and the trawl fisheries, in 2003, the USFWS issued an incidental take limit of 2 short-tailed albatross during the period of time in which the Biological Opinion is in effect (USFWS, 2003). If this limit is reached, NMFS and USFWS could consider raising the take limit or implementing new mitigation measures for trawl gear. Zador et al. (2008) examined the potential impact trawl fisheries could have on the recovery of short-tailed albatross. They determined that as many as 20 birds could be taken with trawl gear during a 5-year period and have little impact on the recovery plan timeline. Researchers are currently focusing on finding ways to reduce the potential for albatross interactions with the trawl fisheries (Melvin et al., 2011).

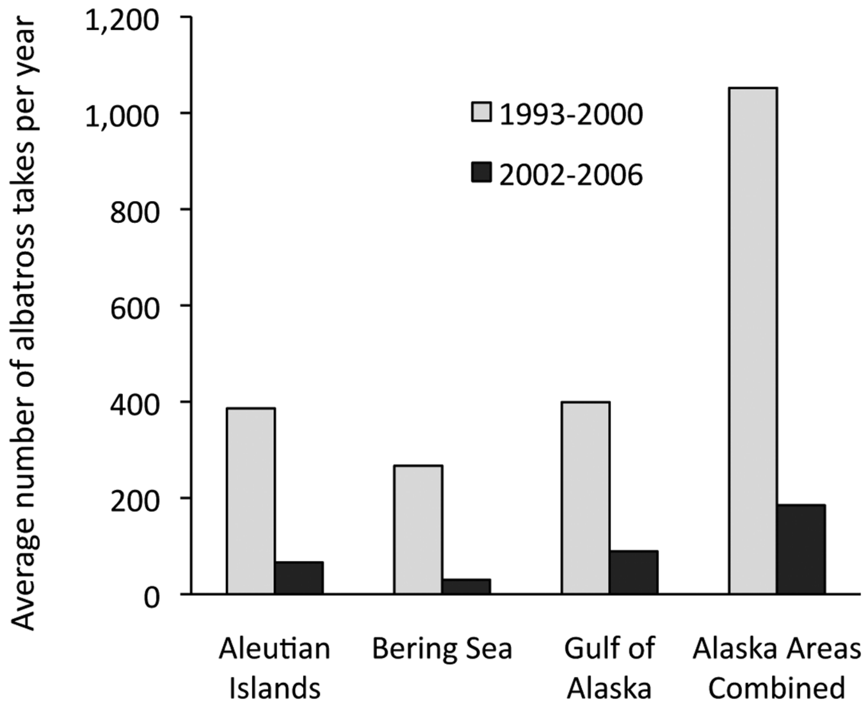

Figure 7.—Annual albatross bycatch in Alaska demersal longline groundfish fisheries, averaged for 1993–2000 and 2002–06.

Precautionary Measures for Species Without Known Fisheries Interactions

North Pacific Right Whale

The endangered North Pacific right whale, *Eubalaena japonica,* is one of the rarest great whale species in Alaska waters, with an estimated 30 individuals recorded in recent surveys (Wade et al., 2011). Most recent sightings have occurred in the southeastern Bering Sea (Wade et al., 2006). This species was once relatively abundant in the North Pacific, but commercial whaling that continued until the late 1960's, including hundreds killed illegally by the Soviet Union in the 1960's, severely depleted the population (Brownell et al., 2001). Visual surveys, historical catch records, and acoustic monitoring indicate that right whales primarily occur in the waters off Alaska during May through December (Brownell et al., 2001; Munger et al., 2008). An analysis of call detection rates found that right whale abundance in the southeastern Bering Sea may peak in July through October (Munger et al., 2008). Wintering areas where calving occurs are unknown, but may be located in more temperate waters (Clapham et al., 2004). Migration routes between feeding and wintering areas are also unknown.

In 2006, NMFS designated critical habitat for the North Pacific right whale in the southeastern Bering Sea and in the Gulf of Alaska southeast of Kodiak Island (NMFS, 2006; Fig. 8). The areas were identified based on an analysis of historical and recent right whale sightings which determined that these were likely important foraging areas (Clapham et al.[1]). Right whales are known to feed in areas with dense aggregations of large copepods, and the areas where most right whales have been sighted recently may support high concentrations of these prey species (Shelden et al., 2005; Clapham et al.[1]).

Fishery-related activities have not been restricted within North Pacific right whale critical habitat because no fisheries target the prey species identified as important to right whales (Shelden et al., 2005; Clapham et al.[1]). Moreover, there are no documented interactions between North Pacific right whales and the fisheries off Alaska (Allen and Angliss, 2011). In contrast, North Atlantic right whales, *Eubalaena glacialis*, are frequently entangled with

[1]Clapham, P. J., K. E. W. Shelden, and P. R. Wade. 2006. Review of information relating to possible critical habitat for eastern North Pacific right whales. *In* K. E. W. Shelden and P. J. Clapham (Editors), Habitat requirements and extinction risks of eastern North Pacific right whales, p. 1–27. U.S. Dep. Commer., NOAA, Alaska Fish. Sci. Cent., AFSC Proc. Rep. 2006-06.

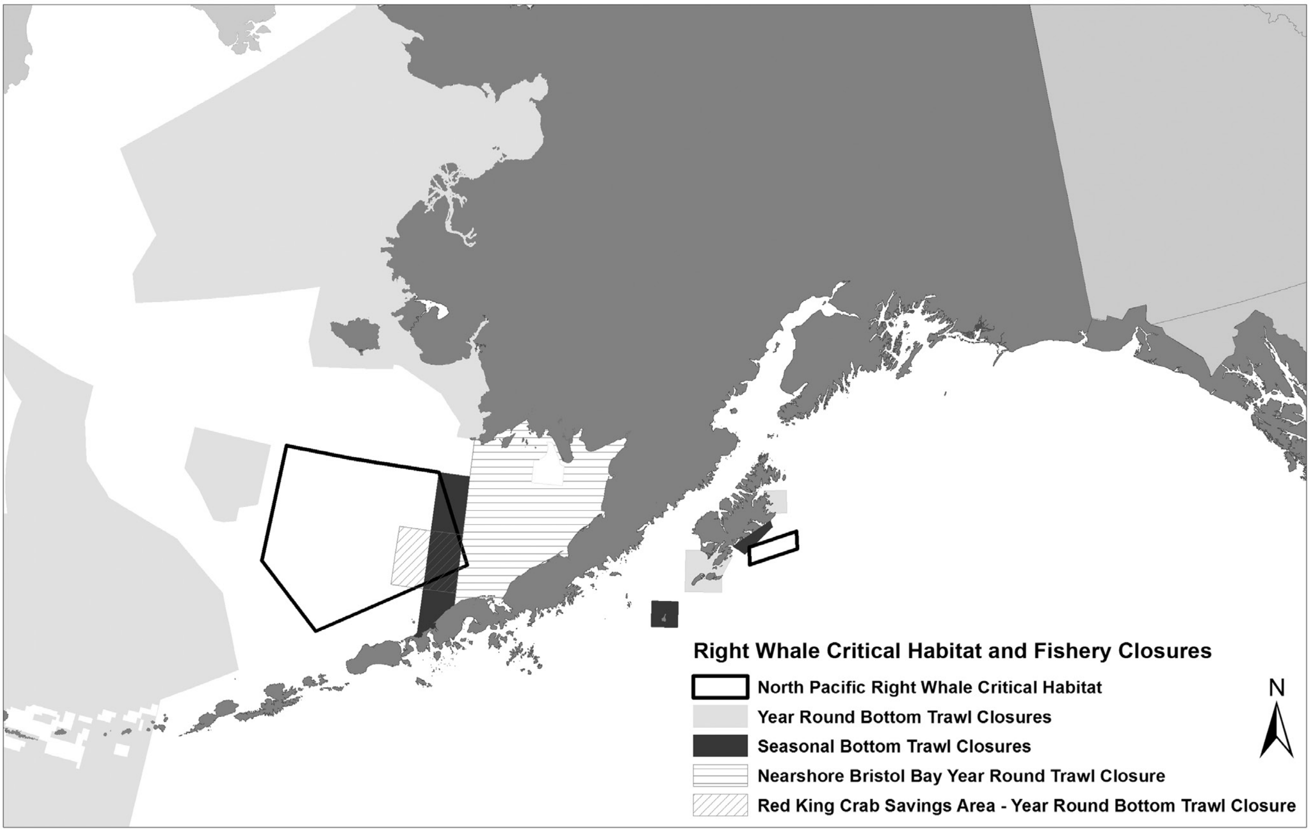

Figure 8.—Right whale critical habitat and fishing closures in the Bering Sea and Gulf of Alaska.

fishing gear, most often with pot gear and to a lesser extent with gill nets (Johnson et al., 2005).

Ship strikes are believed to be the most common anthropogenic cause of mortality of North Atlantic right whales (Knowlton and Kraus, 2001), but have not been documented in the North Pacific. Because of slower speeds, fishing vessels may pose less risk; higher speed cargo or other vessels transiting the Great Circle Route travel well to the south of the North Pacific right whale critical habitat. Large groundfish, crab, and halibut fisheries occur inside the Bering Sea and Gulf of Alaska critical habitat areas (NPFMC, 2005), and the majority of groundfish catches occur inside critical habitat during January through March, when right whales may be less likely to occur in the area (NPFMC, 2005).

However, substantial groundfish catches are also made during summer and fall. Most catches in the Bristol Bay red king crab, *Paralithodes camtschaticus*, fishery, which occurs from 15 October through 15 January, are made within or near the Bering Sea critical habitat area (NPFMC, 2005). The Bering Sea Tanner crab, *Chionoecetes bairdi,* and snow crab, *C. opilio,* fisheries are also prosecuted inside the Bering Sea critical habitat area and open on 15 October, and these fisheries typically remain open until early spring. The timing of the crab fisheries may reduce the likelihood of interactions with right whales, which may be most abundant in Alaska waters during late summer or early fall.

Several marine protected areas overlap with North Pacific right whale critical habitat and may indirectly provide protection to right whales in key foraging areas. In the Bering Sea, right whale critical habitat encompasses 92,282 km^2 (26,905 nmi^2), and partially overlaps or is adjacent to areas closed year-round or seasonally to certain fishing activities to protect red king crab habitat (Fig. 8). The Red King Crab Savings Area (13,713 km^2 or 3,998 nmi^2), established in 1995, is closed year-round to bottom trawling and dredging. The Nearshore Bristol Bay Trawl Closure Area (65,398 km^2 or 19,067 nmi^2), established in 1997, is closed year-round to all trawling except for a small area open from 1 April to 15 June. In addition, other areas in the Bering Sea are closed seasonally to all trawling (15 March through 15 June) to protect red king crab while they are molting.

In the Gulf of Alaska, right whale critical habitat 3,042 km^2 (887 nmi^2) is adjacent to several bottom trawl closures designated to protect red king crab habitat. In addition, the Gulf of Alaska critical habitat area overlaps areas where observer coverage requirements were recently augmented to improve monitoring of Tanner crab bycatch (NPFMC, 2010f).

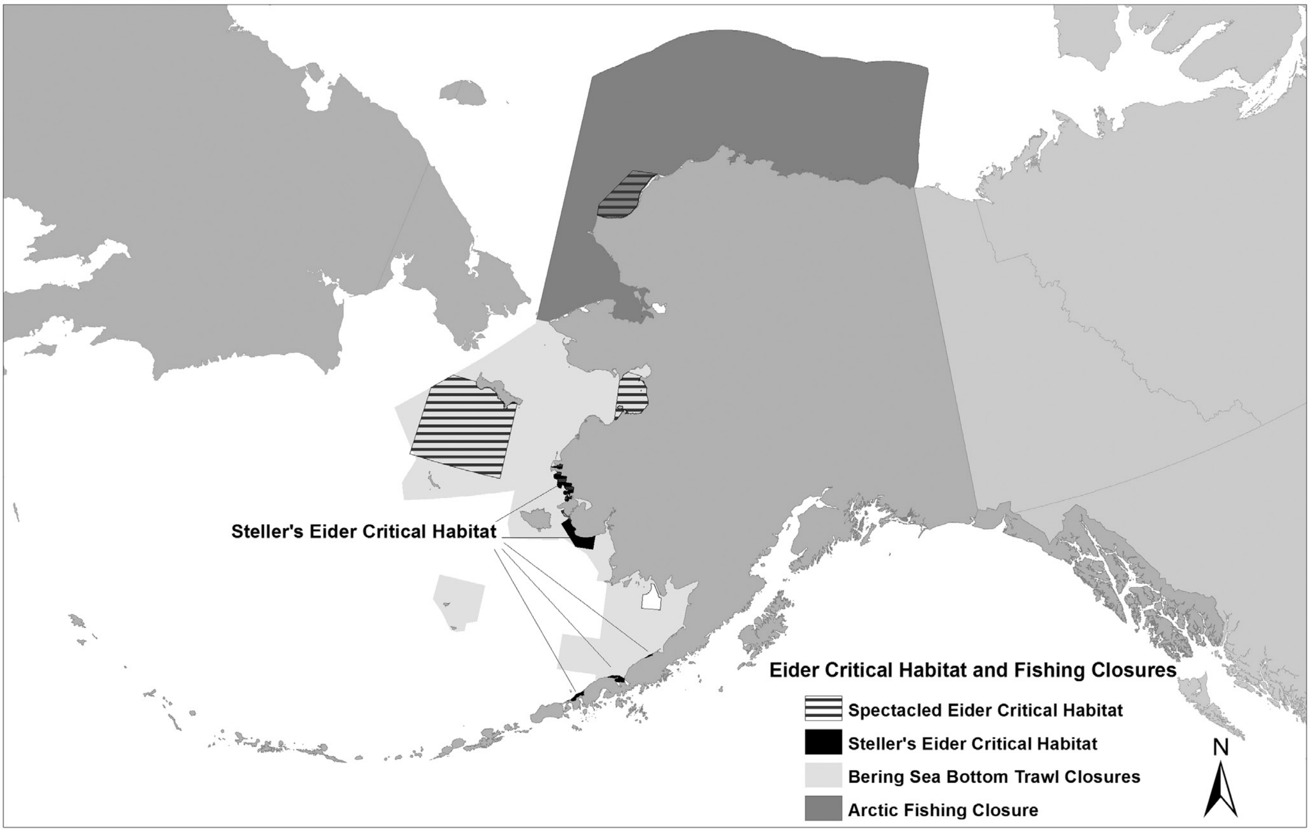

Figure 9.—Steller's eider and spectacled eider critical habitat and fishing closures off Alaska.

Vessels bottom trawling in the designated areas will be required to have 100% of fishing days observed and vessels using pot gear will be required to have 30% of fishing days observed, which increases the likelihood that any adverse interactions with fishery activities will be documented (NPFMC, 2010f).

Spectacled and Steller's Eiders

Spectacled eiders, *Somateria fischeri*, occur in marine waters during most of the year and were listed as threatened by the USFWS in 1993 following a large decline in the western Alaska breeding population. In 2001, the USFWS designated several areas in the Bering Sea as critical habitat for spectacled eiders (USFWS, 2001a; Fig. 9). In winter, spectacled eiders are found in large, concentrated flocks in areas where openings in the sea ice have formed (Peterson et al., 1999; Lovvorn et al., 2003). The only wintering site known was discovered in the 1990's and is located in a persistently-formed polynya in the Bering Sea south of St. Lawrence Island (Peterson et al., 1999). This site is designated as critical habitat (USFWS, 2001a). In the wintering area, spectacled eiders dive up to 70 m and feed on clams, primarily *Nuculana radiata* (Lovvorn et al., 2003).

Steller's eiders, *Polysticta stelleri*, also occur primarily in marine waters and were listed as threatened by USFWS in 1997 due to a long-term decline of the breeding population in Alaska. Several nearshore areas in the Bering Sea and Aleutian Islands are designated as critical habitat for Steller's eiders (Fig. 9; USFWS, 2001b). The seasonal distribution and diet of Steller's eiders is described in detail in the Steller's Eider Recovery Plan (USFWS, 2002). Steller's eiders use shallow bays and lagoons along the Alaska Peninsula in the fall when they are molting. In winter, Steller's eiders occur in nearshore areas along the Alaska Peninsula, the Aleutian Islands, Kodiak Island, and Cook Inlet. In spring, large concentrations of Steller's eiders use shallow bays along the Alaska Peninsula as staging areas before migrating to nesting grounds. While in marine waters, Steller's eiders feed on benthic invertebrates, and diet varies depending on the site.

No incidental takes of spectacled or Steller's eiders have been recorded in the groundfish fisheries (Fitzgerald et al., 2008). Bottom trawling has the potential to disturb benthic habitat used by foraging spectacled and Steller's eiders (NPFMC, 2007). In 2007, the Council took final action to close large areas in the Bering Sea to bottom trawling, and the closures overlap with Steller's and spectacled eider critical habitat (NPFMC, 2007; Fig. 9). In addition, the Council closed the Arctic Management Area to fishing in 2009, and this closure overlaps with spectacled eider critical habitat (NPFMC, 2009a; Fig. 9). Some bottom trawling has occurred in the past in spectacled eider critical habitat in the Bering Sea. The extent of this activity is documented in NPMFC (2007).

Bottom trawling has also occurred to a limited extent in Steller's eider critical habitat in the Yukon-Kuskokwim shoals, primarily by vessels targeting yellowfin sole (NPFMC, 2007). Because fishing effort in these areas was limited, the economic impact of the bottom trawling closures is considered minimal (NPFMC, 2007) but these closures consider possible shifts in fishing effort northward if climate change continues to favor movement of target fish species northward. This was a precautionary measure taken by the Council that may not provide an immediate, tangible benefit, because fishing effort was low in these areas.

Polar Bears

Polar bears are listed as threatened under the ESA, and in 2009 the USFWS designated critical habitat for polar bears (USFWS, 2010). The designated area does not overlap with any existing commercial fisheries, and there have been no documented interactions between polar bears and the commercial fisheries (Allen and Angliss, 2011). Nearly all of the area designated as critical habitat for polar bears was recently closed by the Council to any commercial fishing as part of the Arctic Fishery Management Plan (Wilson and Ormseth, 2009).

Potential Future Issues

In addition to the actions described above, the Council monitors developments in the management status of other marine mammal and seabird species that are listed under the ESA or have the potential to be listed in the future. For example, in 2008 the southwest DPS of northern sea otters, which ranges from Kodiak west to the Aleutian Islands, was listed as threatened under the ESA. In 2009, the USFWS designated critical habitat for the southwest DPS of sea otters (USFWS, 2009). The designated area does not overlap with any existing commercial fisheries managed by the Council, and no significant restrictions on fishery-related activities are anticipated, but the consultation process continues to be monitored by the Council.

The Cook Inlet DPS of beluga whales, *Delphinapterus leucas*, is listed as endangered under the ESA, and more than one-third of Cook Inlet has been identified as critical habitat (NMFS, 2011). The population declined from an estimated 1,300 whales in the 1960's (NMFS, 2008b) to approximately 340 whales in 2010. Interactions with commercial fisheries have not been identified as a primary reason for the population decline (NMFS, 2008b). This population of beluga whales is not believed to range outside of Cook Inlet, and the whales are not likely to occur in areas where groundfish fisheries are prosecuted (NMFS, 2008b). There are no documented fishery-related mortalities of Cook Inlet belugas (Allen and Angliss, 2011). However, the groundfish fisheries may have indirect effects on the availability of prey species important to beluga whales, such as Chinook salmon, *Oncorhynchus tshawytscha* (NPFMC, 2009b). In recent years, high levels of Chinook salmon bycatch in the Bering Sea and Gulf of Alaska groundfish fisheries have been closely monitored and managed by the Council and NMFS (NPFMC, 2009b).

Northern fur seals, *Callorhinus ursinus*, range throughout the North Pacific and overlap in distribution with the commercial fisheries off Alaska. Northern fur seals spend the majority of the year foraging in the open ocean and breed during summer months at only a small number of locations. The majority of fur seals breed on the Pribilof Islands in the Bering Sea, and a small breeding population occurs on Bogoslof Island (NMFS, 2007).

Northern fur seal numbers have declined to less than half of population levels in the 1950's (NMFS, 2007). Pup production on the Pribilof Islands declined by more than 50% from 1975 to 2004 (Towell et al., 2006). The species is designated as depleted under the MMPA, but is not listed as threatened or endangered under the ESA. To date, the Council has not taken any direct actions to mitigate any potential effects of fishery-related activities on northern fur seals. A conservation plan was prepared by NMFS that identifies possible causes of the population decline and outlines potential measures to reduce any adverse anthropogenic impacts on northern fur seals (NMFS, 2007). NMFS continues to examine trends in pup production and investigate possible interactions between fur seals and commercial fisheries.

The USFWS has completed a status review to determine whether to recommend listing black-footed albatross as threatened or endangered under the ESA because of conservation concerns, many of which are summarized in Naughton et al. (2007). On October 6, 2011, the USFWS determined that listing this albatross was not warranted based on the best available scientific and commercial information available on the condition of this species' habitat, the importance of disease and predation, the utilization of this species for scientific and commercial purposes, and other factors (USFWS, 2011). The population of black-footed albatross consists of approximately 61,700 breeding pairs (Arata et al., 2009). Incidental takes in the pelagic and demersal longline fisheries in the North Pacific are the largest source of human-caused mortality (Arata et al., 2009). Fisheries bycatch may be impacting the long-term population viability of black-footed albatross (Lewison and Crowder, 2003; Veran et al., 2007). The majority of bycatch occurs in the pelagic longline fisheries in the central North Pacific Ocean (Lewison and Crowder, 2003; Arata et al., 2009). Bycatch in the demersal longline fisheries off Alaska (<100 birds per year; Fitzgerald et al., 2008) is much less than the estimated take in the pelagic longline fisheries (5,000–6,000 birds per year; Arata et al., 2009).

In Alaska waters, satellite-tagged black-footed albatross overlap spatially and temporally with the longline sablefish, pot sablefish, and longline halibut fisheries (Fischer et al., 2009). Based on observer data, incidental takes of black-footed albatross in Alaska waters occurred primarily in the longline sablefish fishery (83% of takes), the longline Pacific cod fishery (15% of takes), and the longline halibut fishery (2%) (Fitzgerald et al., 2008), but only a small proportion of the halibut fishery is observed. The majority of these takes were recorded in the Gulf of Alaska, where 75 black-footed albatross were taken per year from 2002 to 2006. If the black-footed albatross is listed under the ESA in the future, incidental take statements could potentially be issued by USFWS to limit bycatch in the commercial fisheries off Alaska.

Discussion

For over 30 years, the Council, working closely with the NMFS Alaska Region and NMFS Alaska Fisheries Science Center, has developed and implemented proactive and precautionary management policies consistent with an ecosystem-based approach, resulting in sustainable fisheries with minimal environmental impacts (Witherell et al., 2000; NMFS, 2004, 2005). These conservation policies, developed through a scientifically based, transparent, and deliberative process, have resulted in healthy and profitable fisheries (Witherell and Peterson, 2011). Fish stocks and protected species have directly benefited from the ecosystem-based approach, and the good socioeconomic conditions for the fishery make it easier to develop and implement precautionary measures for protected species.

The Council's approach to managing fisheries interactions with protected species has been adaptive and accounts for multiple management objectives. Management measures have been tailored depending on the nature of interactions with the fisheries, incorporating economic trade-offs to allow measures to be practical while still providing conservation for protected species. In balancing objectives, managers take into account the relative costs to the fishery, potential benefits to protected species, effects on communities, legal requirements, and the scientific uncertainty about the magnitude and direction of adverse effects due to fisheries.

In instances where the interaction is known or scientific information suggests such an interaction may exist, gear requirements or marine protected areas have been established to mitigate these interactions. Seabirds are primarily impacted by bycatch in the longline fisheries, and management measures have focused on reducing adverse encounters with longline fishing gear. Incidental takes do not pose a significant threat to any of the North Pacific marine mammal stocks, in contrast with fisheries elsewhere. Pacific walrus are impacted by vessel activity near coastal haulouts, and area closures around designated sites are intended to reduce such disturbances. Fishery-related impacts to Steller sea lions have been addressed through fishery closures around rookeries and haulouts, seasonal distribution of catch limits, and limits on catches in key foraging areas.

In the absence of scientific information, the Council has taken precautionary actions to address protected species concerns if the scientific consensus is that such action may be prudent. For example, the Council required fishing vessels to stay away from sensitive benthic habitat areas where Pacific walrus, spectacled eider, and Steller's eider are known to forage. Similarly, the Council's decision to close U.S. waters in the Arctic to commercial fisheries is a risk-averse management approach (Stram and Evans, 2009; Wilson and Ormseth, 2009).

In several cases, the Council has examined potential interactions between the groundfish fisheries and other marine mammal and seabird species, but has not taken any direct action to restrict fishing activities when there has been no evidence that adverse interactions with the fisheries exist. The biological opinions for all species that are listed under the ESA are periodically updated. As new information becomes available regarding the status of the species or their interactions with the fisheries, the Council may develop new management measures or modify existing regulations.

Currently, there is little scientific information available to evaluate the effectiveness of the management measures adopted by the Council and NMFS, with the exception of the seabird avoidance measures. While the Council's high level of at-sea observer coverage on most commercial fishing vessels contributes important data on fishery interactions with protected species, this remains an important research gap that has been discussed extensively by the Council and will likely be addressed as new measures are developed (Witherell, 2004, 2005)

Throughout the United States and in many other countries of the world, the effects of fisheries on marine mammals, seabirds, and other species are a serious concern. Based on the experience in Alaska, a precautionary ecosystem-based approach to fisheries management can address these concerns as information becomes available.

Although mitigating impacts due to fishing may not be a panacea for a species in decline if environmental conditions or other factors are involved, it can at least reduce effects due to fisheries. In the future, ecosystem modeling tools that are being developed for the North Pacific Ocean should improve our understanding of the factors that affect populations of protected species and the relative impacts due to fisheries (Hollowed et al., 2011). Because the management program in the North Pacific is science-based and adaptive, we would anticipate that fishery managers will respond accordingly.

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