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Considerations for Research Planning in the Northern Bering Sea Research Area

Prepared by

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For

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Summary

As a changing climate warms waters of the North Pacific and changes the timing of the ice cover in the northern Bering Sea, an ecosystem shift is expected that may extend the distribution of crab and fish populations northward into the subarctic Regions. In anticipation of commercially important stocks shifting northward, the North Pacific Fishery Management Council (Council) established the Northern Bering Sea Research Area (NBSRA) in 2008. This area is closed to nonpelagic (bottom) trawling pending understanding of its impacts on the near-pristine ecosystem. The National Marine Fisheries Service (NMFS) Alaska Fisheries Science Center (AFSC) was charged with developing a Research Plan to investigate the impacts of nonpelagic trawling in the NBSRA.

The remoteness, harsh climate and extended periods of ice cover in the NBS have long deterred commercial fishing. Historically, there has been very low levels of nonpelagic trawling and consequently almost no knowledge of fisheries potential, benthic habitat, and trawl impacts. In 2010, funded by the NOAA Loss of Sea Ice (LOSI) program to understand the impacts of ocean warming on the ecosystem, the AFSC annual summer bottom-trawl survey in the eastern Bering Sea was extended into the NBS. Survey results indicate that essentially the only groundfish species with any commercial nonpelagic fishery potential in the NBS is the yellowfin sole *Limanda aspera*. Recent data also cast doubt on whether and which groundfish species might migrate northward, and revealed high uncertainty in predicting ecosystem trends.

The AFSC held a NBSRA Research Plan Community and Subsistence Workshop in February 2010 and a Science Workshop in January 2011 in Anchorage, Alaska to solicit input from the NBS Native Alaskan communities, scientists, fishing industry, conservation groups, government agencies, and other stakeholders. The Native Alaskan communities generally opposed opening the NBSRA to commercial nonpelagic trawling for fear of impacts to subsistence species. The fishing industry indicated that there is currently no urgent desire to move in the NBS. Scientists and conservationists cautioned disturbance to protected resources and the environment.

Upon review of research data, the outcome of the workshops, and a draft Research Plan presented by the AFSC in June 2011, the Council decided to suspend development of a NBSRA Research Plan. Instead, the Council requested that the AFSC prepare a document compiling background information on the NBS ecosystem, bottom-trawl impacts, outcomes of the workshops, and some discussion on the feasibility of trawl impact studies in the existing Modified Gear Trawl Zone (MGTZ).

This is the document in response to the Council's request. This document summarizes the best available information on the NBS ecosystem that are relevant to planning research on nonpelagic trawl impacts in the NBSRA. The NBS ecosystem is driven mainly by sea-ice climatology and benthic productivity. As climate changes, the ecosystem is also undergoing large-scale shifts in the location, timing, magnitude, and mode of production. The most obvious resources of concern are protected and subsistence species, which ultimately depend on benthic prey sources. This document identifies the habitat and prey of the main species of concern, which include cetaceans, ice-associated seals, Steller

sea lion, Pacific walrus, crabs, salmon, and seabirds. The impacts of nonpelagic trawling on these species are largely unknown.

The National Science Foundation's Bering Sea Ecosystem Study (BEST, 2007 – present) and the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Program (BSIERP, 2008 – present), and AFSC's 2010 bottom trawl surveys are the most recent research programs in the NBS. Results from these programs indicate that few species are present in the NBS with the abundance and distribution to be of commercial interest. Although the snow crab *Chionoecetes opilio* were abundant in patches in the NBS, their sizes were too small to be of commercial value. Yellowfin sole appears to be the only species with commercial potential. The density was highest southeast of St. Lawrence Island. However, it is difficult to predict where commercial bottom-trawling may occur because bottom-trawl operations depend on many economic and logistic factors.

The principles and design of trawl impacts studies are presented. Before-After-Control-Impact (BACI) experiments, where changes in the benthic habitat and fauna are examined before and after trawling to test for short-term (acute) impacts, are suitable in the NBSRA. The study area should be placed according to resource-management needs for the area. The duration of the BACI experiments from design to execution to analysis is expected to be five or more years. If commercial trawl fisheries do develop, the cumulative (chronic) effects of bottom-trawling disturbances could eventually be examined through a judicious use of closed- and open-area boundaries (e.g. the MGTZ). Modified bottom-trawl gear is mandatory for use in the MGTZ, and will eventually be used throughout the Bering Sea. The modified gear elevates the footrope of the net higher above the seafloor, thus reducing contact with the seafloor and damage to the non-target benthic fauna. Since the history of contemporary fisheries and ecosystem research in the NBS is relatively short and the components of the ecosystem are many and complexly linked, discerning bottom-trawl impacts on the NBS ecosystem will require substantial commitment in time and resources.

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1. The Northern Bering Sea Research Area – a synopsis

As a changing climate warms waters of the North Pacific and changes the timing of the ice cover in the northern Bering Sea (NBS), an ecosystem shift is expected that may extend the distribution of crab and fish populations northward into the subarctic regions. As commercially important species shift northward, it is expected that commercial nonpelagic (bottom) trawlers will also begin to look northward to access these populations. Nonpelagic trawlers primarily target flatfishes (e.g. yellowfin sole, rock sole, arrowtooth flounder) but may also target other groundfish species (e.g. Pacific cod). Nonpelagic trawls may directly impact benthic habitat and communities, and effects may propagate to higher trophic levels, the pelagic environment, and to human communities dependent on marine resources for commercial or subsistence needs. Historically, there have been very low levels of nonpelagic trawling in the NBS, and there is currently very little data available about the NBS habitats or the potential impacts of nonpelagic trawling on bottom habitats or community ecology in the NBS.

The North Pacific Fishery Management Council (Council) passed Amendment 89 to the Bering Sea and Aleutian Islands (BSAI) Groundfish Fisheries Management Plan (FMP) in 2008. The Amendment established the Northern Bering Sea Research Area (NBSRA), and closed the area to nonpelagic trawling pending the results of research designed to investigate the potential impacts of nonpelagic trawling on the habitats and communities of the NBS. The Council charged the Alaska Fisheries Science Center (AFSC) of the National Marine Fisheries Service (NMFS) with developing a research plan for nonpelagic trawl impact studies.

At the June 2011 Council meeting, the Council received a progress report and research plan outline from the AFSC, and heard considerable public testimony from tribal organizations and members of the public. Based on this report and public testimony, the Council suspended work on the research plan. It instead requested the AFSC to compile background information on the environment, ecology and fisheries of the NBSRA in a discussion paper. The information is intended to be used in reevaluating the feasibility and need to continue developing a research plan. This paper is the response to the request.

History of the NBSRA

In 2005, NMFS and the Council completed an Environmental Impact Statement (EIS) for Essential Fish Habitat (EFH) Identification and Conservation in Alaska. The EFH EIS provided a thorough analysis of alternatives and environmental consequences for amending the Council's FMPs to include EFH information pursuant to Section 303(a)(7) of the Magnuson-Stevens Fishery Management and Conservation Act (MSA) and 50 CFR 600.815 (a). Specifically, the EFH EIS examined three actions:

(1) Describing and identifying EFH for Council managed fisheries,
(2) Adopting an approach to identify Habitat Areas of Particular Concern (HAPC) within EFH, and
(3) Minimizing to the extent practicable the adverse effects of fishing on EFH.

The Council's preferred alternatives from the EFH EIS are implemented through Amendments 78/65 and 73/65 to the Gulf of Alaska (GOA) and BSAI groundfish FMPs, respectively, Amendments 16 and 12 to the FMP for BSAI king and tanner crab, Amendments 9 and 7 to the scallop FMP, and Amendments 7 and 8 to the salmon FMP. A Record of Decision was issued on August 8, 2005. NMFS approved the amendments on May 3, 2006. Regulations implementing the EFH/HAPC protection measures were effective July 28, 2006 (71 FR 36694, June 23, 2006). The Final EIS is found on the NMFS Alaska Region (AKR) website at http://www.alaskafisheries.noaa.gov/habitat/seis/efheis.htm.

The EFH EIS concluded, based on the best available scientific information at the time, that the effects of fishing activities in the Bering Sea on EFH are minimal because the analysis found no indication that fishing activities at the current rate and intensity would alter the capacity of EFH to support healthy populations of FMP managed species over the long term. The analysis also concluded that cumulative impacts from fishing activities on EFH are minimal, but not necessarily temporary. Therefore, rather than identify measures to conserve habitat in the Bering Sea, the Council initiated a more detailed examination of reasonable alternatives and options for addressing EFH in the Bering Sea.

In December, 2005, the Council and its Scientific and Statistical Committee (SSC) and Advisory Panel (AP) received a report from Council staff on a proposed problem statement and preliminary alternatives drawn from the EFH EIS. Public input was also provided at the Council, SSC, and AP meetings. The conversation in the Council focused on an "open area" concept wherein the location of recent nonpelagic trawl effort delineated areas that would remain open to trawling. The concept was based on the principle that the first trawl in an area was most impactful and that subsequent trawls had incrementally less impact. Thus, closing areas to trawling that had not yet been trawled was the most conservative action, and leaving areas that had previously been trawled open to trawling minimized economic impacts to the fleet. Throughout 2006 and the first half of 2007, the Council continued to review and modify methods to identify a northern boundary for the open area in the Bering Sea.

At the June 2007 meeting, the Council reviewed a final draft Environmental Assessment/Regulatory Impact Review/Initial Regulatory Flexibility Analysis (EA/RIR/IRFA). The Council adopted a preferred alternative and options for further analysis that comprised an open area approach, modified gear requirements for all nonpelagic trawl gear used in flatfish target fisheries in the Eastern Bering Sea, and establishing a Northern Bering Sea Research Area (NBSRA) (Fig. 1.1).

In September 2010, Amendment 94 to the BSAI FMP required modified trawl sweeps to elevate them off the seafloor, revised the boundaries of the NBSRA and established a Modified Gear Trawl Zone (MGTZ), an area of the NBS which will be re-opened to nonpelagic trawling following implementation of gear modification requirements for flatfish fishing (Fig. 1.1).

NBSRA Research Plan

The preferred option for the NBSRA also required the development of a management plan for Council review. The plan should identify areas where nonpelagic trawl fishing is allowed, pursuant to a scientific research plan. The Council requested that the AFSC design an adaptive management experiment in the closed northern area to study "the effects of nonpelagic trawl gear in previously untrawled areas. The study should include open and closed areas and appropriate monitoring to study fishing impacts on benthic communities and ecological process, particularly as this relates to juvenile snow crab (*Chionoecetes opilio*). In these open areas, control closures will be established based on representative habitats needed to allow scientifically valid comparisons of the effect of nonpelagic trawl fishing. Access to the NBSRA by operations fishing nonpelagic trawls will be established once the protection measures and control areas … are delineated in regulations."

In April 2009, scientists from the AFSC held a public meeting in Anchorage, AK to explain the approach that AFSC was using to develop the NBSRA research plan and a tentative schedule for Council action. AFSC scientists also presented the information at the June 2009 Council meeting, and presented a timeline for proposed research. According to the June 2009 proposed research timeline, two or more annual bottom trawl surveys would be conducted in the first few years to characterize pre-disturbance habitat conditions and the variability under those conditions. These data would be analyzed to design a Before-After-Control-Impact (BACI) experiment to detect effects of trawling, and to characterize the spatial structure of the invertebrate communities as a basis for studying representative types. In years 4-5+, a series of replicate BACI studies would take place to investigate the effects of bottom trawling on distinct invertebrate communities and to better understand the linkages between NBSRA habitats and managed fish stocks.

In February 2010, the AFSC and the Council hosted a Community and Subsistence Workshop in Anchorage, AK to gather input from subsistence fishing communities for the development of the NBSRA research plan. Specifically, the AFSC and the Council wished to gather information to delineate areas of subsistence harvest and habitat of subsistence marine species in the NBSRA, understand the nature of subsistence activities, register community concerns about the potential impacts of commercial bottom trawling, and collect local and traditional ecological knowledge of the NBSRA. At that meeting, community and tribal members recommended that NMFS foster ongoing participation and communication with affected communities and tribes, and that they conduct an outreach effort in the communities throughout the development of the NBSRA research plan. The community and tribal representatives generally supported a position for the least amount of disturbance possible in the NBSRA, and opposed any commercial bottom trawling in the NBSRA and research trawl surveys by the AFSC. They also supported a slower process to develop the research plan.

In March 2010, NMFS staff also traveled to Unalakleet, AK to formally consult with tribal representatives from Unalakleet, St. Michael, Stebbins, Shaktoolik, Koyuk, King Island, Elim, Savoonga, Gambell, and Nome. At that meeting, tribes recommended, among other things not related to the NBSRA, that NMFS postpone planned 2010 bottom trawl research in the NBSRA, and that no commercial bottom trawling should expand northward into the NBSRA. NMFS responded with a March 26, 2010 letter, wherein NMFS explained that the trawl surveys were designed to support NMFS needs to monitor changes in the Bering Sea related to the effects of climate change and the potential loss of seasonal sea ice, that the surveys were not new, and would only impact a negligible proportion of the NBS area. The 2010 surveys took place in July and August 2010, as planned.

At the June 2011 Council meeting, the AFSC presented a draft NBSRA research plan. The plan called for an experimental design that would compare conditions in experimental corridors before and after trawling. The primary research questions to be addressed were:

(1) Do bottom trawl have measureable and statistically significant effects, and
(2) If effects are identified, does the affected area recover to its original condition in the absence of fishing?

The plan included a research summary and timeline that called for preliminary surveys in the first few years, initial analyses to determine the design of subsequent trawl experiments, trawl impact experiments, and ecological studies to assess the impacts of the experimental trawling.

Also at the June 2011 Council meeting, the AFSC presented preliminary results of the 2010 bottom trawl research survey in the NBS. The main, pertinent result was the absence of a sufficient quantity of fish species of interest to commercial bottom trawling in the NBS, and not likely to be in the near future. Bottom trawling industry representatives testified that they came to the same conclusion after reviewing the scientific evidence and from the experience of their own fleet. The Council also heard considerable public testimony from tribes and members of communities adjacent to the NBSRA expressing concern about the research plan and the desire for more community engagement and inclusion in the development of a research plan. Therefore, the Council chose to suspend work on the research plan, and requested a discussion paper to compile background information on the NBSRA which would allow the Council to reevaluate the feasibility and need to continue with developing a research plan. The Council requested that the paper provide a review of information on the NBS ecosystem, previous and ongoing relevant research in the NBS, studies on chronic and acute effects of bottom trawling, and outcomes of the 2010 and 2011 science and community/subsistence workshops. The Council also requested that the paper address whether, and to what extent, trawl impact studies could be conducted in the Modified Gear Trawl Zone, adjacent to the NBSRA, and to categorize areas within the NBSRA that are likely to be of interest for commercial trawling. The Council motion reads:

> *The Council requests a compilation of background information on the northern Bering Sea ecosystem, previous and ongoing relevant research in the northern Bering Sea, chronic or acute effects of bottom trawl studies, and outcomes of the 2010 and 2011 science and community and subsistence workshops.*
>
> *This background should be put into a white paper, along with a description of the areas within the NBSRA likely to be attractive in the future to commercial trawling interests, in order to help focus any subsequent outreach to, and input from, northern Bering Sea communities.*
>
> *The white paper should also provide some discussion of the feasibility of conducting additional research into the acute and chronic effects of trawling in the northern Bering Sea region in the existing Modified Gear Trawl Zone.*
>
> *This is not a high priority, nor does it need to result in subsequent action.*

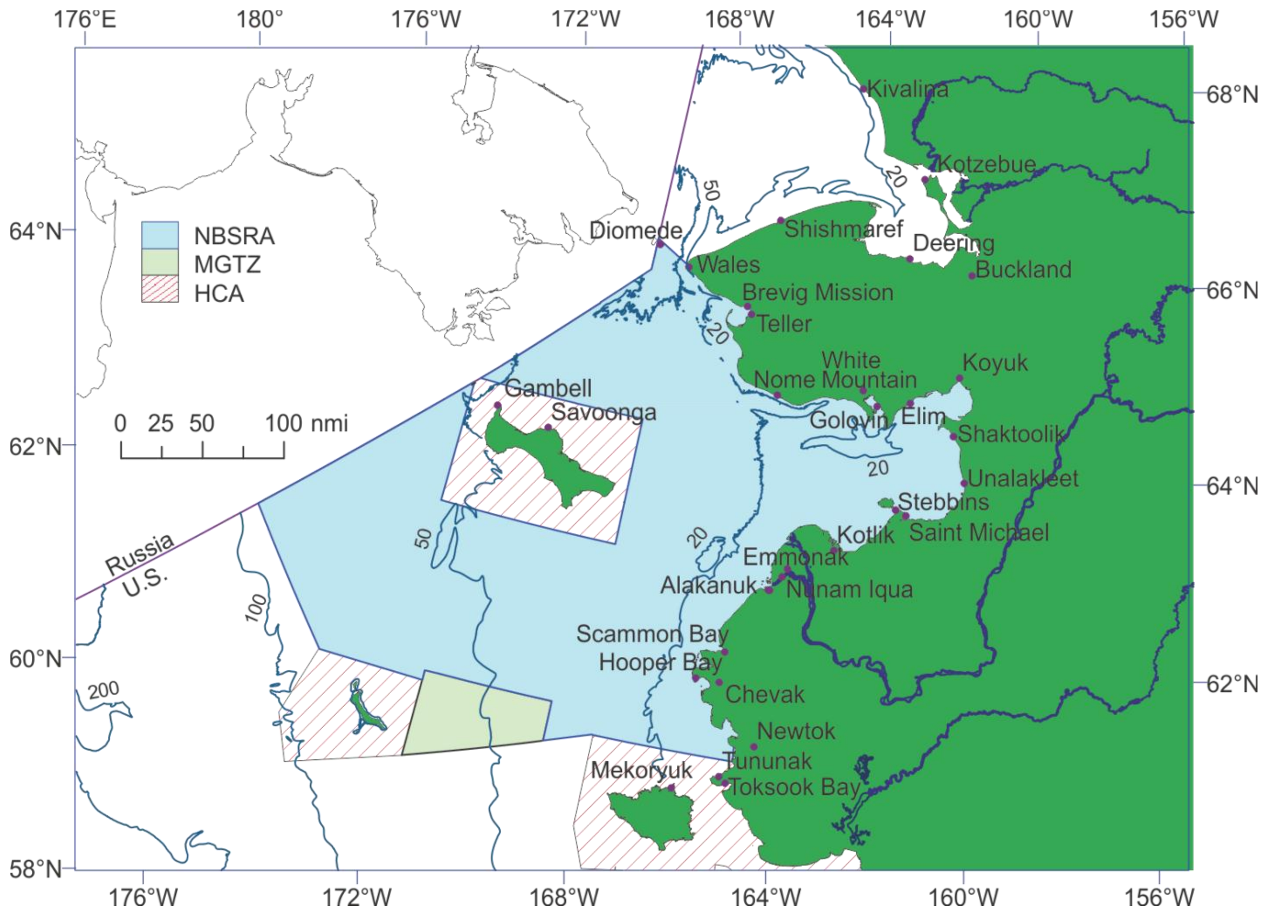

Figure 1.1. The Northern Bering Sea Research Area (NBSRA) and bordering communities, Modified Gear Trawl Zone (MGTZ), and adjacent Habitat Conservation Areas (HCA).

2. Human communities

A total of 22 communities border the NBSRA, from Newtok in the south to Wales in the north, and the communities of Gambell and Savoonga on St. Lawrence Island and Diomede on Little Diomede Island (Fig. 1.1). A list of communities and their populations according to the 2000 and 2010 census are shown in Table 2.1.

The economies of most of the communities that border the NBSRA are dominated by subsistence activities and seasonal employment opportunities. Commercial fishing and seasonal construction and firefighting jobs provide cash income to many of the residents of these communities. Fish processing plants are located in Hooper Bay, Emmonak, Kotlik, Unalakleet, and Golovin. Trapping for fur bearing mammals (fox, wolf, wolverine) also supplements seasonal employment. Subsistence activities occur year round in most villages, and harvests include salmon and other fish, crab, seal, walrus, beluga whales, bowhead whales, gray whales, clams, waterfowl, land birds, moose, caribou, reindeer, rabbit, berries, and roots. Socioeconomic details for each village are available on the State of Alaska Department of Commerce, Community, and Economic Development website at http://www.commerce.state.ak.us/dca/commdb/CF_COMDB.htm.

The Bering Sea Elders Advisory Group (http://www.beringseaelders.org), with support from the Alaska Marine Conservation Council (AMCC), published a report on native Alaskan culture, traditional knowledge, and subsistence activities in the NBS, including maps of subsistence species habitats and areas of subsistence usage (Bering Sea Elders Advisory Group 2011). The report establishes the high stakes held by native Alaskans in the health of the environment and resources in the NBS. It also reflects the communities' concern that the potential movement of nonpelagic trawling and industrial fisheries into the NBS may threaten the traditional subsistence way of life.

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Table 2.1. Communities bordering the NBSRA.

Community	Population	
	2000	2010
Chevak	765	966
Hooper Bay	1,014	1,137
Scammon Bay	465	474
Nunam Iqua	164	187
Alakanuk	652	677
Emmonak	767	762
Kotlik	591	577
St. Michael	368	401
Stebbins	547	556
Unalakleet	747	688
Shaktoolik	230	251
Koyuk	297	332
Elim	313	330
Golovin	144	156
White Mountain	203	190
Nome	3,505	3,598
Teller	268	229
Brevig Mission	276	388
Wales	152	145
Diomede	146	115
Gambell	649	681
Savoonga	643	671
Newtok	321	354

3. Environment

The NBS refers to the ocean domain between latitude 60°N to the south - approximately the location of the March minimum ice extent, and the Bering Strait to the north at approximately latitude 63°N. St. Lawrence Island is at the center of this domain (Sigler et al. 2011). The average depth of the NBS shelf is approximately 50 m and is less than 100 m overall (Fig. 3.1). Influx of sediments into the NBS results primarily from river runoff, particularly the Yukon and Kuskokwim Rivers (US Dep Commer NOAA 1976). The sediments are predominantly mud or muddy sand (Fig. 3.2). Sediments underlying the Bering Shelf-Anadyr Water (Fig. 3.1) north of St. Lawrence Island consist mainly of well-sorted sand (> 90% sand) and have a low organic content (< 0.5% carbon). Sediments underlying the Alaska Coastal Water are a more heterogeneous mixture of gravel, sand, and mud (McManus 1977; Grebmeier et al. 1989; Grebmeier et al. 2006a). Gravel is found mainly nearshore in Norton Sound and around St. Lawrence Island (Fig. 3.2).

The NBS ecosystem is heavily influenced by sea-ice climatology. It is ice-covered on the average of seven to eight months out of the year, opening up only between June and October. Despite the harsh environment, primary and secondary productivity are high due to the constant supply of organic nutrients by the Bering Shelf-Anadyr Water (Grebmeier et al. 1988; Grebmeier et al. 2006a)(Fig. 3.1). Primary production in the NBS occurs during the spring bloom – proliferation of ice algae at the ice edge during the melting of sea ice in April and May. Nutrients are stripped from the upper mixed layer of the water column by the algae, which are fed on by the zooplankton – a pelagic community of mainly copepods, euphausiids, amphipods, and larvae of benthic invertebrates (Sigler et al. 2011). A high portion of the algae is not consumed by zooplankton, and sinks to the bottom to sustain a rich bottom (benthic) fauna.

The NBS has among the highest benthic biomass in the world's oceans. Species diversity is low. Infauna are more important than epifauna in soft sediments. Sediment grain size is the main factor in determining the composition of the benthic infauna community, whereas the amount of organic carbon delivered from the overlying water to the bottom determines the overall biomass of the infauna. Clams, amphipods, and polychaetes dominate the infaunal biomass south of St. Lawrence Island (Figs. 3.3-3.5); amphipods and clams dominate in the central region between St. Lawrence Island to the Bering Strait (Grebmeier and Cooper 1995; Grebmeier et al. 2006a; Grebmeier 2012) (Fig. 3.6). Tube-dwelling amphipods, tellinid and nuculid clams are particularly important food for many fish, seabirds, and marine mammals. Pacific walrus, four species of seals, and ten species of whales are common in the NBS (US Dep Commer NOAA 1976). Many seabirds form colonies along the coast and on offshore islands.

The regions of high predicted benthic biomass in the Gulf of Anadyr and southern Chukchi Sea (Fig. 3.6) are dominated by clams that are food for walrus and spectacled eider. The Chirikov Basin is dominated by amphipods that are food for gray whale. A limited number of fish species inhabit the NBS. Common demersal species include Arctic cod, yellowfin sole, Bering flounder, and saffron cod. Pelagic fishes include herring, smelt, Arctic char, and all five species of Pacific salmon. They are prey for many marine mammals and seabirds (Grebmeier et al. 2006a). The epifauna is dominated by mainly sea stars in the northeastern Bering Sea. Sand dollars, brittle stars, sea squirts (tunicates), small crabs and snails are also abundant depending on the sediment type. Sea stars are important food competitors of marine mammals, and may function as keystone predators of benthic infauna in the absence of large crabs and groundfish (Grebmeier et al. 2006a).

A cold pool of < 2°C from winter ice formation is characteristic of the near-bottom water on the middle shelf between 50- and 100-m depth of the Bering Sea (Fig. 3.7). North of approximately 60°N, the cold pool persists through the summer months with little variation in temperature interannually. South of approximately 60°N, the cold pool varies annually in extent and intensity (Sigler et al. 2011). The cold pool excludes predatory subarctic benthic fish such as walleye pollock, flatfish, and Pacific cod and invertebrates such as opilio snow crab from the NBS. A polynya extends 20-40 km south of St. Lawrence Island in winter/spring. The polynya covers 2500-500 km^2. Within the polynya southward up to 20 km from the island, bottom water is more saline as brine is injected from above. This sets up density and wind-driven currents that flow counter to the general northward flow on the Bering Sea shelf. These currents may be important in transporting carbon nutrients to offshore benthos in the southwest, enhancing biomass of distinct clam communities (Grebmeier and Cooper 1995) (Figs. 3.3-3.5).

Ecosystem changes and effects

The NBS ecosystem has been undergoing changes under climate warming in the Arctic since late 1990s (Grebmeier et al. 2006b). In the long term, sea ice extent and benthic prey biomass are expected to decrease, and pelagic fish populations increase. Such changes may adversely impact managed species that rely on sea ice habitat and benthic prey in the NBS, such as seabirds, ice seals, walrus, and whales, and in so also impact NBS communities who subsist on these species.

Over the past 30 years, climate warming has reduced the annual duration of ice cover. The apparent trend is reduction of sea ice extent, and sea ice breaking up earlier in the year, which may decouple ice algae from the amount of sunlight necessary to produce intense algal blooms. Zooplankton abundance and biomass are likely to increase with warmer ocean temperatures. Timing of zooplankton production and composition of the zooplankton community may change, affecting the food supply to the benthic community and possibly switching the NBS ecosystem from benthic to pelagic-dominated. Species composition of the clam community has undergone changes recently. General abundance of clams and size of individuals have also declined, coincident with dramatic declines in diving sea ducks (Richman and Lovvorn 2003; Lovvorn et al. 2009; Grebmeier 2012).

It has been speculated that this warming trend may erode the cold pool barrier, and lead to a shift northward in the distribution of subarctic or temperate species (Mueter and Litzow 2008; Stevenson and Lauth 2012). However, recent years of oceanographic data and climate models projected that sea ice in the NBS will be less common in May, but will continue to be extensive in April, and the cold pool will persist irrespective of annual average shelf temperature (Stabeno et al. 2012a). The migration of subarctic bottom fish (e.g. walleye pollock and yellowfin sole) that are already at or near the northern extent of their ranges will be curtailed, but pelagic species (e.g. salmon) that dwell in the upper mixed layer and not limited by the bottom cold pool may expand their summer range into the NBS. The projected warming of the southern Bering Sea shelf will limit the distribution of arctic species (e.g. snow crab) to the northern shelf. Overall ecosystem response to climate change will depend on a complex suite of interactions between and among the physical environment and the biological communities, and not expected to be manifested in a simple northward shift in the distribution of species.

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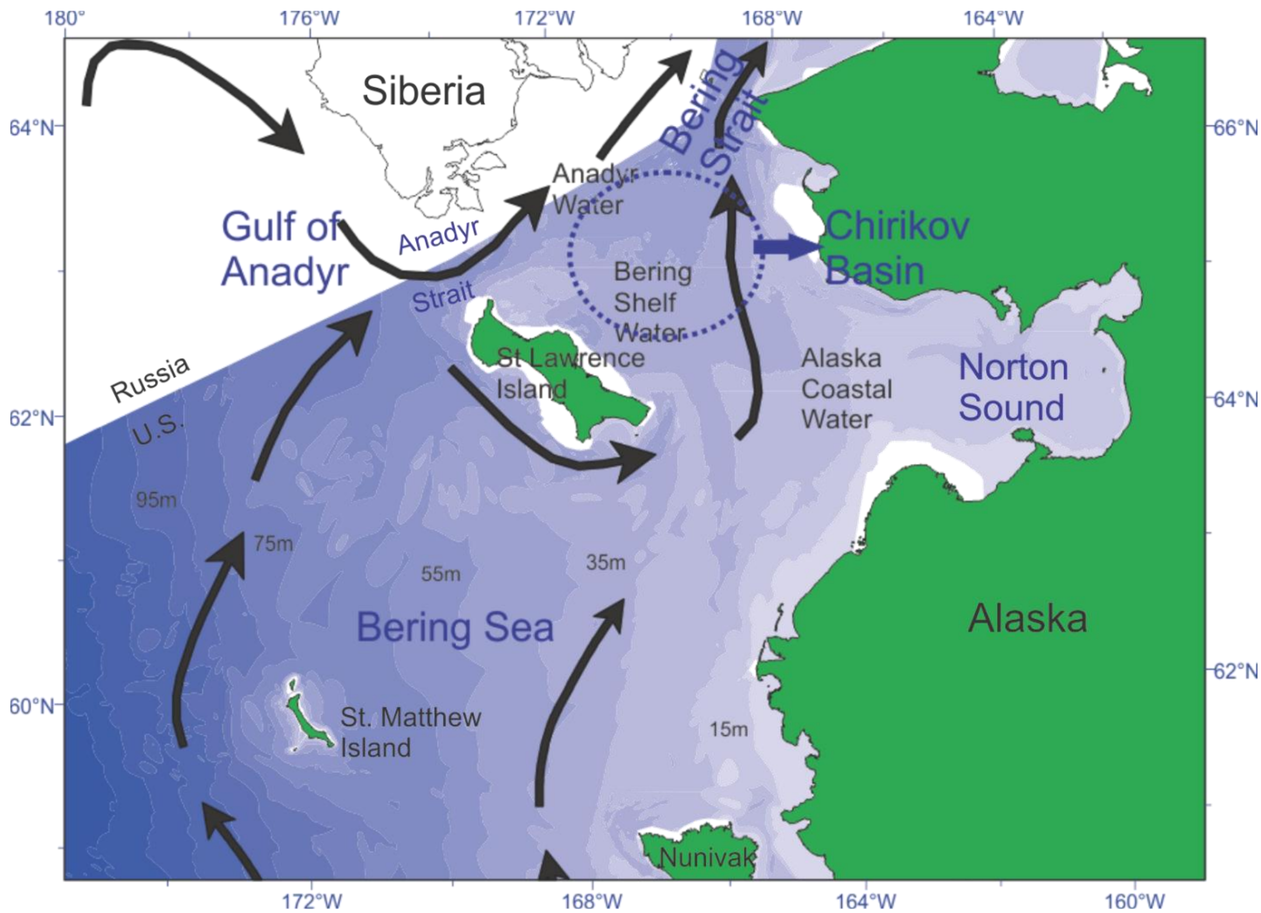

Figure 3.1. Northern Bering Sea - bathymetry and major currents.

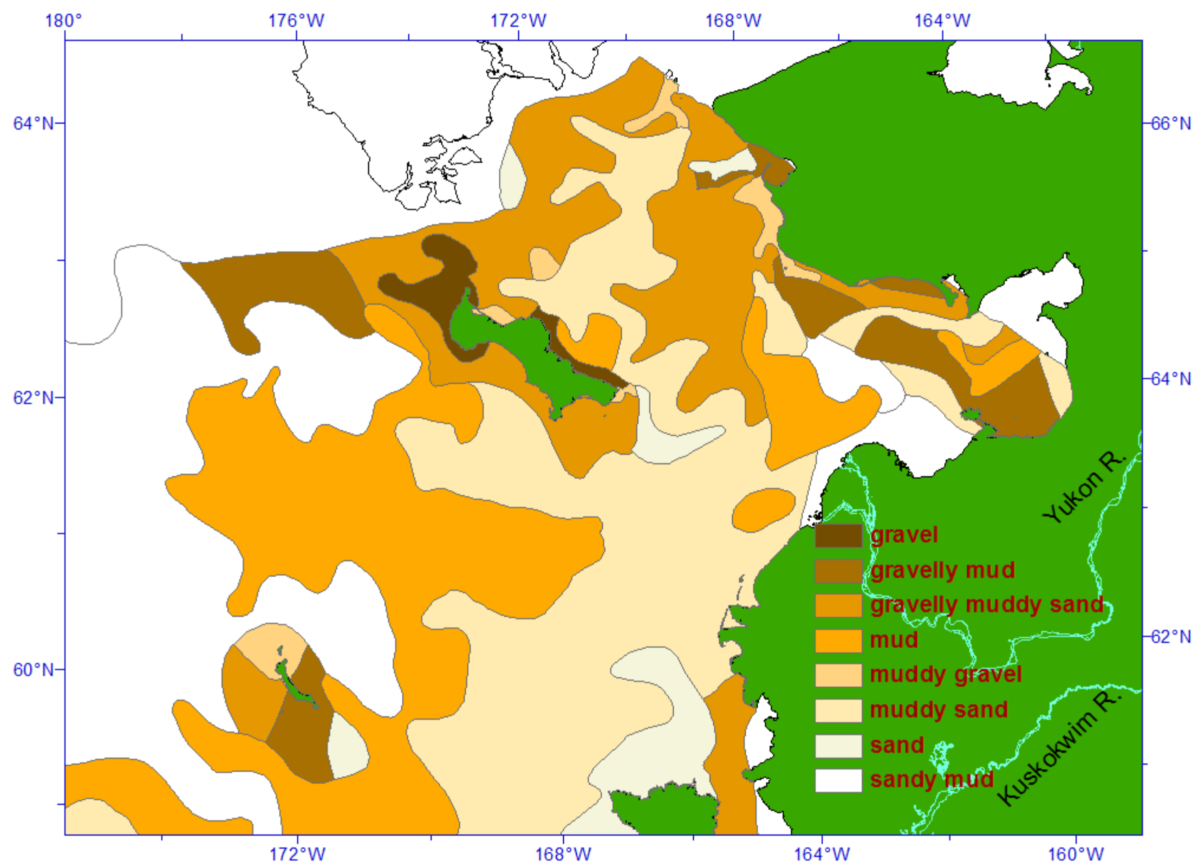

Figure 3.2. Distribution of surface sediment type in the northern Bering Sea (US Dep Commer NOAA 1988).

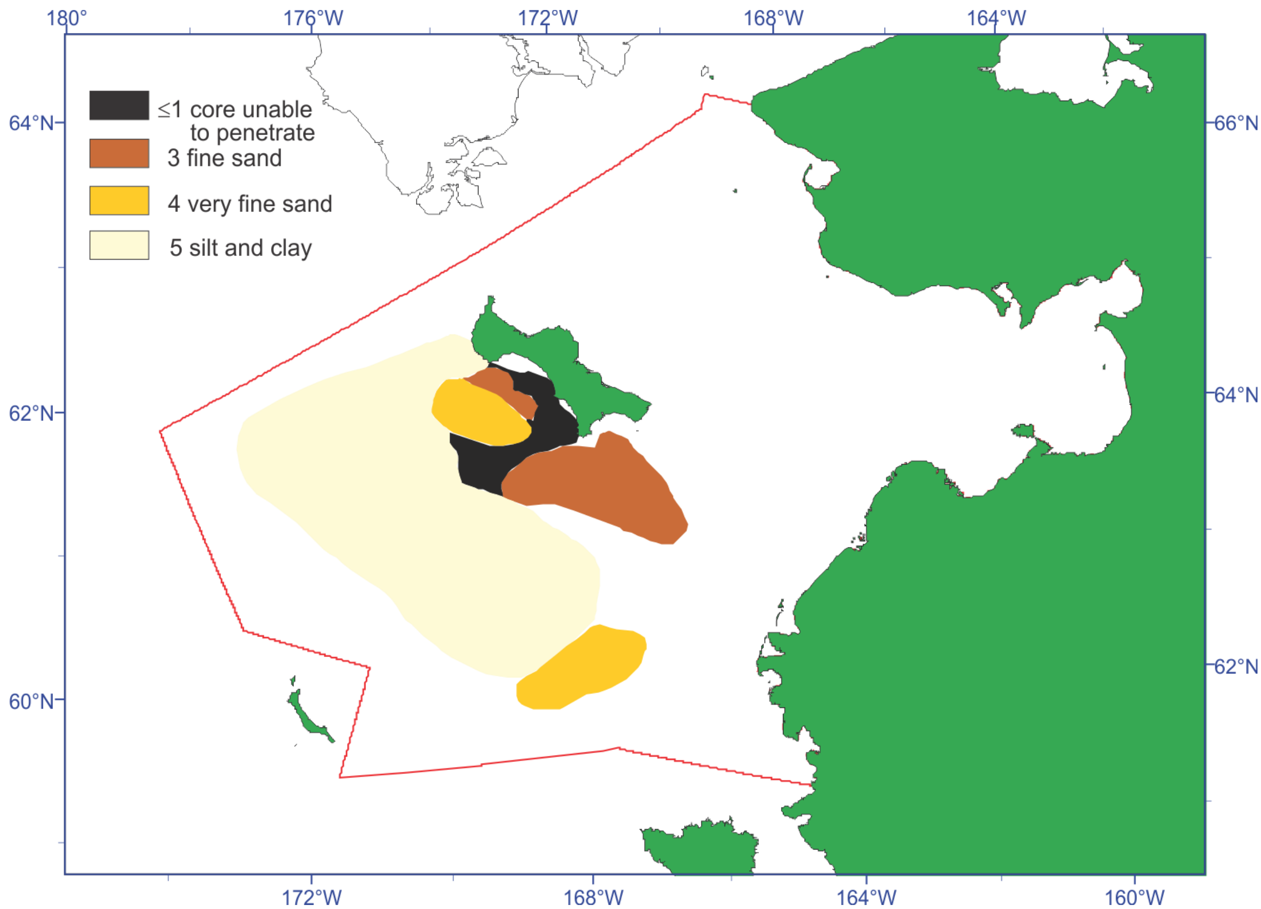

Figure 3.3. Distibution of surface sediment modal grain size (ϕ) in the St. Lawrence Island Polynya region during June 1990 (adapted from Figure 4, Grebmeier and Cooper 1995).

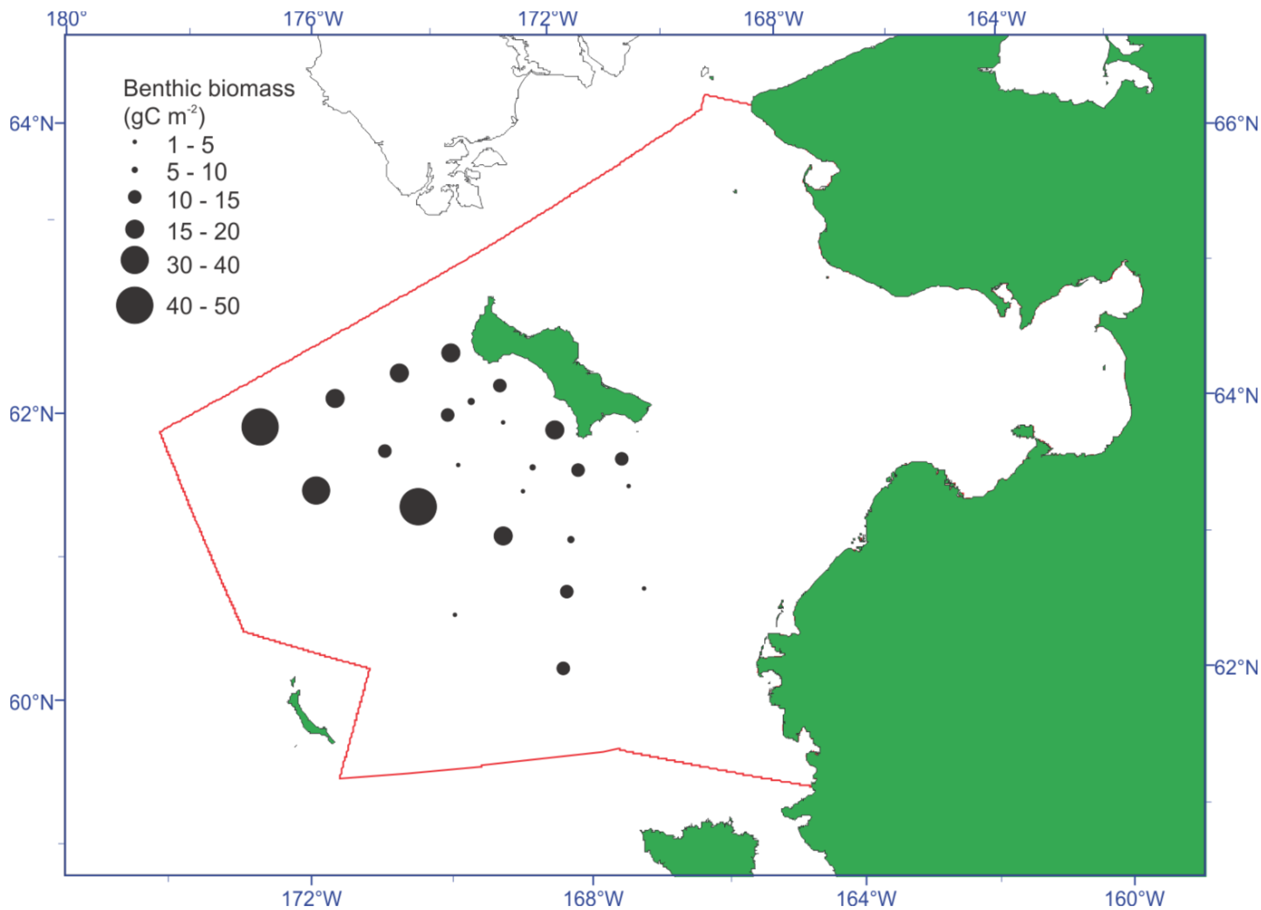

Figure 3.4. Distribution of macrofaunal benthic biomass in the St. Lawrence Island Polynya region during June 1990 (adapted from Figure 5, Grebmeier and Cooper 1995).

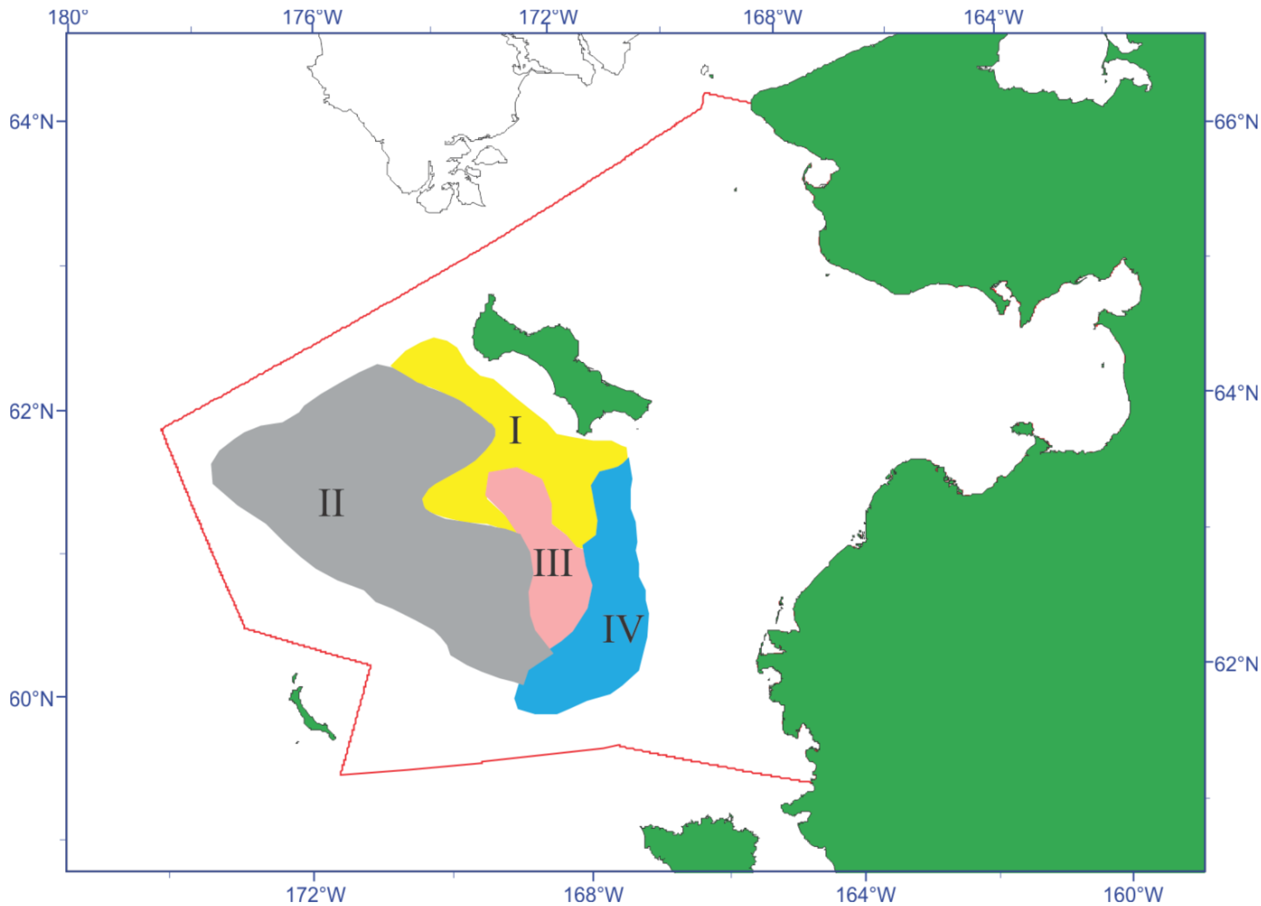

Figure 3.5. Distribution of benthic communities, based on abundance, and dominant faunal families in the St. Lawrence Island Polynya region during June 1990 (adapted from Figure 3, Grebmeier and Cooper 1995). Groups: I - amphipods, II – clams and capitellid polychaetes; III – clams, amphipods, orbiniid and oweniid polychaetes; IV – oweniid polychaetes.

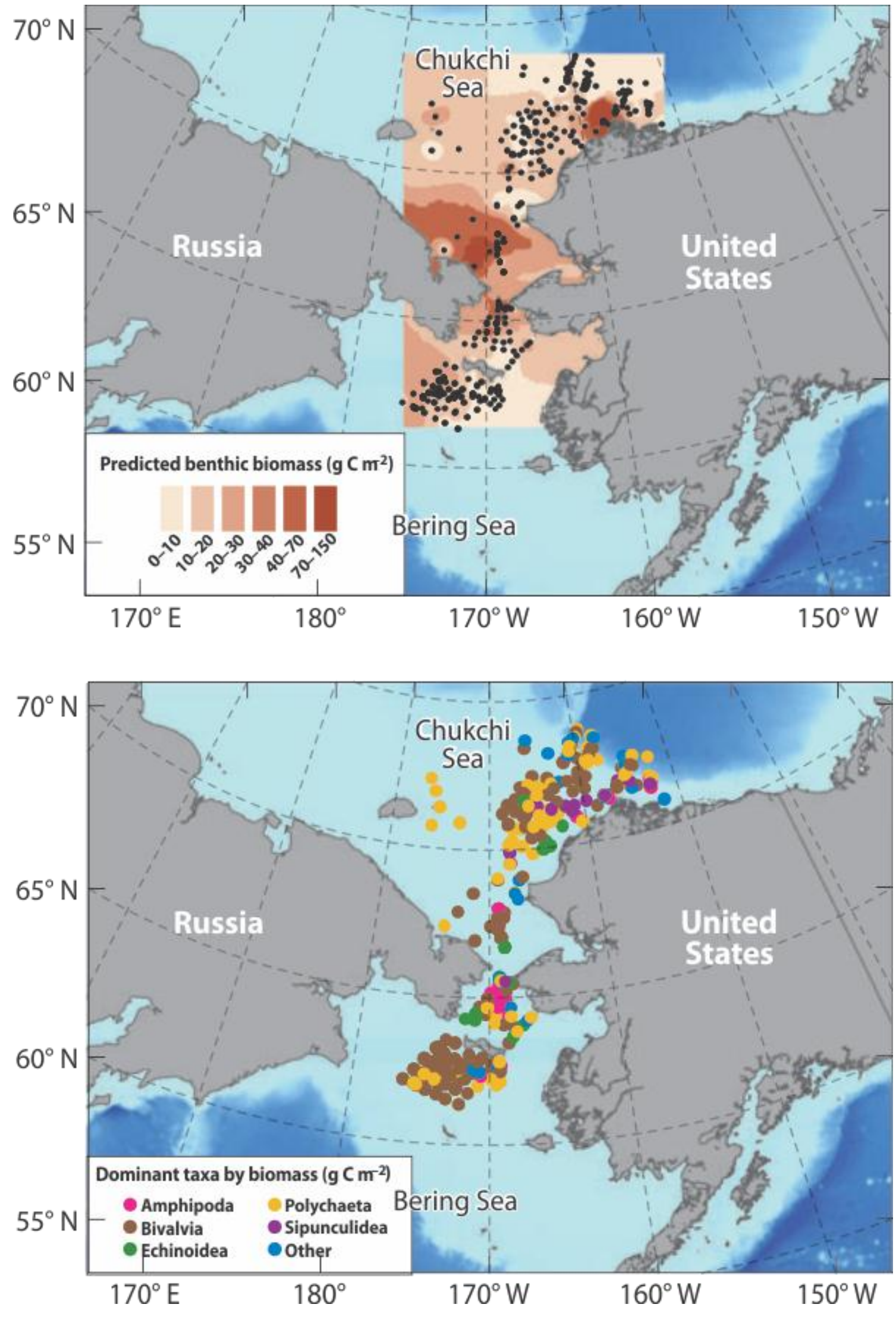

Figure 3.6. Predicted distribution of infaunal biomass (upper); and dominant benthic infaunal taxa identified (lower) at each station in the Pacific Arctic region for 2000-2010 (Figures 4 and 7, Grebmeier 2012).

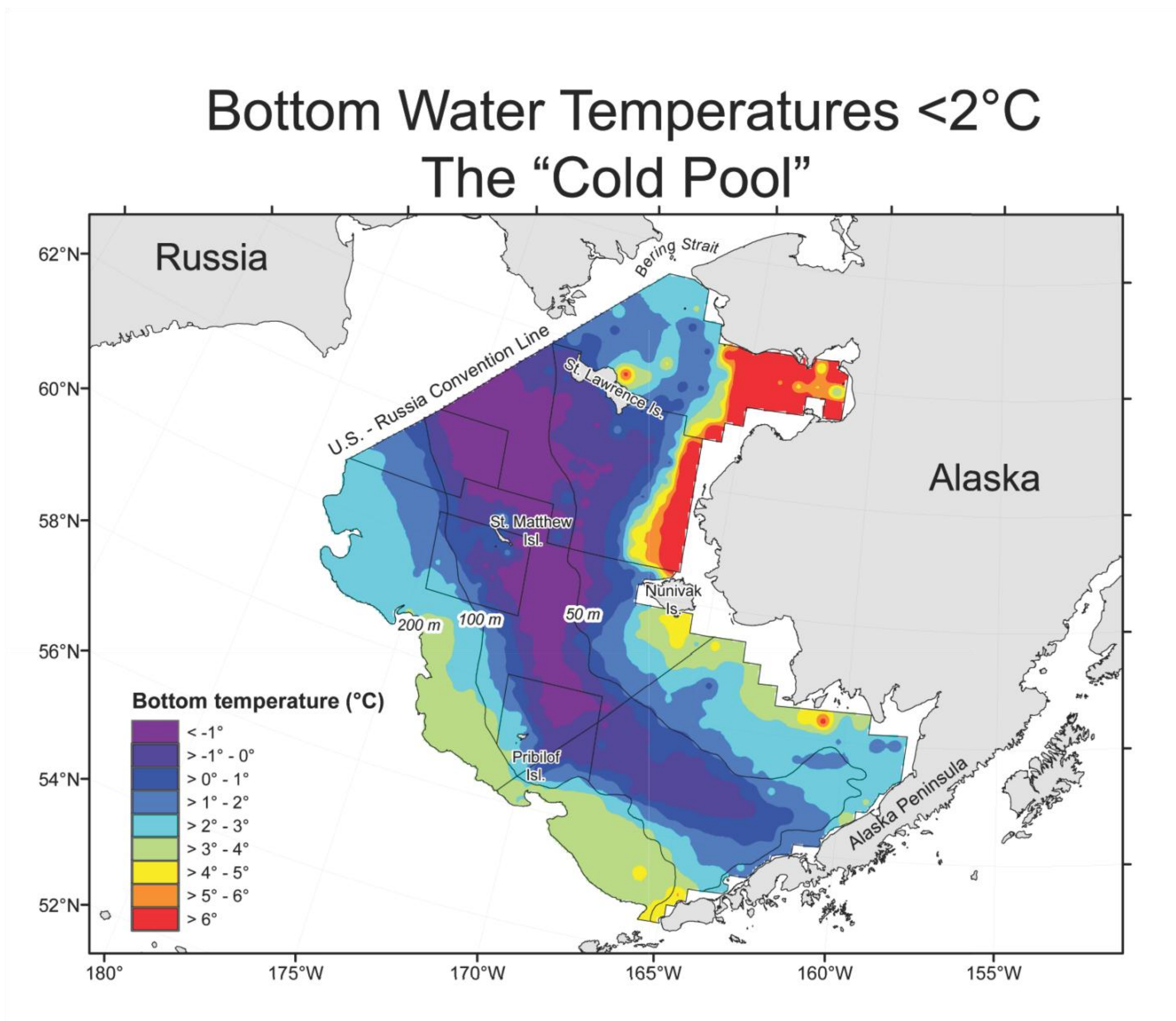

Figure 3.7. The "cold pool" – near-bottom water of less than 2^{o}C - in the middle domain (between depths of 50 m and 100 m) of the Bering Sea shelf.

4. Protected and subsistence species

4.1. Cetaceans

The Bering Sea supports one of the richest assemblages of marine mammals in the world. Twenty-five species are present from the orders Pinnipedia (seals, sea lions, walrus), Carnivora (sea otter, polar bear), and Cetacea (whales, dolphins, porpoises). Marine mammals occur in diverse habitats, including deep oceanic waters, the continental slope, the continental shelf, sea ice, shores and rocks, and nearshore waters (Lowry et al. 1982). Marine mammals that may occur in the NBSRA are listed in Table 4.1.1. The 2010 Marine Mammal Stock Assessment Reports (SARs) (Allen and Angliss 2011) provide population estimates, population trends, and estimates of the Potential Biological Removal (PBR) levels for each stock. The SARs also identify potential causes of mortality and whether the stock is considered a strategic stock under the Marine Mammals Protection Act (MMPA). The SARs are available on the NMFS Protected Resources (PR) Division website at http://www.nmfs.noaa.gov/pr/sars/region.htm.

A number of concerns may be related to marine mammals and the potential impacts of fishing. The Alaska Groundfish Harvest Specifications Final EIS (NMFS 2007) and the Amendment 94 EA/RIR/FRFA (NMFS 2010) provide information on the effects of groundfish fisheries on marine mammals. Direct and indirect interactions between marine mammals and groundfish fishing vessels may occur due to overlap in the size and species of groundfish harvested in the fisheries that are also important marine mammal prey, and due to temporal and spatial overlap in marine mammal occurrence and fishing activities. This discussion focuses on cetaceans that may interact or be affected by nonpelagic trawling if it were to occur in the NBSRA.

(1) Bowhead whale (*Balaena mysticetus*)

Bowhead whales are distributed in seasonally ice-covered waters of the Arctic and near-Arctic. Five management stocks are recognized worldwide by the International Whaling Commission. Only the Western Arctic (also known as the Bering-Chukchi-Beaufort Seas) stock occurs in the NBSRA. The majority of the Western Arctic stock migrates annually from wintering areas (November to March) in the NBS, through the Chukchi Sea in spring (March through June) to the Beaufort Sea where they spend much of the summer (May through September) before returning to overwinter in the NBS.

Bowhead whales are generally considered to be closely affiliated with ice, but during the summer the majority of the population occurs in mostly ice-free waters of the southern Beaufort Sea, an area exposed to industrial activity related to petroleum exploration and development. Some bowheads are found in the Chukchi and Bering Seas in summer, and are thought to be part of an expanding Western Arctic stock (Rugh et al. 2003). The population of Western Arctic bowhead whales was estimated in 2010 to be 11,836 (Allen and Angliss 2011) with an annual growth rate of 3.4%.

Bowhead whales feed on dense concentrations of copepods and euphausiids, and density of these prey items is thought to be a primary driver of bowhead distribution in both summer and winter (Lowry 1993). Commercial fisheries may affect bowhead whales through either direct interaction (e.g., entanglement), or indirectly through disturbance (e.g., noise). Many studies have been conducted to assess the effects of industrial noise on bowhead whales (see Richardson et al. 1995). Direct or indirect competition for prey resources is unlikely. Several cases of rope or net entanglement have been reported from whales taken in subsistence hunts (Philo et al. 1993), and scars that indicate either rope or net entanglement have been reported from aerial survey and harvest records (Craig George, North Slope Borough Department of Wildlife Management, pers. comm.). There are no observer records of bowhead whale mortality incidental to Alaskan commercial fisheries, although NMFS AKR stranding reports include three bowhead whale entanglements between 2001 and 2005. A single bowhead was found entangled in line in Bristol Bay in 2003, and in 2004 a bowhead was seen near Barrow with fishing net and line around its head. No records of interactions with trawling gear have been reported. It is, therefore, very unlikely that limited scientific or commercial trawling would affect bowhead whales in the NBSRA.

(2) North Pacific right whale (*Eubalaena japonica*)

North Pacific right whales were distinguished from North Atlantic right whales (*Eubalaena glacialis*) in 2008 (73 FR 19000, April 8, 2008). Eastern North Pacific right whales are arguably the most endangered stock of large whales in the world (Allen and Angliss 2011) with a minimum population estimate of 17 individuals. Critical habitat for North Pacific right whales consists of an area in the southeast Bering Sea and a small area southeast of Kodiak Island (Fig. 4.1.1), although most North Pacific right whale sightings have occurred within the critical habitat in the Bering Sea. While it is possible that North Pacific right whales occur in the NBSRA, it is unlikely that bottom trawling in the area would significantly affect the population of North Pacific right whales.

After the North Pacific species was designated, the NMFS AKR Sustainable Fisheries (SF) Division requested a Section 7 consultation under the U.S. ESA on the effects of the Alaska groundfish fisheries (Salveson 2008). However, NMFS PR (Brix 2008) concluded that because an analysis in 2006 (Brix 2006) determined that the groundfish fisheries were unlikely to adversely affect North Pacific right whales or their critical habitat, and the 2008 action was a change in taxonomic status, no further consultation was required. Recently NMFS has published a Notice of Intent to prepare a recovery plan for the North Pacific right whale (77 FR 22760, April 17, 2012).

Commercial fishing activities, including nonpelagic trawling, could impact North Pacific right whales directly through entanglement or take, or indirectly through disturbance. Because North Pacific right whales feed on species that are not impacted by nonpelagic trawling, the likelihood of direct competition with commercial fisheries is very remote. Noise disturbance from fishing vessels is possible, although North Atlantic right whales are commonly found in areas of high vessel traffic.

Gillnets were implicated in the death of a North Pacific right whale off the Kamchatka Peninsula (Russia) in October, 1989 (Kornev 1994). No other incidental takes of right whales are known to have occurred in the North Pacific. North Atlantic right whales are known to become entangled in fishing gear, including lobster pot and sink gillnet gear, and entanglement is considered a major source of mortality for right whales in the Atlantic (Waring et al. 2004). Any mortality to North Pacific right whales from fishing activities or other human-caused mortality would be considered significant.

(3) Gray whale (*Eschrichtius robustus*)

Gray whales are found only in the North Pacific (Rice et al. 1984; Swartz et al. 2006), although recently a gray whale that is likely from the eastern North Pacific population was seen in the Mediterranean (Drake 2011). There are two stocks of gray whales found in the North Pacific, the Eastern North Pacific Stock (ENP) and the Western North Pacific Stock (WNP). The WNP occurs along the east coast of Asia, and is unlikely to be found in the NBSRA and will not be considered here. The ENP occurs along the west coast of North America, from Mexico to the Beaufort Sea. Most of the ENP spends the summer feeding in the northern and western Bering and Chukchi Seas. However, gray whales have been reported feeding in the summer in waters near Kodiak Island, Southeast Alaska, British Columbia, Washington, Oregon, and California. Photo-identification studies of these animals indicate that they move widely between these areas, and individuals are not always seen in the same areas in successive years. The majority of the ENP migrates southward along the west coast of North America to protected, shallow lagoons on the Pacific coast of Baja California, where calves are born. The northward migration to the Bering Sea occurs primarily between March and June along the U.S. West Coast.

The population of gray whales in the North Pacific has increased dramatically since the cessation of commercial whaling. Recent population estimates suggest that the population has nearly increased back to the level seen in the 1990s, before the mortality event in 1999 and 2000. The minimum population estimate is now 18,017 (Allen and Angliss 2011). The ENP experienced an unusual mortality even in 1999 and 2000. An unusually high number of gray whales stranded along the coast of North America in the fall of those years. Many of the stranded whales were emaciated, suggesting that starvation could have been a significant contributing factor in the high number of strandings.

The 2011 SAR identifies 22 observed fisheries in the Gulf of Alaska and Bering Sea that use trawl, longline, or pot gear that may affect ENP gray whales; since 2004 there have been no observed serious injuries or mortalities of gray whales in any of those fisheries. Reports of entangled gray whales found swimming, floating, or stranded with fishing gear attached occur along the U.S. west coast and British Columbia. A listing of all reported entanglements and strandings is included in Allen and Angliss (2011), (p. 170). Some of those entanglements were not considered to result in serious injury, or the whale was released from the entangled gear. During the 5 year period from 2003–2007, the stranding network indicated a minimum annual mean of 3.3 gray whale mortalities resulting from interactions with commercial fishing gear along the U.S. West Coast.

Gray whales feed on both pelagic and benthic prey. A warming climate is having profound impacts in the Arctic, including changes in the amount of seasonal ice cover in the Bering Sea. These changes may affect marine mammal species in the Arctic due to changes in the benthic food supply. However, Bluhm and Gradinger (2008) examined the likely trends in the availability of pelagic and benthic prey in the Arctic, and concluded that while benthic prey is likely to decrease in the Arctic, pelagic prey is likely to increase. Moore and Huntington (2008) observed that gray whales are “the most adaptable and versatile” baleen whale species, and noted that recently gray whales have been seen foraging year-round off of Kodiak, Alaska.

There are few, if any, direct studies on the effects of trawling on feeding of gray whales. However, Kaiser et al. (1998) and Schratzberger et al. (2002) found no long-term impacts to megafauna or meiofauna after trawling. Because of the importance of benthic feeding to gray whales, additional studies on the effects of nonpelagic trawling to the feeding habitat of gray whales are recommended.

(4) Humpback whale (*Megaptera novaeangliae*)

The humpback whale is distributed worldwide in all ocean basins. In winter, most humpback whales occur in subtropical and tropical waters. In summer, humpback whales migrate to higher latitudes to feeding areas. The Western North Pacific (WNP) stock of humpback whales winters off of the Asian coast, and feeds in the North Pacific and Bering Sea. The Central North Pacific (CNP) stock of humpback whales also winters in the Hawaiian Islands, but summers around the Alaska Peninsula and Kodiak Islands. The WNP and CNP stocks of humpback whales overlap broadly on summer feeding grounds. Given the small size of the Asian population, WNP whales probably represent a small fraction of all the whales found in the BSAI and GOA.

Line-transect surveys in 1999 (Moore et al. 2000), estimated abundance of humpback whales in the central Bering Sea at 1,175 animals (95% CI 197 – 7,009), although the clumped nature of the sightings limited the utility of the estimate for the entire area. Moore et al. (2002) estimated abundance in the eastern Bering Sea to be 102, and (Zerbini et al. 2006) estimated 2,644 humpback whales for coastal/shelf waters of the central Gulf of Alaska through the eastern Aleutian Islands. Although no confidence values have yet been calculated for the WNP stock, Allen and Angliss (2011) estimated a minimum population of 732 individuals.

The List of Fisheries (69 FR 7094, 2 December 2004) lists 22 fisheries in Alaska that occur within the range of the WNP stock of humpback whales. Between 2002 and 2006, the BSAI sablefish pot fishery accounted for serious injury or mortality to 0.2 humpback whales annually from this stock (Allen and Angliss 2011). However, because of the inability to distinguish WNP and CNP individuals, the mortality is assigned to both stocks. Only one stranding of a humpback entangled in fishing gear is reported for Alaska: in 1997 a single humpback was found floating dead, entangled in netting a trailing orange buoys (Allen and Angliss 2011).

Humpback whales have a varied diet, feeding primarily on euphausiids and small schooling fish, including herring, capelin, sand lance, and mackerel (Clapham 2009). Because of their pelagic feeding, humpback whales are unlikely to be affected by nonpelagic trawling in the NBSRA.

(5) Fin whale (*Balaenoptera physalus*)

Fin whales occur in most oceans of the world, from the equator to the poles, generally moving from higher latitudes in the summer to lower latitudes in the winter. Fin whales occur seasonally in the Bering Sea. It appears from whaling catch data, mark-recovery studies, and opportunistic sighting data (Mizroch et al. 2009) that fin whales from two stocks, the Eastern North Pacific (ENP) and Western North Pacific (WNP) stocks, mingle in the Bering Sea in summer. In the Bering Sea, fin whale abundance was found to be approximately five times higher in the central-eastern Bering Sea than in the southeastern

Bering Sea (Moore et al. 2002), and most sightings occurred in a zone of particularly high productivity along the shelf break (Moore et al. 2000). The southern portion of the NBSRA includes the central-eastern Bering Sea as defined by Moore et al. (2002).

Reliable estimates of the current and historical abundance for the entire Northeast Pacific fin whale stock are currently not available. A minimum estimate of the population in Alaskan waters west of the Kenai Peninsula was estimated in Allen and Angliss (2011), using sums of the estimates from Moore et al. (2002) and (Zerbini et al. 2006) to be 5,700. However, this is considered a minimum estimate because it was estimated from surveys which covered only a small portion of the range of this stock.

Fin whales feed on a variety of planktonic crustaceans, including euphausiids and copepods, and small schooling fishes such as herring and capelin. Fin whales feed in the Bering Sea in summer, and migrate to more temperate waters in the winter, where they fast.

Between 2002 and 2006, there was one observed incidental mortality of a fin whale in the BSAI pollock trawl fishery (Allen and Angliss 2011). In May, 2012, a fin whale became entangled on the anchor line of a fishing vessel anchored near Kodiak Island and drowned. Estimated annual takes due to commercial fisheries is approximately 0.23 fin whales per year.

(6) Minke whale (*Balaenoptera acutorostrata*)

In the North Pacific, minke whales (*Balaenoptera acutorostrata*) occur from the Bering and Chukchi Seas to near the equator (Allen and Angliss 2011). Two stocks of minke whales are recognized in U.S. waters, the Alaska stock, and the California/Oregon/Washington stock. In the Bering Sea, minke whales abundance estimates were similar in the southeastern and central-eastern Bering Sea (Moore et al. 2002). Minke whales occurred throughout the survey area, but most sightings occurred along the upper slope in waters 100-200m deep (Moore et al. 2000).

No estimates have been made for the number of minke whales in the entire North Pacific, but some information is available on the number of minke whales in some areas of Alaska. Estimates from visual surveys in the central-eastern Bering Sea in July 1999 and the southeastern Bering Sea in 2000 (Moore et al. 2000; Moore et al. 2002), indicate 810 whales in the central-eastern, and 1,003 whales in the southeastern Bering Sea. However, these estimates have not been corrected for availability or sightability, and are considered provisional estimates (Allen and Angliss 2011).

Six fisheries in Alaska that operate within the range of minke whales were monitored for incidental take during 2002-2006 (Allen and Angliss 2011). No serious injury or mortality was observed during those years. In 1989 a single minke whale mortality was observed in the Bering Sea/Gulf of Alaska joint-venture groundfish trawl fishery, and a single minke whale mortality occurred in the BSAI groundfish trawl fishery in 2000. Takes are too few to estimate annual mortality.

In the North Pacific, minke whales feed on euphausiids, anchovy, and walleye pollock (Perrin and Brownell 2009). The impacts of nonpelagic trawling on minke whales are unknown, but because of the lack of overlap between trawling targets and minke whale diet, there is low likelihood of fishing activities in the NBSRA affecting minke whales.

(7) Beluga whale (*Delphinapterus leucas*)

Four stocks of beluga whales inhabit the Bering Sea during at least part of the year: the Beaufort Sea stock, eastern Chukchi Sea stock, eastern Bering Sea stock, and Bristol Bay stock. The Beaufort Sea stock of beluga whales is the largest in Alaska, with an estimated population of 39,258 animals, the Chukchi Sea stock is estimated at 3,710, the eastern Bering Sea stock at 7,986, and the Bristol Bay stock at 3,299 (Allen and Angliss 2011).

Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction (Lowry 1985). All stocks (except the isolated Cook Inlet stock) occupy the Bering Sea in summer, but only the eastern Bering Sea and Bristol Bay stocks remain in the Bering Sea during summer. As the sea ice recedes in spring, belugas migrate to their summer areas, often forming dense concentrations at river mouths or estuaries, shallow inlets or bays. In winter, belugas have been tracked with satellite transmitters into heavy pack ice hundreds of kilometers north of the ice edge. Belugas may dive to 300-600 m to the sea floor, and in the deep waters beyond the continental shelf, belugas may dive to depths greater than 1,000 m and remain submerged for up to 25 minutes (Richard et al. 1997; Martin et al. 1998).

Beluga whales are generalist predators and are known to feed on many species of fishes, squids, crabs and clams. Three different commercial fisheries that could have interacted with the Bristol Bay and eastern Bering Sea stocks of beluga whales were monitored for incidental take from 1990-1997: the BSAI groundfish trawl, longline, and pot fisheries. No reports of mortality or serious injury to beluga whales from these stocks were reported, and no reports of mortality or serious injury have been reported for the Chukchi Sea or Beaufort Sea stocks. Observers have never monitored the Bristol Bay salmon set gillnet and drift gillnet fisheries, so a reliable estimate of fisheries related mortality is not currently available. There are no data about the potential effects of nonpelagic trawling in the NBSRA on any stocks of beluga whales.

(8) Harbor porpoise (*Phocoena phocoena*)

Harbor porpoise occur in the North Pacific from Pt. Barrow in the Chukchi Sea to Point Conception, California (Gaskin 1984). They are most commonly found in coastal waters, typically in waters less than 100 m deep. Three stocks are identified in Alaskan waters: Bering Sea, Gulf of Alaska, and Southeast Alaska stocks. The estimated abundance estimate for harbor porpoise in the Bering Sea is 48,215 (Allen and Angliss 2011). This is considered a conservative estimate because areas of known harbor porpoise range were not surveyed.

Harbor porpoise feed primarily on fish, but in some areas they prey on squid and crustaceans as well. Small, pelagic schooling fishes such as herring, and anchovy, as well as a range of bottom-dwelling fish are common prey species. Harbor porpoises forage from the bottom of the sea in waters less than 200 m deep to the surface (Bjørge and Tolley 2009).

The List of Fisheries (75 FR 68468, November 8, 2010) identifies three commercial fisheries that have incidentally killed or injured harbor porpoise in the Bering Sea: the AK Peninsula/Aleutian Islands salmon set gillnet, BSAI flatfish trawl, and AK Kuskokwim, Yukon, Norton Sound, Kotzebue salmon gillnet fisheries. Only the BSAI flatfish trawl fishery is regularly observed, which precludes annual estimates of mortality from the other fisheries. A single harbor porpoise was observed taken in the BSAI flatfish trawl fishery in 2007 (extrapolated to 4.9 harbor porpoise for the entire fishery), which results in an estimated annual mean mortality of 2.45 animals. Because any trawling that would occur in the NBSRA is likely to be flatfish trawling, there is some potential for activity in the NBSRA to affect harbor porpoise, but the extent of that potential take is unknown.

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Table 4.1.1. Marine mammals that may occur in the NBSRA, their management status, and population trends.

Species and stock	***ESA Status***	***MMPA Status***	***Population Trends***	***Distribution in action area***
Steller sea lion - Western Distinct Population Segment (DPS)	Endangered	Depleted, strategic	Stable overall, with some areas of decline and others of population growth.	Western DPS inhabits Alaska waters from Prince William Sound westward to the end of the Aleutian Island chain and into Russian waters. Occur throughout AK waters, terrestrial haulouts and rookeries on Pribilof Is., Aleutian Is., St. Lawrence Is. and off mainland. Use marine areas for foraging. Critical habitat designated around major rookeries and haulouts and foraging areas.
Ringed seal – Alaska	Status under review	None	Reliable data on population trends are unavailable.	Found from Bristol Bay to north of St. George Island and occupy ice.
Bearded seal – Alaska	Status under review	None	Reliable data on population trends are unavailable.	Found from Bristol Bay to north of St. George Island and inhabit areas of water less than 200 m that are seasonally ice covered.
Ribbon seal – Alaska	None	None	Reliable data on population trends are unavailable.	Found throughout the offshore Bering Sea waters.
Spotted seal - Alaska	Status under review	None	Reliable data on population trends are unavailable.	Found throughout Bering Sea waters.
Pacific walrus	Status under review	Strategic	Population trends are unknown. Population size estimated from a 2006 ice survey is 15,164 animals, but this is considered a low estimate. Further analysis is being conducted on the 2006 survey to refine the population estimate.	Occur primarily in shelf waters of the Bering Sea. Primarily males stay in the Bering Sea in the summer. Major haulout sites are in Round Island in Bristol Bay and on Cape Seniavin on the north side of the AK Peninsula.
Humpback whale- Western North Pacific (WNP) Central North Pacific (CNP)	Endangered	Depleted, strategic	Reliable data on population trends are unavailable for the WNP stock. CNP stock thought to be increasing. The status of the stocks in relation to optimal sustainable population (OSP) is unknown.	WNP and CNP stocks occur in Alaskan waters and may mingle in the North Pacific feeding area.
North Pacific right whale Eastern North Pacific	Endangered	Depleted, strategic	Abundance not known, stock is considered to represent only a small fraction of its pre-commercial whaling abundance.	See Figure 4.1.1 for distribution and designated critical habitat.

Species and stock	***ESA Status***	***MMPA Status***	***Population Trends***	***Distribution in action area***
Fin whale Northeast Pacific	Endangered	Depleted, strategic	Abundance may be increasing but surveys only provide information for portions of the stock in the central-eastern and southeastern Bering and coastal waters of the Aleutian Islands and the AK Peninsula. Much of the North Pacific range has not been surveyed.	Found in the Bering Sea and coastal waters of the Aleutian Islands and AK Peninsula. Most sightings in the central-eastern Bering Sea occur in a high productivity zone on the shelf break.
Minke whale Alaska	None	None	Considered common but abundance not known and uncertainty exists regarding the stock structure.	Common in the Bering and Chukchi Seas and in the inshore waters of the GOA.
Gray Whale Eastern North Pacific	None	None	Minimum population estimate is 17,752 animals. Increasing populations in the 1990's but below carrying capacity.	Most spend summers in the shallow waters of the NBS and Arctic Ocean. Winters spent along the Pacific coast near Baja California.
Beluga whale Bristol Bay (BB), EBS, Cook Inlet (CI), Eastern Chukchi Sea (ECS)	Endangered (CI)	Depleted (CI)	CI estimate is 280 whales, declining at 1.1% per anum; BB – 1,600; EBS – 18,000, ECS – 3,700.	Bering Sea coastal waters year round. Cook Inlet population restricted to Cook Inlet.
Source: Allen and Angliss (2011) and List of Fisheries for 2011 (72 FR 68468). North Pacific right whale included based on Brix 2006 and (Salveson 2008) www.nmfs.noaa.gov/pr/species/mammals/cetaceans/spermwhale.htm				

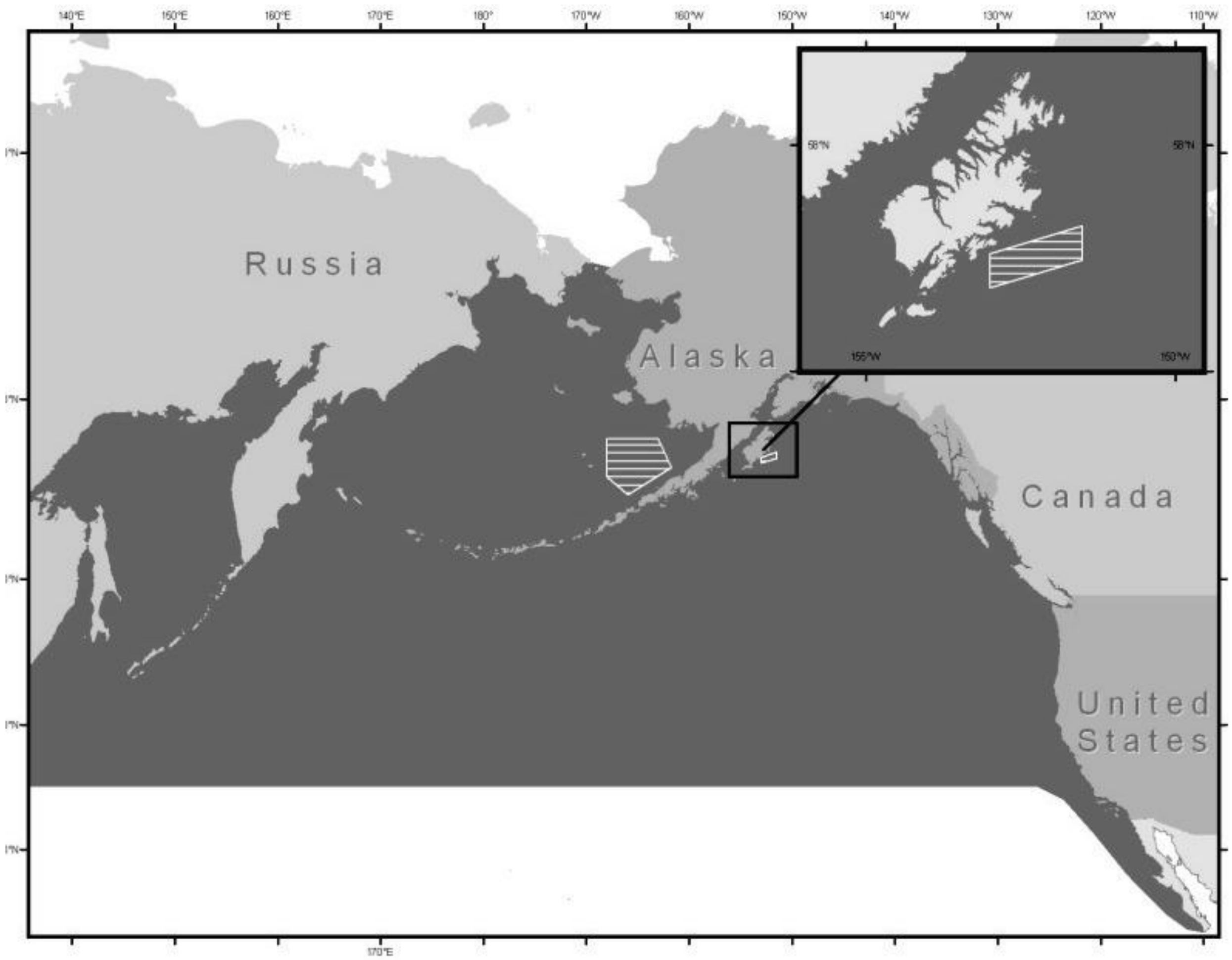

Figure 4.1.1. North Pacific right whale distribution and critical habitat shown in lined boxes (Angliss and Outlaw 2010).

4.2. Ice-associated seals

Four species of ice-associated seals: spotted (*Phoca largha*), ribbon (*Histriophoca fasciata*), ringed (*P. hispida*), and bearded seals (*Erignathus barbatus*), inhabit the Bering, Chukchi, and Beaufort seas of the Alaskan Arctic. Collectively, they are often referred to as ice-associated seals or "ice seals" because they are highly dependent on suitable sea ice condition and distribution, as a platform for giving birth, nursing their pups, resting and molting. Concern about loss of sea ice habitat in the current warming climate has been the basis for petitions to NMFS for listing all four species as threatened or endangered under the Endangered Species Act (ESA). Ribbon seals are currently not listed under the ESA (Boveng et al. 2008). Updated ESA listing decisions for ringed and bearded seals are expected to be announced by the end of 2012.

Ice-associated seals are also protected under the MMPA. They are vital subsistence resources for Alaska Native communities, and key ecological components of arctic marine ecosystems. Yet, relatively little is known of the seals' population status, stock structure, abundance trend, life history, seasonal movements, diving behavior, diet or harvest rates. This is particularly true for areas away from the coasts and at times of the year when they are not hunted for subsistence purposes by Alaska Natives, such as during the open water period.

U.S. fisheries in the North Pacific are carefully managed to prevent overfishing of individual stocks. However, even well-managed fisheries will result in reduced levels of biomass relative to theoretical mean unfished levels. The extent that the lower abundance levels of groundfish stocks may affect the viability of ice-associated seal populations is unknown. In the U.S. EEZ, overall biomass levels of all groundfish species have remained relatively stable between 15 and 20 million metric tons of biomass after showing substantial increases since the 1970s (Mueter and Megrey 2006).

Commercial Alaska nonpelagic-trawl fisheries may impact ice-associated seals through direct interactions (i.e., incidental take or bycatch), which in most cases is considered to be of minor importance; and indirectly through competition for prey resources and impacts on size structure, genetics reproductive capacity, and/or life history characteristics of their prey populations through the destruction or modification of benthic prey and their habitat. Some fisheries may be expected to expand or shift northward in response to an increased length of the ice-free, open-water season in the future. If such shifts occur, the likelihood of both direct and indirect fisheries interactions with ice-associated seals may increase.

Fisheries generally select particular individuals (usually larger and older fish) and focus on particular locations (such as spawning or feeding grounds) such that fishing is non-random. A reduction in the average size of prey species could reduce the per capita energy content and may increase the foraging effort exerted by ice-associated seals. Conversely, older fish may be more cryptic, harder to catch, and less numerous. Groundfish stocks are known to have a high degree of interannual variability in recruitment and it is likely that such fluctuations occurred prior to fishing. As such, most ice-associated seals dependence on different size composition for groundfish species would seem to be fairly adaptable.

Nonpelagic trawl fisheries also have the potential to indirectly affect ice seals through destruction or modification of benthic prey and/or their habitat. The predominant direct effects of bottom trawls include "smoothing of sediments, moving and turning of rocks and boulders, resuspension and mixing of sediments, removal of sea grasses, damage to corals, and damage or removal of epibenthic organisms" (NMFS 2009). Each of these effects has the potential to impact the benthic and pelagic prey important to ice-associated seals. The extent or importance of these impacts are difficult or even impossible to predict, however, given the apparent flexibility in the diets of most ice-associated seals and the general lack of knowledge of their foraging ecology.

(1) Spotted seal

Spotted seals are distributed along the continental shelves of the Bering, Chukchi, and Beaufort Seas, and from the Sea of Okhotsk south to the western Sea of Japan and northern Yellow Sea (Fig. 4.2.1). During spring, spotted seals tend to prefer small floes (i.e., < 20 m in diameter), and inhabit mainly the southern margin of the ice in areas where the water depth does not exceed 200 m, and move to coastal habitats after the retreat of the sea ice (Shaughnessy and Fay 1977; Lowry et al. 2000; Simpkins et al. 2003). In summer and fall, spotted seals use coastal haul-out sites regularly (Frost et al. 1977; Lowry et al. 1998), and may be found as far north as 69-72°N in the Chukchi and Beaufort Seas (Shaughnessy and Fay 1977). To the south, along the west coast of Alaska, spotted seals are known to occur around the Pribilof Islands, Bristol Bay, and the eastern Aleutian Islands.

The spotted seal population is estimated to be 145,700 within the eastern and central Bering Sea (Ver Hoef et al. In review). Satellite-tagging studies showed that spotted seals tagged during summer in the northeastern Chukchi Sea moved south in October and passed through the Bering Strait in November. Spotted seals overwintered in the Bering Sea along the ice edge and made east-west movements along the edge (Lowry et al. 1998).

Satellite tagging results indicate that spotted seals of the Bering Sea population spend an estimated 26.1% of their time north of the Bering Strait, and about 42% of Bering Sea spotted seals use the Chukchi Sea during the summer, open-water period (Fig. 4.2.2) .

Spotted seals are generalist feeders with a varied diet, but most studies have found that fishes are the spotted seals' primary prey (Dehn et al. 2007; Quakenbush et al. 2009). Spotted seals consume a wide variety of prey items from the Bering Sea and Sea of Okhotsk during spring when they are associated with sea ice; primary prey items include many schooling fishes such as walleye pollock *Theragra chalcogramma*, Pacific herring *Clupea pallasii*, Arctic cod *Boreogadus saida*, Pacific sand lance *Ammodytes hexapterus*, capelin *Mallotus villosus*, saffron cod *Eleginus gracilis*, and Japanese smelt *Hypomesus japonicas*, as well as greenlings (Hexagrammidae), Atka mackerel *Pleurogrammus monopterygius*, eelpouts (Zoarcidae), sculpins, flatfishes, cephalopods, and crustaceans (Frost et al. 1977; Lowry 1985b; Bukhtiyarov 1990). In the summer, spotted seals primarily consume fishes and crustaceans similar to those they prey on in spring; however, at this time, seals will often redistribute and gather near rivers where they frequently prey on runs of spawning salmon (Kosygin et al. 1986; Burkanov 1989; Sobolevsky 1996). There are only limited food habits data for spotted seals in fall and winter, but Lowry (1985b) suggested that herring, capelin, smelt, saffron cod, and Arctic cod all may be important in the diet during these times of year. However, non-fish prey items, such as octopuses, small crabs, and shrimps, are abundant and comprise 40-50% of the diet near the coast in the fall (Sobolevsky 1996). Though nonpelagic trawling could decrease the local densities of these types of prey items, the level of that impact on spotted seals is not known.

An analysis of incidental take data reported by NMFS observers monitoring up to 22 fisheries from 1990 to 1999 (Angliss and Lodge 2002) suggested that the current abundance of spotted seals in U.S. waters is high enough to sustain a level of annual mortality much higher than the estimated bycatch rates (average of one mortality per year) , implying that the threat due to bycatch is likely insignificant .

Commercial fisheries target a number of known spotted seal prey species, such as walleye pollock, Pacific cod, herring, and capelin, but not with nonpelagic trawl. These fisheries may affect spotted seals indirectly through reductions in prey biomass. The extent that the lower abundance levels of these individual stocks affect the viability of spotted seal populations is unknown. In a conceptual assessment of marine mammal-fishery interactions in the Bering Sea, Lowry and Frost (1985) ranked spotted seals as a species with moderately-high probability for significant indirect fisheries interactions based on their feeding moderately and opportunistically on commercial species, high and stable population size relative to carrying capacity (i.e., historic levels), and the moderate importance of the Bering Sea as a feeding area.

Changes in spotted seal prey, anticipated in response to ocean warming and loss of sea ice, have the potential for negative impacts, but the possibilities are complex. Some changes already documented in the Bering Sea and the North Atlantic Ocean are of a nature that could be ameliorative or beneficial to spotted seals. For example, several fish species, including walleye pollock, a common spotted seal prey, have shown northward distribution shifts and increased recruitment in response to warming, at least initially. These ecosystem responses may have very long lags as they propagate through trophic webs. Apparent flexibility in spotted seal foraging locations and habits may make these threats of lower concern than more direct impacts from changes in sea ice.

(2) Ribbon seal

In Alaska waters, ribbon seals are found in the open sea, on the pack ice, and only rarely on shorefast ice or land (Kelly 1988a). They range northward from Bristol Bay in the Bering Sea into the Chukchi and western Beaufort Seas (Fig. 4.2.3). During its whelping, mating, and pelage molt periods (late March through June), ribbon seals inhabit the Bering Sea ice front (Burns 1970, 1981b; Braham et al. 1984). They are most abundant in the northern part of the ice front in the central and western parts of the Bering Sea. As the ice recedes in May to mid-July the seals move farther to the north in the Bering Sea, where they haul out on the receding ice edge and remnant ice (Burns 1970, 1981b; Burns et al. 1981); most of the rest of the year is spent at sea. Although the current total population size is unknown, Ver Hoef et al. (In review) estimated 62,478 (95% CI 31,000 - 218,970) ribbon seals in a portion of their range within the eastern and central Bering Sea in 2007. Synoptic aerial surveys of the entire Bering and Okhotsk seas are scheduled for April and early-May of 2012 and 2013.

Satellite tracking data indicate that ribbon seals disperse widely and that ribbon seals of the Bering Sea population spend an estimated 9.5% of their time north of the Bering Strait, and about 21% of Bering Sea ribbon seals use the Chukchi Sea during the summer, open-water period (Fig. 4.2.4).

The year-round food habits of ribbon seals are not well known, in part because almost all information about ribbon seal diet is from the months of February through July, and particularly March through June. No diet samples have been collected for ribbon seals from either the Bering Sea or Sea of Okhotsk during the ice-free period (Shustov 1965), and only two stomach samples have been collected during mid-winter (Burns 1981b).

Frost and Lowry (1980) found that ribbon seal food habits in the spring in the Bering Sea varied by geographic location. The major prey were: walleye pollock in the south-central Bering Sea; eelpouts in the central Bering Sea; Arctic cod in the NBS. Walleye pollock were also consumed by ribbon seals in the NBS but were not the major prey. Several studies have indicated that young ribbon seals primarily consume small crustaceans (Popov 1982; Lowry 1985b). Fedoseev (2002) stated that first year ribbon seals eat mostly euphausiids and one- to two-year-olds mainly eat shrimp. Other fish prey species found in multiple studies were Arctic cod, Pacific cod, saffron cod, Pacific sand lance, smooth lumpsucker *Aptocyclus ventricosus*, eelpouts, capelin, and flatfish species (Frost and Lowry 1980; Burns 1981b; Bukhtiyarov 1990; Deguchi et al. 2004; Dehn et al. 2007). Cephalopods are also important prey for ribbon seals throughout their range.

Because there is little or no fishery activity near aggregations of ribbon seals when they are associated with ice, and they are highly dispersed in the remainder of the year, by-catch is unlikely to be a significant threat to ribbon seal populations. For the same reasons, competition from fisheries that reduce local abundance of ribbon seal prey is unlikely to be significant.

(3) Bearded seal

Bearded seals have a circumpolar distribution and 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 (Fig. 4.2.5). Bearded seals in Alaska tend to prefer shallow (less than 200 m) areas with 70% to 90% sea-ice coverage (Simpkins et al. 2003), and are typically more abundant 20-100 nmi from shore than within 20 nmi of shore (Bengtson et al. 2005), although high concentrations are found nearshore south of Kivalina, AK in the Chukchi Sea. A reliable population estimate for this stock is currently not available. However, based on studies by Ver Hoef et al. (2010), Fedoseev (2000), and Bengtson et al. (2005), Cameron et al. (2010) estimated about 125,000 bearded seals in the Bering Sea and 27,000 bearded seals in the Chukchi Sea.

During the breeding season in May-June, bearded seals in the Bering Sea are near the ice front, but usually farther north and in heavier pack ice than ribbon or spotted seals (Fiscus and Braham 1976; Braham et al. 1981). As the ice retreats in the spring, most adults in the Bering Sea are thought to move north through the Bering Strait where they spend the summer and early fall at the southern edge of the Chukchi and Beaufort Sea pack ice and at the wide, fragmented margin of multi-year ice (Heptner et al. 1976; Burns and Frost 1979; Burns 1981a; Nelson et al. 1984). A smaller number of bearded seals, mostly juveniles, remain near the coasts of the Bering and Chukchi Seas for the summer and early fall instead of moving with the ice edge (Burns 1967; Heptner et al. 1976; Burns 1981a). These seals are found in bays, brackish water estuaries, river mouths, and have been observed to travel up some rivers. As the ice forms again in the fall and winter, most seals move south with the advancing ice edge through Bering Strait and into the Bering Sea where they spend the winter (Burns and Frost 1979; Frost et al. 2008; Cameron and Boveng 2009).

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 south 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). Satellite tagging indicates that adults, subadults and to some extent pups focus on very localized feeding areas, often remaining in the same general area for weeks or months at a time (Cameron 2005; Cameron and Boveng 2009). At least some individuals return to the same locations year after year (Cameron and Boveng 2011). In 2009, one adult and two sub-adult bearded seals were tagged with satellite data recorders in Kotzebue, AK. Throughout much of the winter of 2009 and early-spring of 2010, all three seals occupied fairly distinct and localized areas, each about 50 nmi in diameter. One sub-adult foraged to the south and east of St. Matthew Island while the other sub-adult and adult preferred Norton Sound. Despite returning north again into the Chukchi Sea each summer, all three seals occupied the same Bering Sea locations in the winters of 2010 and 2011.

Bearded seals feed primarily on benthic organisms, which include epifaunal and infaunal invertebrates, and demersal fishes. They are also able to switch their diet to include schooling pelagic fishes, when advantageous (Finley and Evans 1983; Antonelis et al. 1994). They have a diverse diet, with a large variety of prey items taken throughout their circumpolar range (Finley and Evans 1983; Antonelis et al. 1994; Dehn et al. 2007). The bulk of their diet consists of relatively few prey types, primarily clams, and crustaceans like crab and shrimps, but fishes like sculpins, eelpouts, capelin, Arctic cod, polar cod *Arctogadus glacialis*, or saffron cod can also be significant (Burns and Frost 1979; Finley and Evans 1983; Nelson et al. 1984; Bukhtiyarov 1990; Antonelis et al. 1994; Dehn et al. 2007). Several studies indicate that bearded seals in the Bering and Chukchi Seas mainly consume crustaceans and mollusks and that fishes are much less important or even nonexistent in their diet (Johnson et al. 1966; Lowry et al. 1980; Fedoseev 2000). But other research in the same areas reported that fishes are an important, even primary, component of their diet (Kosygin 1971; Heptner et al. 1976; Lowry et al. 1979; Antonelis et al. 1994; Dehn et al. 2007). Although most studies found that clams were one of the most important prey items for bearded seals, Kosygin (1971) found that crustaceans occurred most frequently in the diet of seals sampled in the Bering Sea, fish were also important, but he did not find any evidence of clams. Quakenbush et al. (2010) reported that the consumption of fishes increased while fewer invertebrates were consumed in the 2000s compared to the 1960 and 1970s.

Seasonal changes in diet composition have been observed (Johnson et al. 1966; Burns 1967; Lowry et al. 1980; Finley and Evans 1983). Clams and fishes were more important in spring/summer months than in fall/winter; when shrimps (e.g., *Sabinea septemcarinata*) and brachyuran crabs (e.g., *Hyas coarctatus*) made up a greater proportion of the diet (Johnson et al. 1966; Burns 1967; Lowry et al. 1980; Nelson et al. 1984). Clams appear to be the most variable of the major prey types consumed by bearded seals;

with changes in the proportion of clams in the diet depending on age class, time of year, and location (Lowry et al. 1980). Other prey types also showed some seasonal variation. Shrimp were very important in the diet, from November to June and crabs were a major part of the diet from April through June (Johnson et al. 1966).

Changes in bearded seal diet over a 20 year period (1958-1979) were observed at locations in the Bering and Chukchi Seas. Lowry et al. (1980) indicated that the frequency of clams in the diet had declined by the end of the study period in the late 1970s. They suggested that the decline may have been due to the expansion of walrus in areas between Bering Strait and St. Lawrence Island. However, the lower availability of clams in the area may not have had a major effect on the bearded seal population because bearded seals have a variable diet and consume many other benthic prey items. For example, as the number of clams in the diet decreased, the proportion of shrimps increased.

Prey composition showed some variation with age in bearded seals (Lowry et al. 1980). Clams were more important to older seals and the importance of brachyuran crabs, sculpins, and flatfish also increased with age. Isopods, saffron cod and shrimps however, were more important to younger animals (Lowry et al. 1980; Nelson et al. 1984).

From 2002-2006, incidental mortalities of bearded seals were only observed in the BSAI pollock mid-water trawl fishery: two in 2006 for a mean annual mortality of one during this period (Allen and Angliss 2010). For indirect interactions, commercial fisheries, although not nonpelagic trawl, target a number of known bearded seal prey species, such as walleye pollock and cod. The extent these interactions affect the viability of bearded seal populations is unknown.

(4) Ringed Seal

Ringed seals have a circumpolar distribution and are found in all seasonally ice-covered seas of the Northern Hemisphere as well as in certain freshwater lakes (Fig. 4.2.6). Throughout their range, ringed seals have an affinity for ice-covered waters and are well adapted to occupying both shorefast and pack ice (Kelly 1988b). They remain in contact with ice most of the year and use it as a platform for pupping and nursing in late winter to early spring, for molting in late spring to early summer, and for resting at other times of the year.

In Alaskan waters, during winter and early spring when sea ice is at its maximal extent, ringed seals are abundant in the northern Bering Sea, Norton and Kotzebue Sounds, and throughout the Chukchi and Beaufort Seas. They occur as far south as Bristol Bay in years of extensive ice cover, but generally are not abundant south of Norton Sound except in nearshore areas (Frost 1985). Most ringed seals that winter in the Bering and Chukchi Seas migrate north in spring as the seasonal ice melts and retreats (Burns 1970) and spend summer in the pack ice of the northern Chukchi and Beaufort Seas, as well as in nearshore ice remnants in the Beaufort Sea (Frost 1985). During summer, ringed seals range hundreds to thousands of kilometers to forage along ice edges or in highly productive open-water areas. With the onset of freeze-up in the fall, ringed seal movements become increasingly restricted and seals that have summered in the Beaufort Sea are thought to move west and south with the advancing ice pack. Many seals disperse throughout the Chukchi and Bering Seas while some remain in the Beaufort Sea. Many adult ringed seals return to the same small home ranges they occupied during the previous winter. A reliable population estimate for this stock is currently not available.

Most ringed seal prey is small and preferred prey tend to be schooling species that form dense aggregations (Kovacs 2007). Ringed seals rarely prey upon more than 10-15 species in any one area, and not more than 2-4 species are considered as important prey (Węsławski et al. 1994). Gadid fishes, such as Arctic cod, saffron cod, and navaga *Eleginus nawaga* tend to dominate the diet from late autumn through early spring in many areas (Kovacs 2007). Other fishes reported to be locally important to ringed seals include smelt (*Osmerus* sp.) and herring (*Clupea* sp.) in the Sea of Okhotsk (Fedoseev 1965); sculpins (Cottidae) in the Chukchi Sea (Johnson et al. 1966); capelin, redfish (*Sebastes* sp.), and snailfish (*Liparis* sp.) around Greenland (Siegstad et al. 1998).

Invertebrates appear to become more important to ringed seals in many areas during the open-water season, and are often found to dominate the diets of young seals (Węsławski et al. 1994; Siegstad et al. 1998; Holst et al. 2001). Large amphipods (e.g., *Themisto libellula*), mysids (e.g., *Mysis oculata*), euphausiids (e.g., *Thysanoessa* spp.), shrimps (e.g., *Eualus*, *Lebbeus*, and *Pandalus* spp.), and squid (e.g., *Gonatus* sp.) are all commonly found in the diet of ringed seals.

Ringed seals were not believed to be significantly competing with or affected by commercial fisheries in the waters of Alaska (Frost 1985; Kelly 1988b). From 2002-2006, incidental mortalities of ringed seals were only observed in the BSAI flatfish trawl fishery: one mortality was observed in 2005 and one in 2006 for mean annual mortality of 0.46 during this period (Allen and Angliss 2010).

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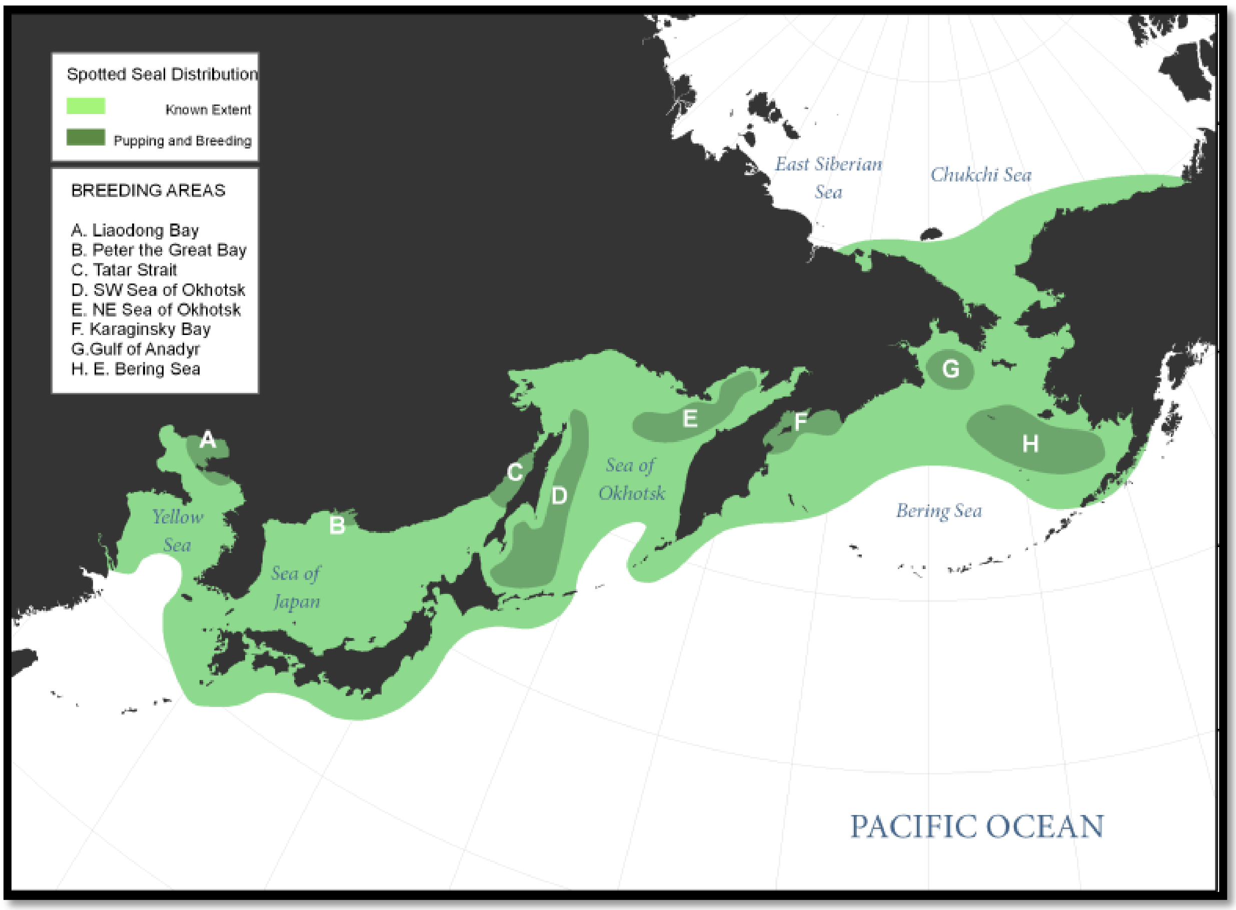

Figure 4.2.1. Approximate distribution of spotted seals.

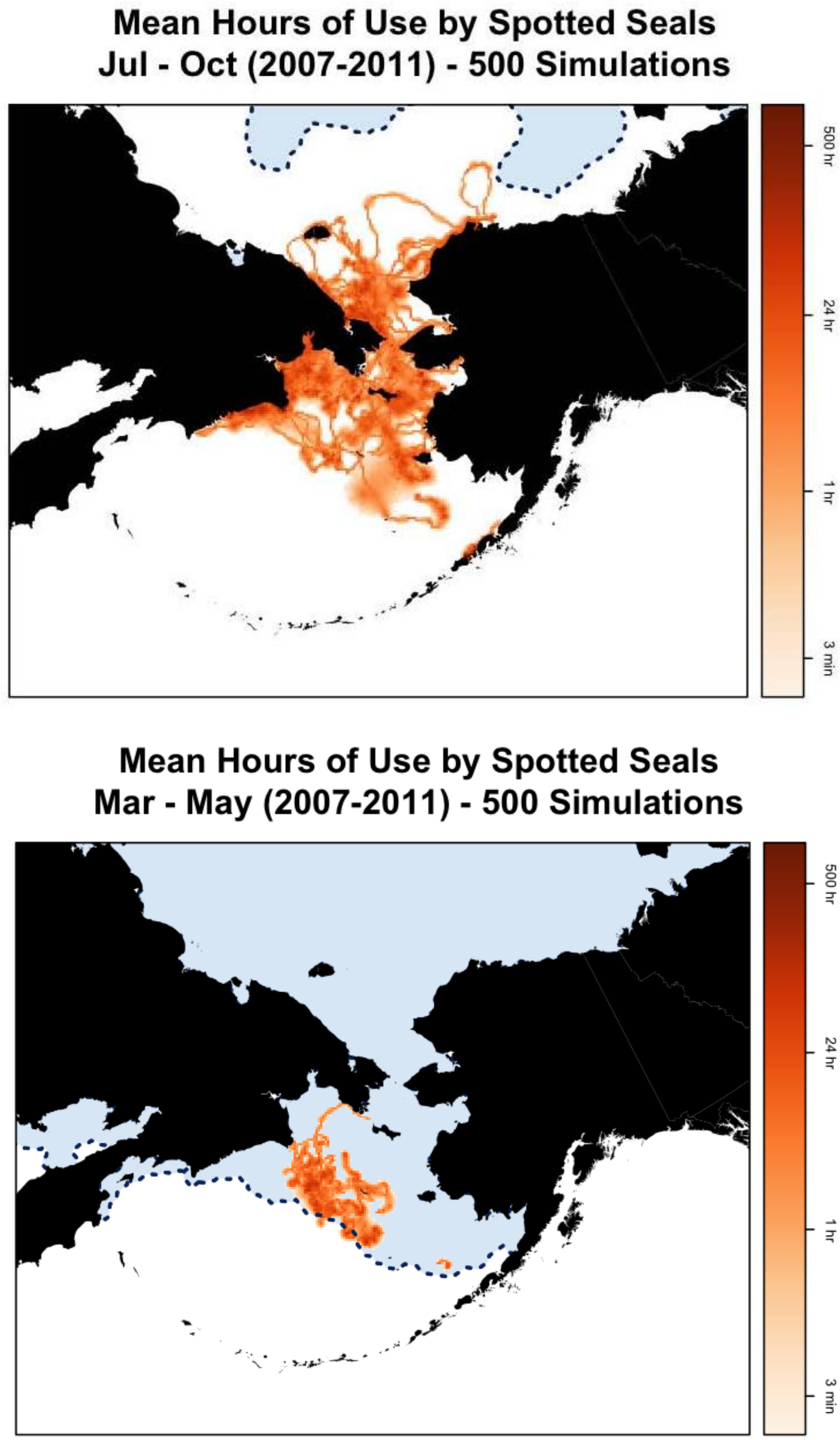

Figure 4.2.2. Use of the Bering and Chukchi Seas by spotted seals during the open water (Jul-Oct) and pupping/molt periods (Mar-May). Ice extent is indicated by the dashed line.

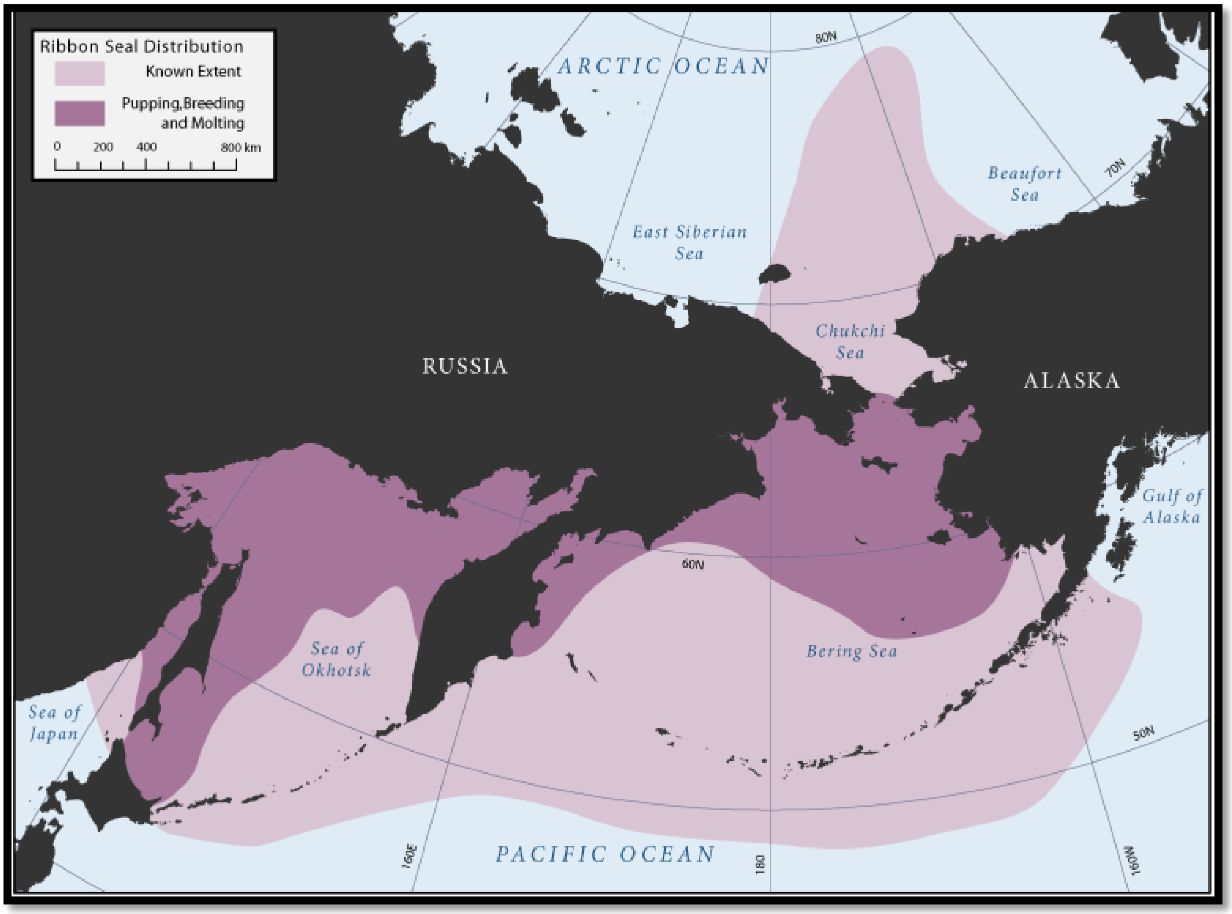

Figure 4.2.3. Approximate distribution of ribbon seals.

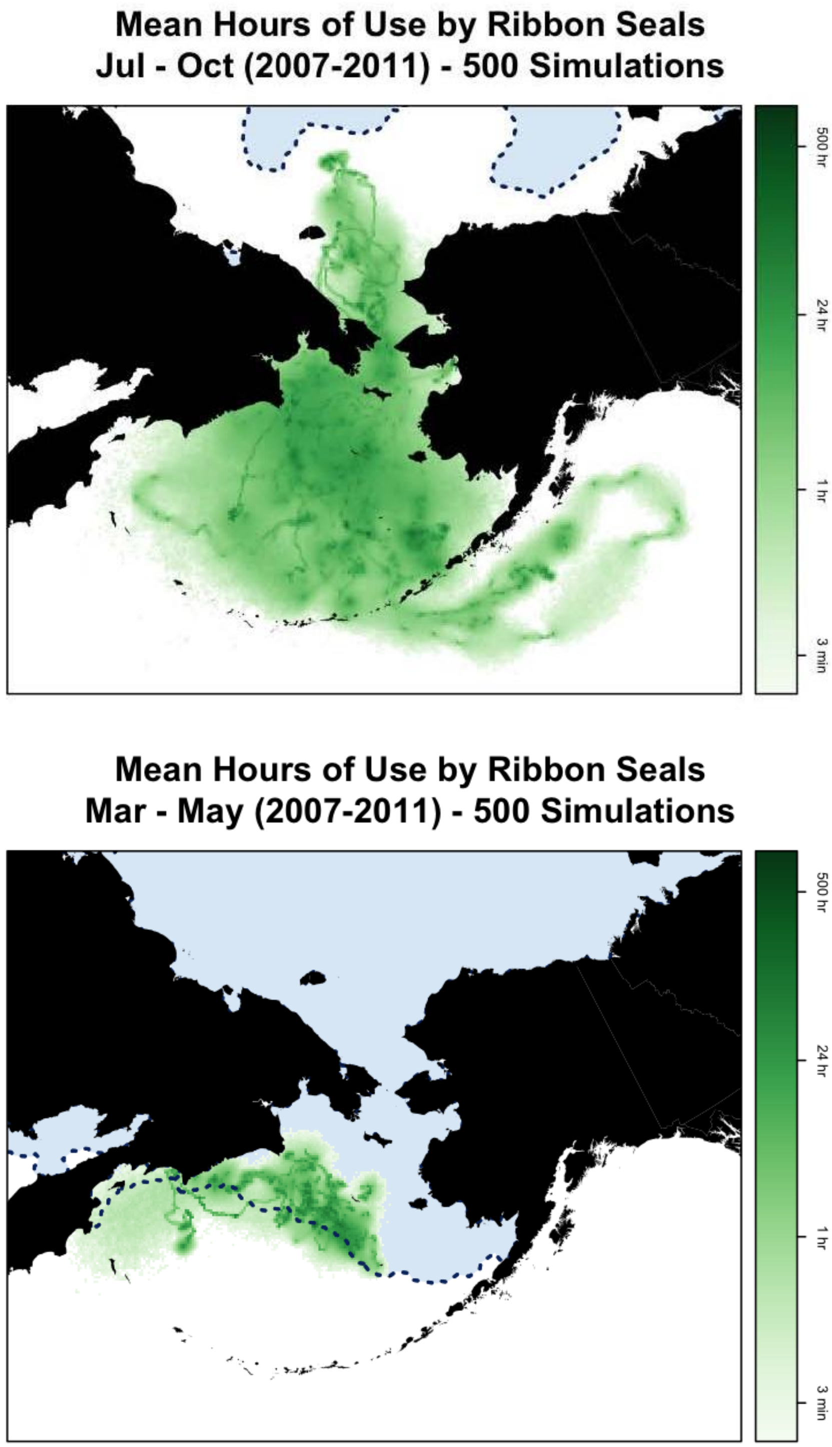

Figure 4.2.4. Use of the Bering and Chukchi Seas by ribbon seals during the open water (Jul-Oct) and pupping/molt periods (Mar-May). Ice extent is indicated by the dashed line.

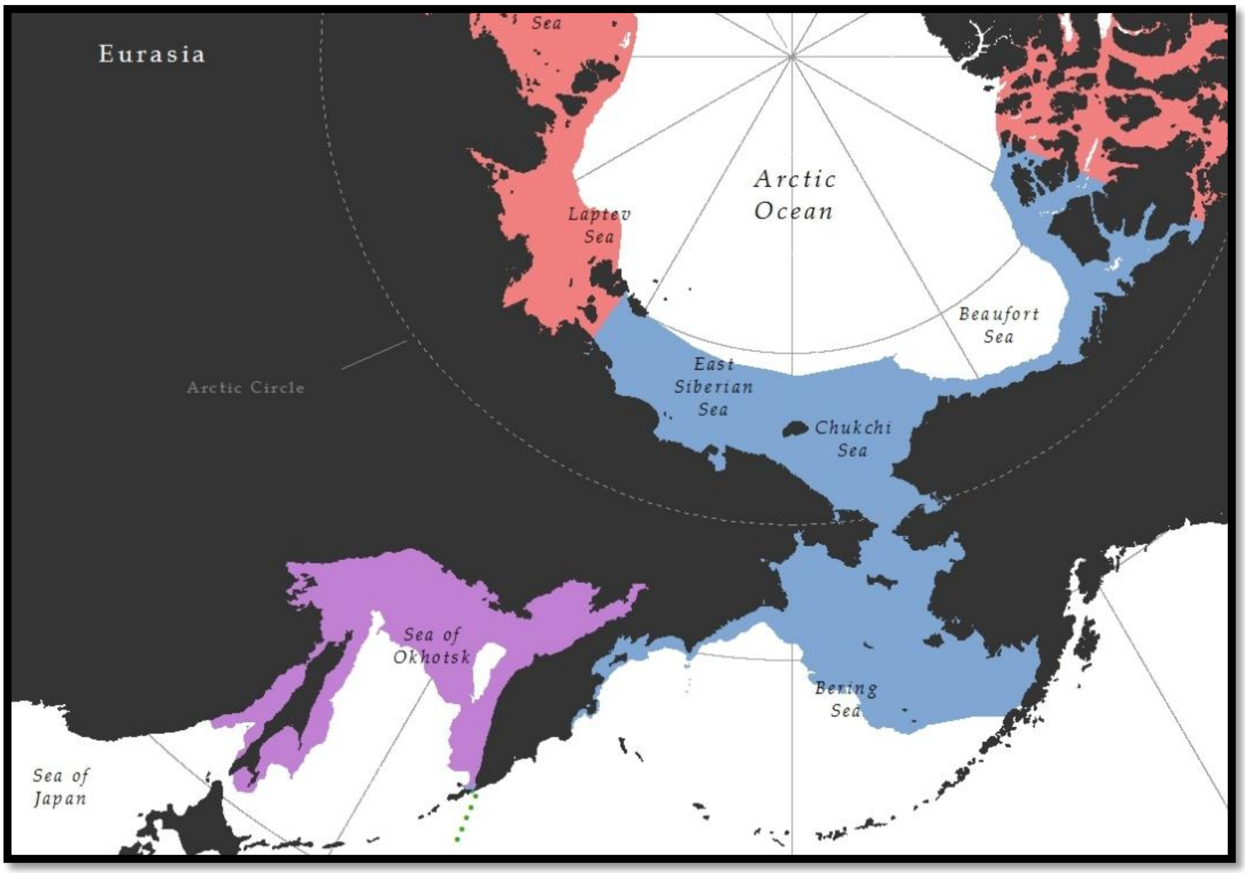

Figure 4.2.5. Approximate distribution of bearded seals. The Alaska stock is depicted in blue.

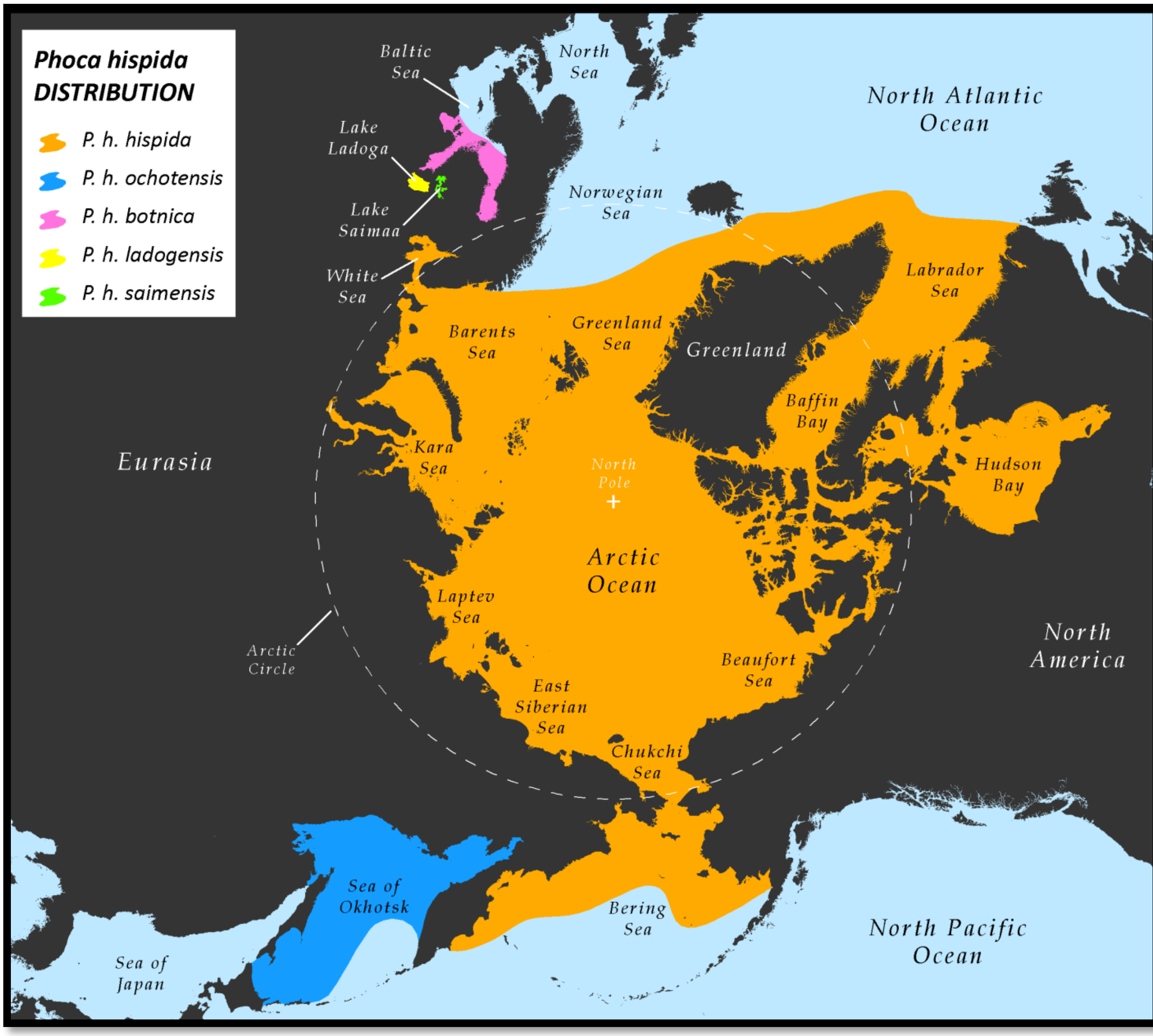

Figure 4.2.6. Approximate distribution of ringed seals. The Alaska stock of ringed seals is considered the portion of *Phoca hispida hispida* that occurs within the U.S. EEZ of the Beaufort, Chukchi, and Bering Seas.

4.3 Steller sea lion (*Eumetopias jubatus*)

The Steller sea lion population west of 144°W longitude (Western District Population Segment (DPS)) inhabit Alaska waters from Prince William Sound westward to the end of the Aleutian Island chain and into Russian waters (Fig. 4.3.1, NMFS Office of Protected Resources, http://www.nmfs.noaa.gov/pr/species/mammals/pinnipeds/stellersealion.htm). The western DPS occur throughout the Bering Sea, with terrestrial haulouts and rookeries on Pribilof Is., Aleutian Is., St. Lawrence Is., southwest Alaska, and all along the Alaska peninsula. They forage in marine waters for fish (e.g. capelin, cod, herring, mackerel, pollock, rockfish, salmon, sand lance), bivalves, squid, octopus, and mollusks. There are approximately 39,000-45,000 Steller sea lions in the Western DPS. The Western DPS declined by 75% between 1976 and 1990, and decreased another 40% between 1991 and 2000 (the average annual decline during this period was 5.4%). Since the 1970s, the most significant drop in numbers occurred in the eastern Aleutian Islands and the western Gulf of Alaska. The Western DPS is listed as endangered under the ESA, and classified as "strategic stock" and "depleted" under the MMPA.

Steller sea lions are harvested by natives in Alaska and Canada for subsistence (150-300 per year). They are also threatened by boat strikes, contaminants, habitat degradation, illegal hunting, and offshore oil and gas exploration. Direct fishing impacts are largely due to fishing gear (drift and set gillnets, longlines, trawls) that has the potential to entangle, hook, injure, or kill sea lions. They have been seen entangled in fishing equipment with what are considered "serious injuries". Between 2007-2009, there were incidental serious injuries and mortalities of western Steller sea lions in the following BSAI fisheries: Atka mackerel trawl, flatfish trawl, Pacific cod trawl, pollock trawl, and Pacific cod longline (Allen and Angliss 2012). The mean annual mortality in the BSAI flatfish (nonpelagic) trawl between 2007-2009 was six. The impact of incidental take by fisheries on Steller sea lion recovery is considered low. Indirect fisheries impacts include competition for food resources and possible modifications to critical habitat by fishing activities. The impact of competition with fisheries on Steller sea lion recovery is potentially high.

NMFS has implemented a complex suite of fishery management measures designed to minimize competition between fishing and the endangered population of Steller sea lions. Critical Habitat has been designated (50 CFR 226.202, Aug. 27, 1993) for Steller sea lions as a 20-nmi buffer around all major haul-outs and rookeries, as well as associated terrestrial, air, and aquatic zones, and three large offshore foraging areas (Fig. 4.3.2, NMFS Office of Protected Resources, http://www.nmfs.noaa.gov/pr/species/mammals/pinnipeds/stellersealion.htm). Three-nmi no-entry zones are also designated around rookeries (50 CFR 223.202). Groundfish (nonpelagic) trawling is prohibited in the Steller Sea Lion Critical Habitat at St. Lawrence and St. Matthew Islands in the NBS.

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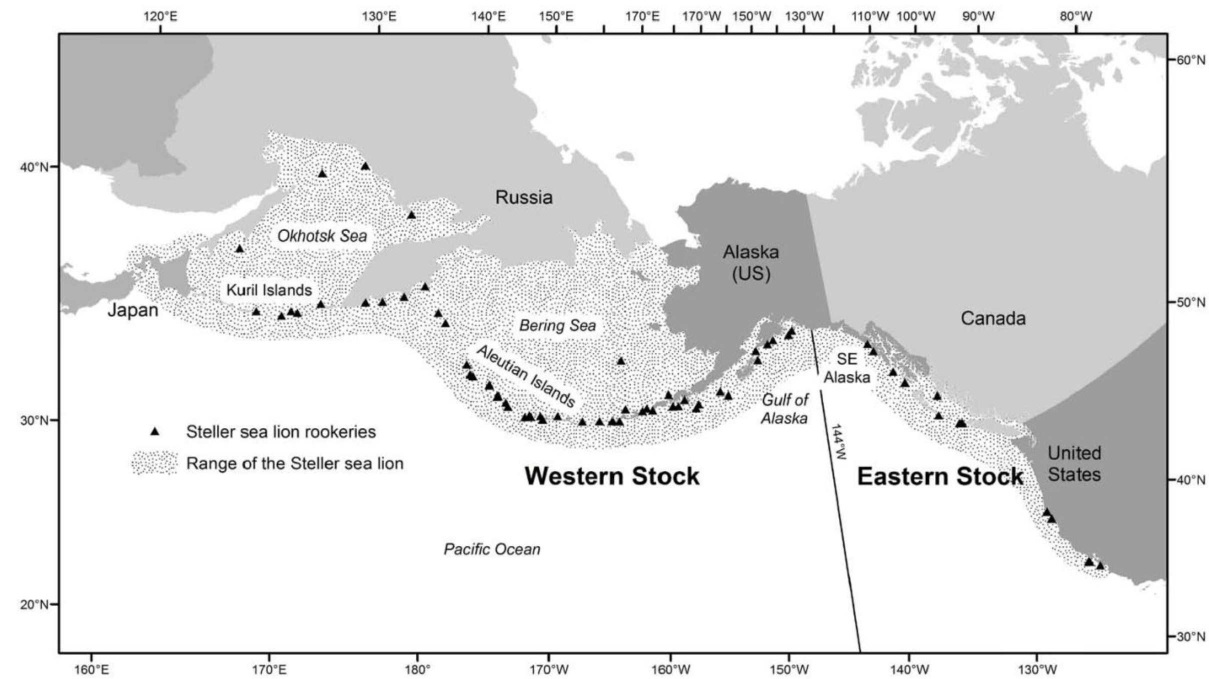

Figure 4.3.1. Steller sea lion distribution (NMFS Office of Protected Resources, http://www.nmfs.noaa.gov/pr/species/mammals/pinnipeds/stellersealion.htm)

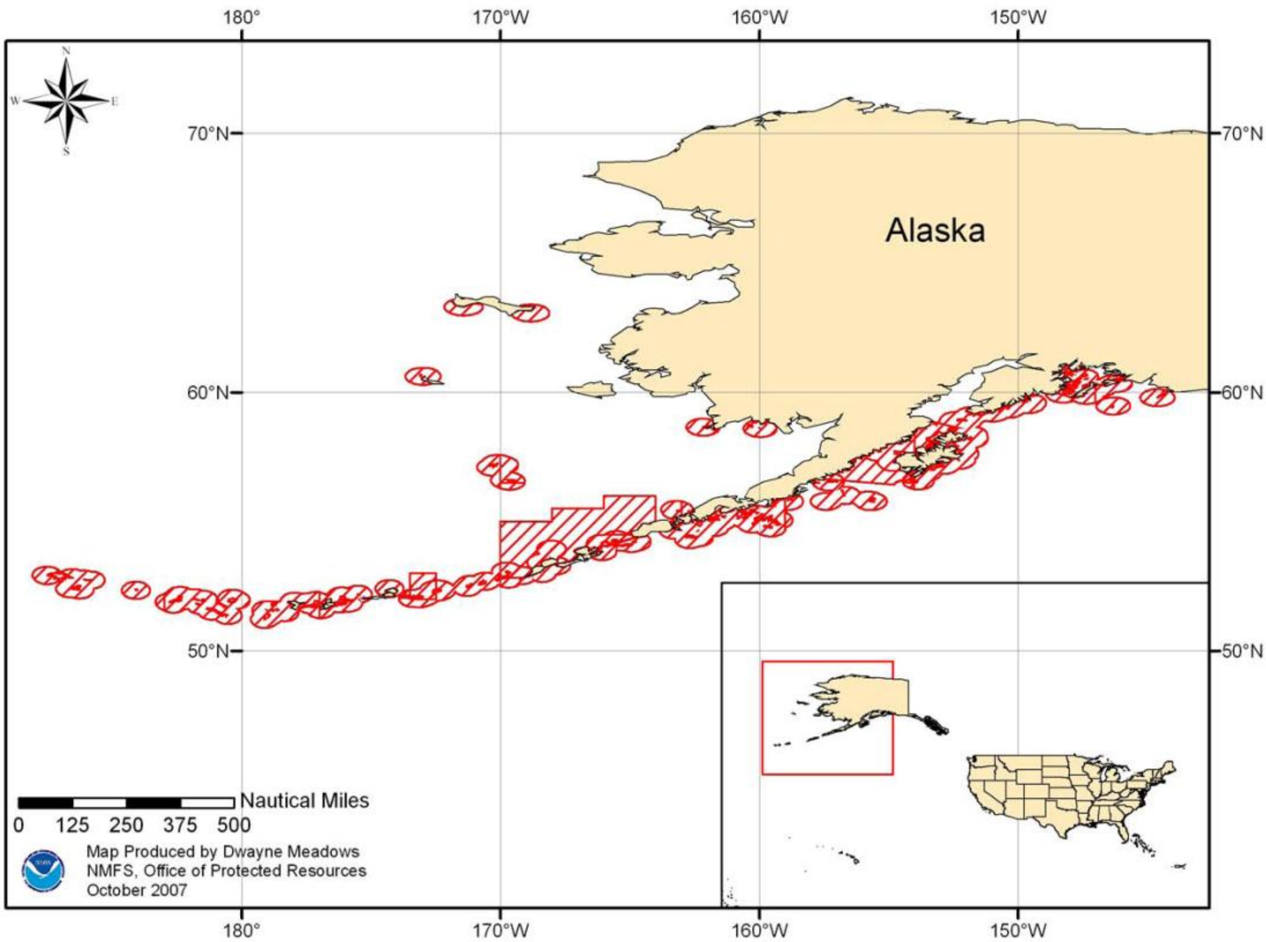

Figure 4.3.2. Steller sea lion Critical Habitat in Alaska

4.4. Pacific walrus (*Odobenus rosmarus*)

The Pacific walrus inhabit the arctic and subarctic continental shelf waters of the Chukchi and Bering seas. During the summer months most of the population migrates to the Chukchi Sea; however, several thousand animals, primarily adult males, aggregate near coastal haulouts in the Gulf of Anadyr, Bering Strait region, and in Bristol Bay. During the winter breeding season they are found in polynyas, generally in the areas from the Gulf of Anadyr to southwest of St Lawrence Island, and from south of Nunivak Island into northwestern Bristol Bay (Allen and Angliss 2010) (Fig. 4.4.1).

Walruses are highly specialized benthic (ocean bottom) feeders. Bivalve mollusks (clams) are their most common food; however, other invertebrates such sea cucumbers, crabs, and segmented worms are also frequently found in their stomachs. Walrus frequently feed at night and in murky water, suggesting that the sensitivity of their whiskers may be more important than vision in locating food items. Walrus feed intermittently, hauling out on land or ice floes to rest between foraging bouts. Feeding trips can last up to several days, during which they dive to the bottom nearly continuously. Most feeding dives last between five and ten minutes, with a relatively short surface interval of one to two minutes (USFWS Walrus Fact Sheet, http://alaska.fws.gov/fisheries/mmm/walrus/pdf/Walrus_FS.pdf).

The Pacific walrus is under the management of the USFWS, who monitors and mitigates potential impacts of human activities on walrus and polar bears through incidental tale regulations (ITR) as authorized under the MMPA. Oil and gas activities in the Chukchi Sea exist in a particularly important habitat for female walrus and their dependent young. Subsistence harvest by Russian and U.S. communities of Bering and Chukchi seas ranged from 3 to 16 thousand per year for the past five decades. Recent harvests trend towards the lower end of the range. Pacific walrus occasionally interact with trawl and longline gear of groundfish fisheries. There was no reported incidental injury during the 5-year period of 2002-2006. One incidental mortality was reported for the BSAI flatfish nonpelagic trawl fishery for the period. Serious injury is estimated to be zero (Allen and Angliss 2010) .

Extensive and rapid loss of sea ice in the Arctic is projected to negatively impact the Pacific walrus population (Jay et al. 2011). Broken sea ice provides a platform for resting within access to offshore feeding areas. Reliance on coastal haulout increase potential injury and disturbance through human activities. The effects of ocean warming, loss of sea ice, and ocean acidification on benthic prey production are unpredictable and may vary locally. Nonpelagic trawling could possibly impact the benthic prey of the Pacific walrus but the direction and extent have not been studied in detail and are difficult to predict. Trawling may reduce benthic prey or may change the composition of the benthic community.

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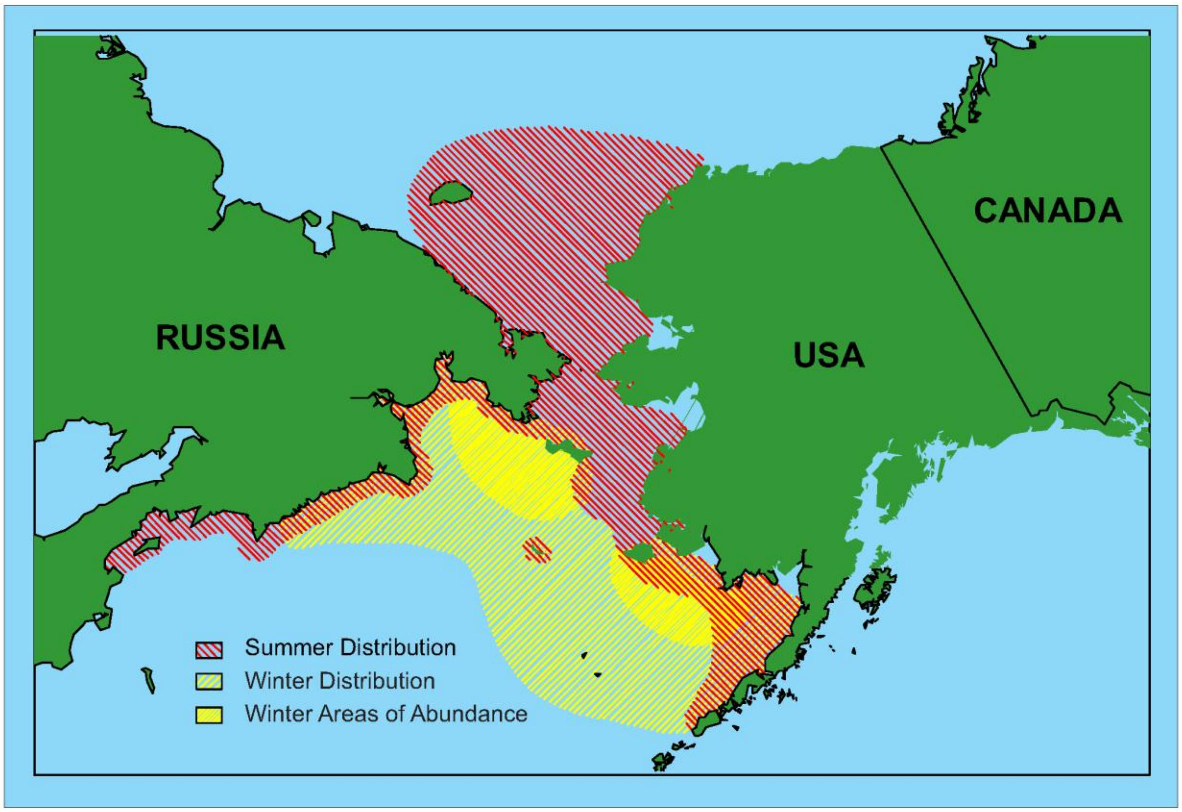

Figure 4.4.1. Pacific walrus distribution (adapted from USFWS Walrus Fact Sheet, http://alaska.fws.gov/fisheries/mmm/walrus/pdf/Walrus_FS.pdf).

4.5. Crabs

Three species of crab that are commercially fished in the eastern Bering Sea also inhabit the NBSRA. These include the red king crab (*Paralithodes camtschaticus*), the blue king crab (*Paralithodes platypus*), and snow crab (*Chionoecetes opilio*). Commercial stocks of red king crab are confined to Norton Sound but they are also found along the coast in the warmer waters of the NBSRA (Fig. 4.5.1, Chilton et al. 2011; Soong and Hamazaki 2012). Blue king crab are found over a broader area in discreet concentrations around St. Matthew Island on the southern edge of the NBSRA, around St. Lawrence Island and King Island and also off the southwest coast of the Seward Peninsula as far north as Little Diomede Island (Fig. 4.5.2, Kohler and Soong 2005; Chilton et al. 2011; Herter et al. 2011). Snow crab are widely distributed throughout the western portion of the NBSRA with the highest densities to the north and southwest of St. Lawrence Island (Fig. 4.5.3, Chilton et al. 2011). The federal management plan for king and Tanner crab in the Bering Sea establishes a State/Federal cooperative management regime that defers crab management to the State of Alaska with Federal oversight (NPFMC 2011a).

(1) Red King Crab

The Norton Sound red king crab stock (RKC) is one of the most northerly commercially harvestable stocks (Powell et al. 1983) with the majority of the harvest occurring during the large boat summer fishery. Approximately 25 vessels participate, harvesting 1.3 million crab (NPFMC 2011b). A small commercial fishery also occurs during the winter through the ice using hand lines and pots with an average harvest during the years 1978-2007 of 2,400 crab (Soong 2007). In addition, Norton Sound RKC supports a winter subsistence fishery which also uses hand lines and pots. From 1984-2005, ADF&G issued an average of 69 subsistence permits per year with a yearly harvest of 5,350 crab (Soong and Kohler 2005).

Conducting research in the area is challenging, making basic RKC life history data difficult to obtain (Howard and Hamazaki 2012). Norton Sound RKC mature at a smaller size and do not attain as large a maximum size as more southerly stocks (Otto et al. 1990). It is unknown, however, how other life history parameters differ between Norton Sound and other stocks (Howard and Hamazaki 2012). It is thought this RKC stock migrates between deeper offshore waters during molting/feeding and inshore shallow waters during the mating period (NPFMC 2011b) but this is not known definitively due to a lack of seasonal surveys (Soong 2008). Timing of the migrations is not known exactly but it is assumed that the inshore migration for mating occurs in March-June, and the offshore migration occurs in May-July (Howard and Hamazaki 2012). It is likely that these crabs form large pods during various stages of their life, similar to RKC in other parts of their range (Dew 1990).

(2) Blue King Crab

There have been very limited commercial harvests of blue king crab (BKC) from within the NBSRA (the St. Matthew BKC fishery takes places just south of the NBSRA). Harvests have occurred near the southeast coast of St. Lawrence Island, with a peak harvest of 52,557 pounds in 1983. In 1984, regulations were implemented by the Alaska Board of Fisheries to close all waters within 10 miles of the island to commercial crab harvest to protect the subsistence crab fishery and reduce impacts on marine mammal subsistence harvests (Kohler and Soong 2005). Since then only 12 deliveries averaging 746 pounds have been made. The most recent landing was made in 1995 (Menard et al. 2011). Villagers in the area have long taken BKC in the winter for subsistence both for trade and sale to other villagers but good records of the fishery are not available (Magdanz and Olanna 1985; Kohler and Soong 2005). Current regulations allow the sale of subsistence BKC caught nearshore.

Blue king crab are similar to RKC in morphology and life history (Jensen and Armstrong 1989; Klitin and Nizyaev 1999) with habitat being the main factor separating the species. Red king crab prefer relatively shallow, muddy or sandy substrates while BKC prefer deeper areas of cobble, gravel, or rock. Female BKC tend to aggregate in shallow water (10-80 m) for mating and brooding eggs from spring to summer but then move to deeper waters (130-180 m). Males move shallow to mate in the spring but otherwise would be found in deeper water (120-250 m) (Pereladov et al. 2002).

(3) Snow crab

Snow crab are generally found in denser concentrations in the NBSRA than on the Bering Sea shelf to the south. The 2010 NMFS survey caught on average 5.5 times more snow crab per nautical mile^2 in the NBSRA than in the survey area further to the south. The crabs, however, were smaller. No crab over the current minimum marketable size of 102 mm carapace width was seen in the NBSRA. Because of the small size of the crab and the distance from processors, very little commercial harvest of snow crab takes place in the NBSRA. For the years 1985-2010, only 0.03% of the Bering Sea landings came from the NBSRA (source: ADF&G fish ticket database). This situation could be altered if climate change brings warmer waters to the area as size of snow crab is positively correlated with temperature (Orensanz et al. 2007; Burmeister and Sainte-Marie 2010).

Snow crab life history and movements have been studied extensively in other parts of their range including the Bering Sea (Ernst et al. 2005; Orensanz et al. 2007; Parada et al. 2010; Ernst et al. 2012), Atlantic Canada (Sainte-Marie and Hazel 1992; Sainte-Marie et al. 1995), Greenland (Burmeister and Sainte-Marie 2010), and Japan (Yasuda 1967; Atsushi et al. 2011). The complex mating system of the snow crab has been recently reviewed by Sainte-Marie et al. (2008). Snow crab populations are characterized by recruitment pulses, increasing size with temperature, and preference for cold waters of -1.5^{o} to 4^{o} C year-round (Orensanz et al. 2004; Burmeister and Sainte-Marie 2010). It is assumed that female snow crab aggregate into mounds, similar to Tanner crab *Chionoecetes bairdi* (Stevens et al. 1994; Sainte-Marie et al. 2008). Despite detailed studies from other parts of the snow crab range, little research has been conducted on snow crab in the NBSRA.

Potential trawl impacts on crab

Researchers in Alaska have long been concerned about the effect that trawl nets have on the crab they encounter (Donaldson 1990; Stevens 1990). It is even hypothesized that intensive trawl harvest may have led to the abrupt collapse of the Bristol Bay RKC population in the early 1980s (Dew and McConnaughey 2005). These concerns led to the closure of large portions of the eastern Bering Sea to non-pelagic trawls (Armstrong et al. 1993). However, the actual mortality rates caused by non-pelagic trawl nets on crab are difficult to determine.

It would be expected that trawling in the NBSRA would have similar impacts on crab as those seen in the eastern Bering Sea and elsewhere. Repeated trawling in an area has been shown to significantly reduce the biomass of snow crab and other large epibenthic fauna (Prena et al. 1999). While some studies have shown injury rates as low as 2.5% for RKC encountering a trawl net (Donaldson 1990), other studies have shown higher injury and mortality rates. Overall mortality rates for crab encountering a flatfish trawl net were estimated to be 6% for snow crab and 11% for RKC but rates vary depending which part of the net passes over the crab. For RKC passing under the footrope wing, the mortality rate was estimated to be over 30% (C. Rose, unpublished data). Nonpelagic trawl nets would be particularly damaging to crab populations if they encountered pods of RKC or snow crabs mounded into spawning aggregates.

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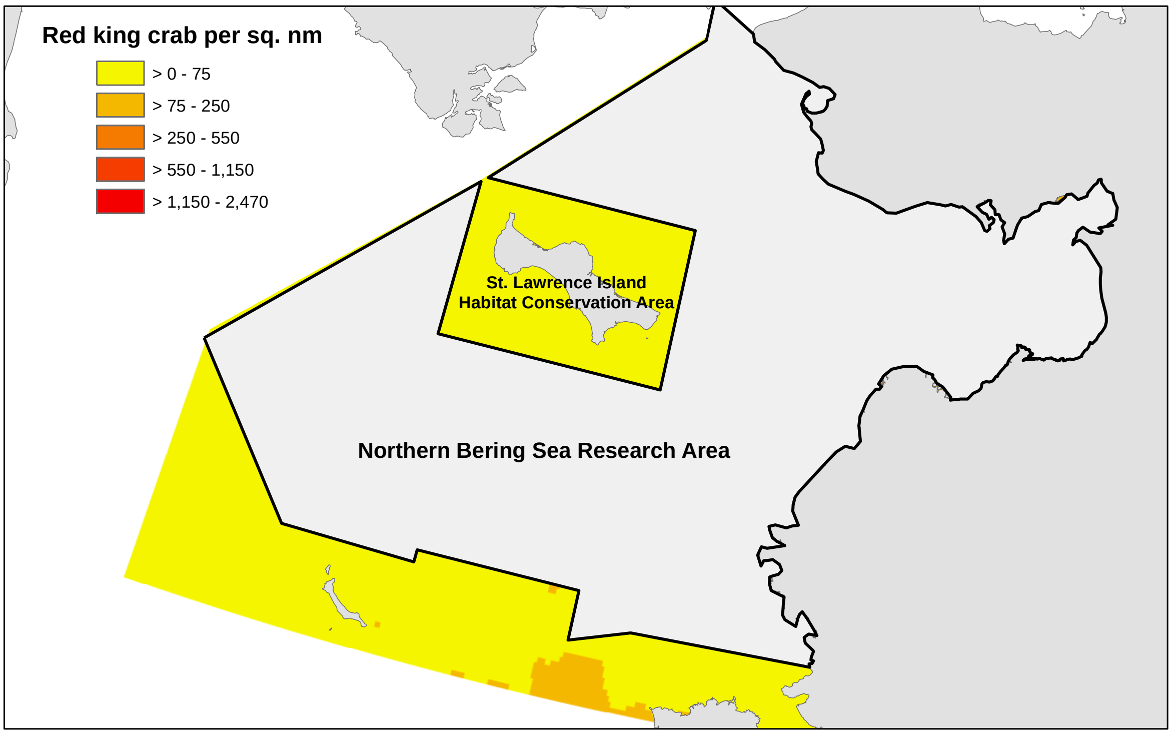

Figure 4.5.1. Number of red king crab captured per nmi^2 during the NMFS AFSC 2010 bottom trawl survey.

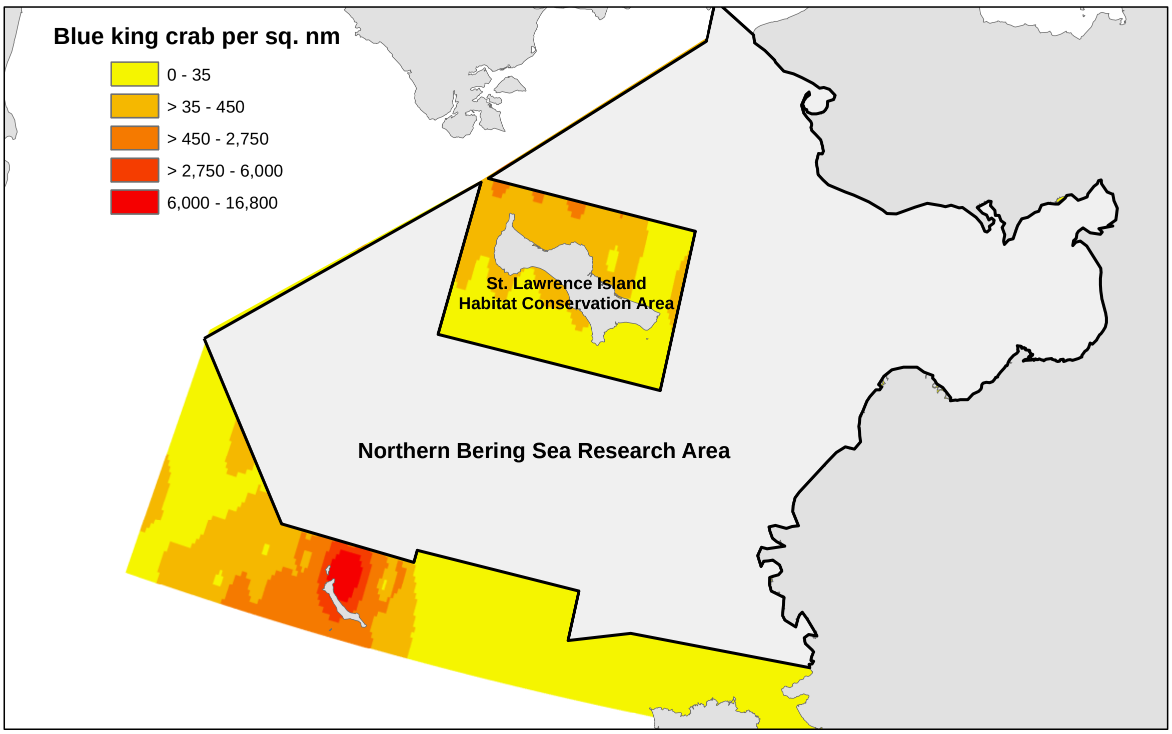

Figure 4.5.2. Number of blue king crab captured per nmi^2 during the NMFS AFSC 2010 bottom trawl survey.

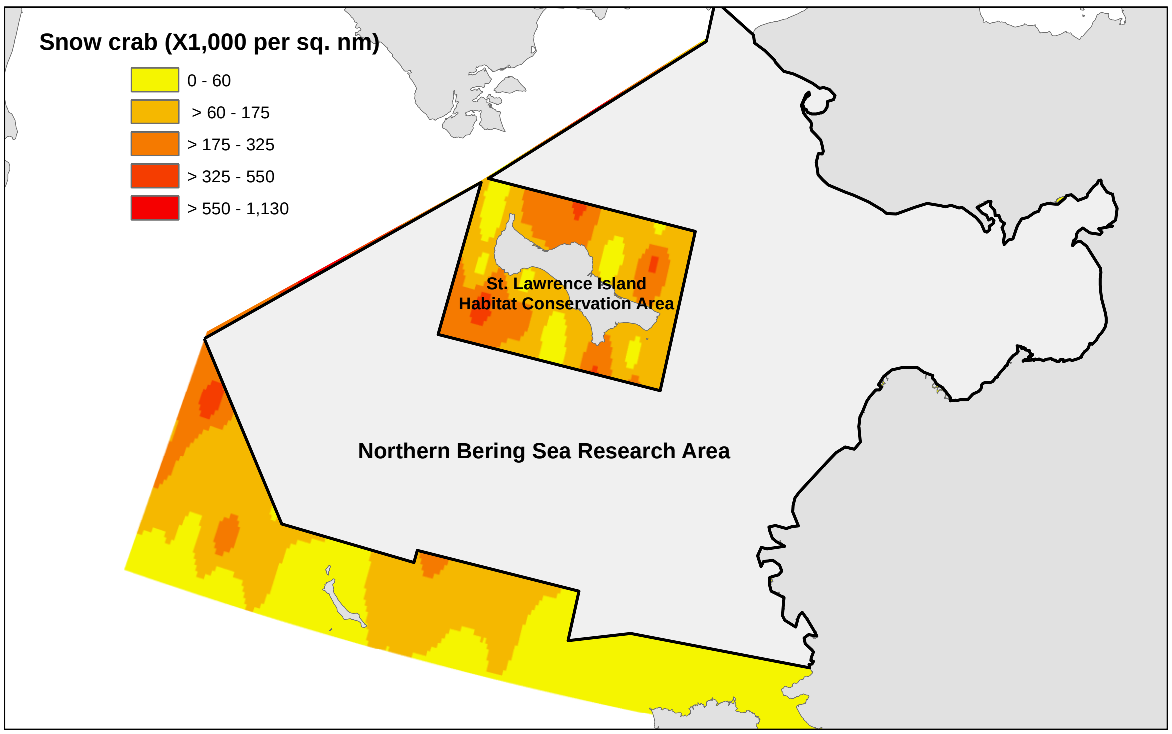

Figure 4.5.3. Number of snow crab captured per nmi^2 during the NMFS AFSC 2010 bottom trawl survey.

4.6. Salmon

The five salmon species that occur in the Bering Sea are Chinook/king (*Oncorhynchus tshawytscha*), chum/dog (*O. keta*), coho/silver (*O. kisutch*), sockeye/red (*O. nerka*), and pink/humpback (*O. gorbuscha*) (Echave et al. 2012). They range from the North Pacific Ocean to the Chukchi Sea in U.S., and in adjacent international waters. Spawning occurs in the fall in freshwater. Juveniles migrate to the ocean and grow to maturity. They utilize both nearshore and offshore habitats depending on species, origin, and age. Most salmon species leave the Bering Sea in winter, migrating southward through the Aleutian passes to the North Pacific Ocean. Timing and route of migration are varied and not well known (National Research Council 2004). They may move offshore or remain nearshore in their migration through the Bering Sea. Western Alaska Chinook salmon are an exception. They may spend their entire ocean life in the Bering Sea. Salmon return to the rivers to spawn between summer and fall (Murphy and Farley 2012).

Relatively high densities of juvenile pink and chum salmon were observed around St. Lawrence Island, the Bering Straits and Chukchi Sea in the 2007 BASIS survey (Moss et al. 2009)(Fig. 4.6.1-4.6.2). In coastal waters, juvenile salmon were usually less than 15 m from the surface. In offshore waters, salmon were usually within the top 40 to 60 m, above the thermocline, but occasionally were found from 80 to 120 m. They usually were nearer the surface at night, and migrated deeper during the day (Walker et al. 2007). Salmon pursue mainly fish (e.g. juvenile pollock) and other nektonic prey (e.g. crab megalopa, euphausiids, squid).

Salmon runs along the western Alaska coast sustain local communities (Wolfe and Spaeder 2009). In the NBS, subsistence salmon fishing is practiced by communities of the Norton Sound-Port Clarence districts, including St Lawrence Island. A limited commercial salmon fishery occurs in six communities in the Norton Sound district. The commercial fishery in the NBS is similar in nature to the subsistence fishery, carried out mostly by local native Alaskans with small boats nearshore in state waters (Magdanz et al. 2009). These fisheries are managed by the ADF&G.

Climate change and nonpelagic trawling impact

How and whether climate change will impact salmon productivity is uncertain (Kruse 1998; Shuntov and Temnykh 2009). Warmer sea surface temperatures seemed to increase salmon productivity, but climate change impacts on salmon are expected to be complex. The impacts may act through altered prey and predator dynamics or directly on salmon physiology. The impacts may also vary by salmon species, age, and area (Farley et al. 2009; Mantua 2009; Ruggerone and Nielsen 2009). Thus, it is concluded that the specific impacts of climate change on salmon cannot currently be assessed (NMFS 2012).

Nonpelagic trawl interaction with salmon is rare. For the BSAI in 2012 through July, the bycatch rate for chinook and non-chinook salmon by non-pelagic trawl is <0.2 fish per haul (http://www.fakr.noaa.gov/2012/pscinfo.htm). Nonpelagic trawl, usually for flatfish, does not operate in shallow waters nearshore, nor fish the pelagic layer where salmon are distributed. Salmon do not depend heavily on benthic habitat and prey which may be impacted by nonpelagic trawl, although diets, especially of juveniles, can vary (Farley et al. 2009). Nonpelagic trawling is thus unlikely have a significant impact on salmon in the NBS.

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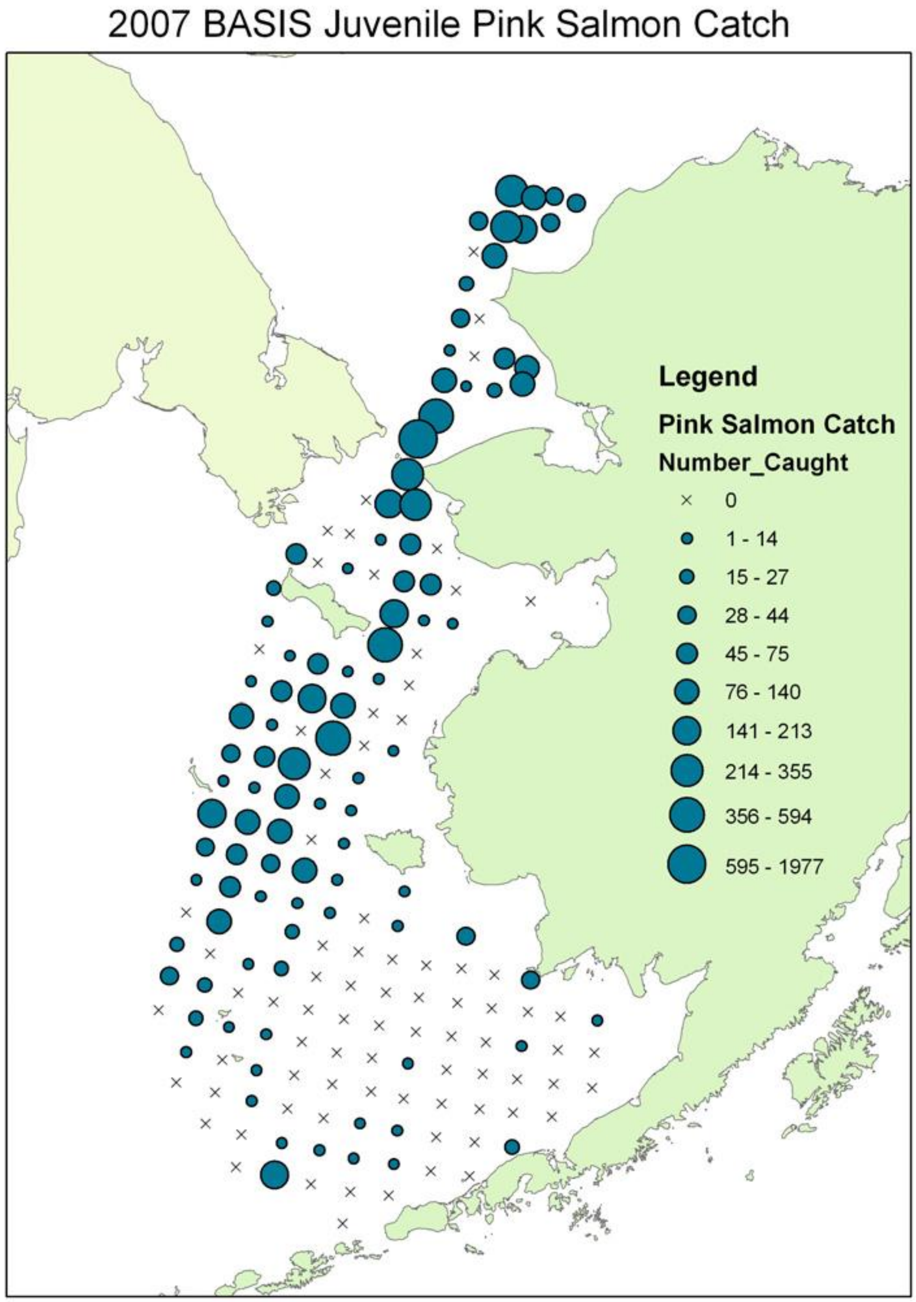

Figure 4.6.1. Relative abundance of juvenile pink salmon inhabiting the eastern Bering Sea, Bering Strait, and Chukchi Sea during late August and early September 2007. Circle size represents catch per unit effort for a 30-minute surface trawl (Figure 2, Moss et al. 2009).

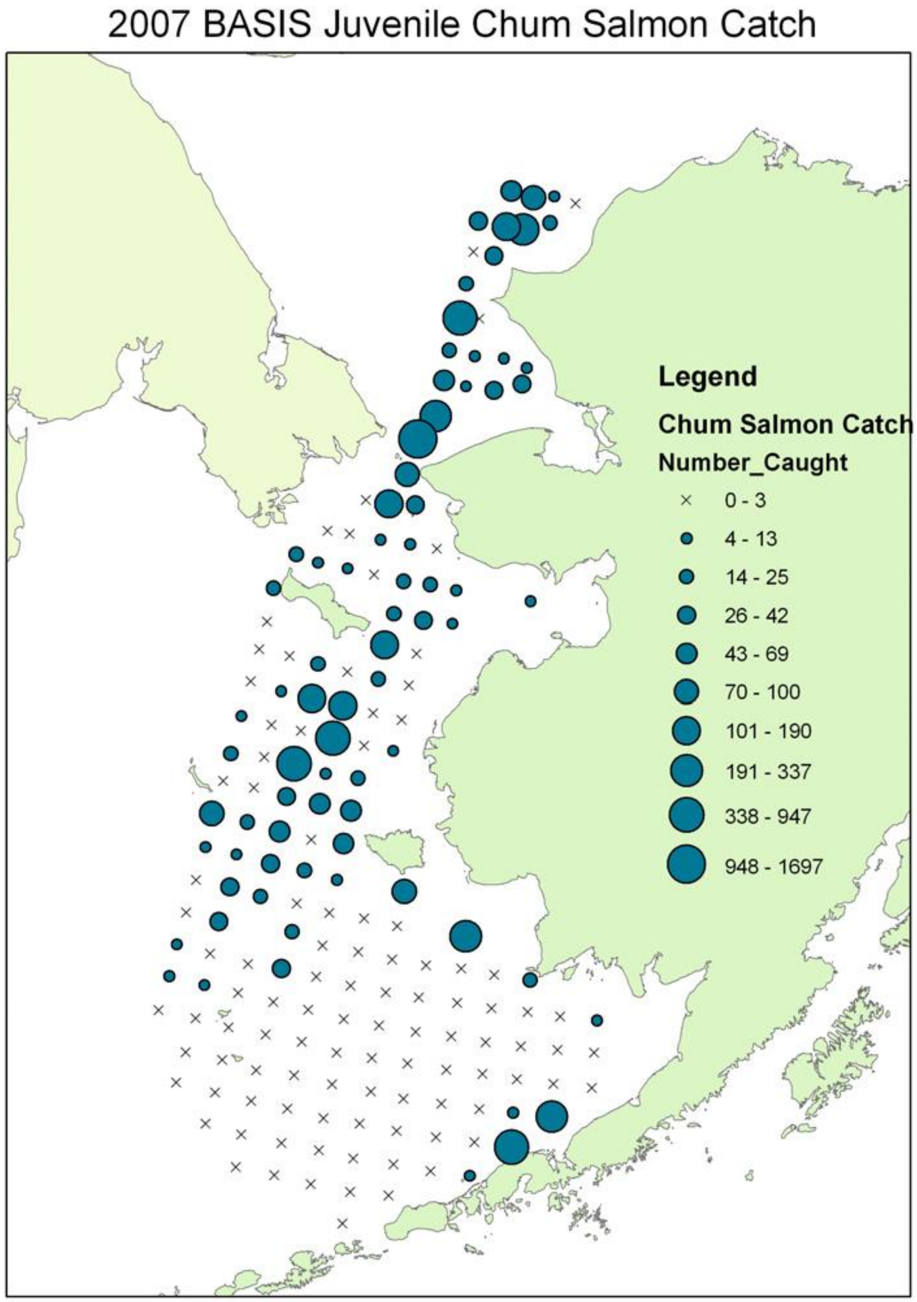

Figure 4.6.2. Relative abundance of juvenile chum salmon inhabiting the eastern Bering Sea, Bering Strait, and Chukchi Sea during late August and early September 2007. Circle size represents catch per unit effort for a 30-minute surface trawl (Figure 2, Moss et al. 2009).

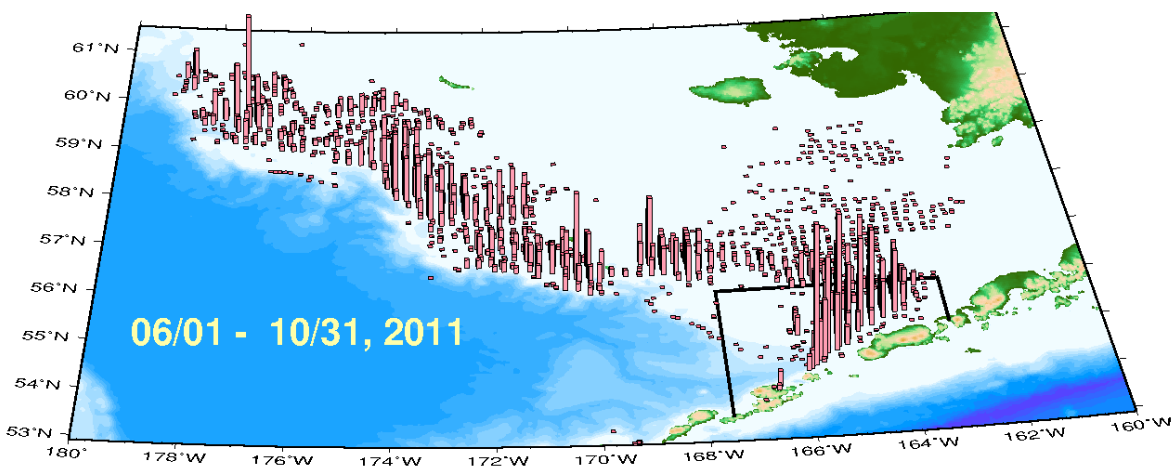

Figure 4.6.3. Pollock catch distribution during June-December 2011. The line delineates the catcher-vessel operational area (CVOA) and the height of the bars represents relative removal (Figure 1.5, p. 119, NPFMC 2011).

4.7. Seabirds

Seabird breeding populations in the Bering Sea are estimated at 36 million birds, and total population size (including breeding and non-breeding birds) is estimated to be approximately 30 percent higher. More than 30 species of seabirds occur in the BSAI, including resident species, migratory species that nest in Alaska, and migratory species that occur in Alaska only outside of the breeding season. A list of species present in the BSAI is provided in Table 4.7.1. Seabirds are managed by the USFWS, who maintains the North Pacific Pelagic Seabird Database (NPPSD) with information and maps of seabird distributions, observations, habitat use (http://alaska.usgs.gov/science/biology/nppsd/products.php#lit).

ESA-listed seabirds in the Bering Sea

Three species of ESA-listed seabirds live in the Bering Sea: the endangered short-tailed albatross (STAL), and the threatened Steller's eider (STEI) and spectacled eider (SPEI).

(1) Short-tailed albatross (*Phoebastria albatrus*)

The short-tailed albatross once ranged throughout most of the North Pacific Ocean and Bering Sea. Short-tailed albatross populations were decimated by feather hunters and volcanic activity at nesting sites in the early 1900s, and the species was considered extinct by 1949. In 1952, a small colony of 25 birds was discovered on Toroshima Island, Japan. Toroshima is an active volcano located southeast of Japan, and is the only known breeding colony for STAL. Prohibition of hunting and habitat enhancement have allowed the population to grow at approximately 7-8% per year based on egg counts from 1990 to 1998, however the volcanic nature of this island places the only known rookery at great risk. To alleviate some of this risk, an international, collaborative effort was initiated to relocate STAL chicks to a safer island within their historic breeding range in hopes that they would establish a new colony there. In February, 2008 ten STAL chicks were moved from Toroshima Island to Mukojima Island. All ten chicks fledged successfully. Recently, one of the fledged chicks returned to Mukojima, a promising sign that the chicks may return to Mukojima to breed.

Short-tailed albatross feed at continental shelf breaks and areas of upwelling and high productivity (U.S. Fish and Wildlife Service 2008). Although recent reliable diet information is lacking, STAL likely feed on squid and forage fish (U.S. Fish and Wildlife Service 2008). Piatt et al. (2006) described STAL hotspots as areas characterized by vertical mixing and upwelling caused by currents and bathymetric relief which persist over time. In the Bering Sea, such hotspots occur at Zhemchug, Pervenets, and Pribilof Canyons along the continental shelf, and near St. Matthew Island. A single STAL flock was noted at Prevenets Canyon in 2004, which was estimated to contain approximately 10% of the known world's population.

Because the STAL population is increasing at approximately 7% per annum (Zador et al. 2008), the potential for interaction with North Pacific fisheries is also increasing. However, recent modeling of the impacts of trawling (Zador et al. 2008) suggests that maintaining existing take limits (4 observed takes during a two-year reporting period) are sufficient to achieve the species' proposed recovery goals, barring catastrophic stochastic events at the breeding colony.

(2) Steller's eider (*Polysticta stelleri*)

Steller's eiders are diving ducks that spend most of the year in shallow, nearshore marine waters. Molting and wintering flocks congregate in protected lagoons and bays, rocky headlands, and inlets. Steller's eiders feed by diving and dabbling for mollusks and crustaceans in shallow water. In summer they nest on coastal tundra adjacent to small ponds or within drained lake basins. During the breeding season they feed on aquatic insects and plants in freshwater ponds and streams.

There are five distinct areas of critical habitat in western Alaska: Izembeck, Nelson, Seal Island, Kuskokwim Shoals, and the Yukon-Kuskokwim (Y-K) Delta (Final Determination of Critical Habitat for the Alaska-Breeding Population of the Steller's Eider, 66(23) FR 8850, February 2, 2001; http://www.gpo.gov/fdsys/pkg/FR-2001-02-02/pdf/01-1334.pdf; Fig. 4.7.1). Current nesting habitat in Alaska consists of a portion of the central Arctic coastal plain between Wainwright and Prudhoe Bay, primarily near Barrow. Biologists estimate that the total world's population of STEI is approximately 220,000 birds, the majority of which nest in Russia. The number of pairs nesting in Alaska's Arctic coastal plain is roughly estimated at 1,000. Overall the world's population of STEI may have decreased by as much as 50% over the last 30 years. At least 150,000 STEI winter in Alaska from the eastern Aleutian Islands to lower Cook Inlet. During their northward spring migration STEI can be found in large flocks close to shore from northern Bristol Bay to Hooper Bay (U.S. Fish and Wildlife Service 2002b).

There are no reported takes of STEI in Alaskan fisheries, although incidental catch is considered a "major threat" in Baltic gillnet and setnet fisheries (OSPAR Commission 1999).

(3) Spectacled eider (*Somateria fischeri*)

Spectacled eiders are large diving sea ducks that spend most of the year in marine waters where they primarily feed on bottom-dwelling mollusks and crustaceans. Spectacled eiders historically had a discontinuous nesting distribution from the Nushagak Peninsula north to Barrow, and east nearly to the Canadian border. Today, two breeding populations remain in Alaska in the Y-K Delta, and on the North Slope between Icy Cape and the Shaviovik River. Spectacled eiders molt in North Sound and Ledyard Bay, where they congregate in large, dense flocks that may be particularly susceptible to disturbance and environmental perturbations. During winter, SPEI congregate in exceedingly large and dense flocks in pack ice openings between St. Lawrence and St. Matthew Islands. Spectacled eiders from all three known breeding populations use this wintering area (Final Determination of Critical Habitat for the Spectacled Eider, 66(25) FR 9146, February 6, 2001; http://ecos.fws.gov/docs/federal_register/fr3706.pdf). Larned and Tiplady (1999) estimated the entire wintering population, and possibly the world's population, at 374,792 birds.

Between the 1970s and 1990s, SPEI on the Y-K Delta declined by about 96% from 48,000 pairs to fewer than 2,500 pairs in 1992 (66 FR 9146 Feb. 6, 2001). The breeding population on the North Slope is currently the largest breeding population of SPEI in North America. The most recent population estimate is approximately 4,750 pairs. However, this breeding area is approximately nine times the size of the Y-K Delta, so although more breeding pairs may occur on the North Slope, the density of breeding SPEI on the North Slope is about 25% of that on the Y-K Delta.

Critical habitat has been designated for the SPEI on the Y-K Delta, in Norton Sound, and Ledyard Bay, and in their wintering area in the NBS between St. Lawrence and St. Matthew Islands (Final Determination of Critical Habitat for the Spectacled Eider, February 6, 2001, 66(25) FR 9146, 50 CFR pt 17; Fig. 4.7.1). An estimated 250,000 to 300,000 SPEI were observed aboard the USCG Cutter *Healy* about 80 km off Southwest Cape on St. Lawrence Island (Liz Labunski, USFWS, pers. comm.). The most important feature of the critical habitat is the density of benthic fauna available for foraging eiders (NMFS 2010). A 2001 survey of prey eaten by SPEI in this winter habitat showed almost exclusive use of *Nuculana radiata* clams (Lovvorn et al. 2003). Spectacled eiders do eat other bivalve species and may eat other benthic prey, such as polychaetes and amphipods, depending on abundance (NMFS 2010).

There is no recorded take of SPEI in Alaskan fisheries.

Other seabird species of conservation concern in the Bering Sea

(1) Kittlitz's murrelet (*Brachyramphus bravirostris*)

Kittlitz's murrelet is a small diving seabird that forages in shallow waters for small forage fish, zooplankton, and other invertebrates. The entire North American, and most of the world's population, inhabits Alaskan coastal waters discontinuously form Pt. Lay to Southeast Alaska. The Alaskan population is estimated to be between 9,000 and 25,000 breeding birds, and some populations have recently undergone significant declines in several of its core population centers – Prince William Sound (up to 84%), Malaspina forelands (up to 75%), Kenai Fjords (up to 83%), and in Glacier Bay. The USFWS believes that glacial retreat and oceanic regime shifts are the factors that are most likely causing population-level declines in this species.

No Kittlitz's murrelets were reported taken in the observed groundfish fisheries from 2007-2010 (NMFS 2011). While Kittlitz's murrelets have been observed in the Bering Sea, their foraging techniques, diet composition, and the apparent fact that they are not attracted to fishing vessels reduces the likelihood of incidental take in groundfish fisheries (NMFS 2010).

(2) Yellow-billed loon (*Gavia adamsii*)

Yellow-billed loons breed abundantly in the Alaska tundra on the North Slope all summer, in association with large, permanent fish-bearing lakes more than two meters deep. They are believed to be long-lived and dependent upon high annual adult survival to maintain current populations. The global population is estimated to be 16,500 and the total Alaska population is estimated to be between 3,700 and 4,900 animals. Limitations to current data and limited surveys preclude meaningful population trends. Yellow-billed loons are threatened by destruction of habitat, introduced predators, disturbance, and pollutants from oil and gas exploration and development. Human disturbances can cause changes in yellow-billed loon behavior, including abandonment of chicks and eggs, at distances of up to a mile.

There have been no reported takes of yellow-billed loons in groundfish fisheries in Alaska.

(3) Black-footed albatross (*Phoebastria nigripes*)

Although not listed on the U.S. ESA, the black-footed albatross (BFAL) is a bird of conservation concern (U.S. Fish and Wildlife Service 2002a) because some of the major colony population counts may be decreasing or are of unknown status. World population estimates range from 275,000 to 328,000 individuals (Brooke 2004), with a total breeding population of 58,000 pairs (U.S. Fish and Wildlife Service 2006). Most of the population breeds in the Hawaiian Islands.

Black-footed albatross occur in Alaska waters mainly in the northern Gulf of Alaska, but do occur in the Bering Sea (Naughton et al. 2007). Black-footed albatross are taken in the tuna and swordfish pelagic longline fisheries in the North Pacific, and to a lesser extent in the Alaska groundfish demersal longline fishery. From 2007 to 2010, an estimated 39 Black-footed albatross (5-18 estimated annually) were taken in Bering Sea federal groundfish fisheries (NMFS 2011). An assessment of the black-footed albatross is available online at http://pubs.usgs.gov/sir/2009/5131/pdf/sir20095131.pdf.

(4) Red-legged kittiwake (*Rissa brevirostris*)

The red-legged kittiwake is a small gull that breeds only at a few locations in the world, all of which are in the Bering Sea (Gibson and Byrd 2007). Red-legged kittiwakes feed primarily on small forage fish, squid, and marine zooplankton. During the summer breeding period, they forage over deep water by plunging or dipping into the water. Red-legged kittiwakes feed both during the day and the night, but the large eyes of the red-legged kittiwake may be adapted to catch diurnal migrants at the surface during the nighttime (Hatch et al. 1993).

Eighty percent of the world's population of red-legged kittiwakes nests on St. George Island in the central Bering Sea, the remainder nest on St. Paul Island, the Otter Islands, and Bogoslof and Buldir Islands. The global population is estimated at around 209,000 birds (U.S. Fish and Wildlife Service 2006). Severe population declines have been reported, but remain unexplained (Byrd et al. 1997).

No red-legged kittiwakes were reported taken in Alaska groundfish fisheries from 2007 to 2010, although 20 "kittiwakes" (either red-legged or black-legged) were reported taken in the Bering Sea demersal longline fishery (NMFS 2011).

Impacts on Seabirds

The Programmatic Supplemental EIS for groundfish fisheries in the GOA and BSAI contains a detailed description of the effects of the groundfish fisheries on seabirds in the BSAI (NMFS 2004). Additionally, Section 7 consultations (e.g. NMFS 2009a) have evaluated the effects of groundfish harvest on ESA-listed seabirds (STAL, STEI). Those consultations have concluded that groundfish fisheries, with existing seabird avoidance measures[1], were not likely to cause jeopardy or adverse modification of critical habitat for ESA-listed species.

The availability of "free food" in the form of offal and bait attracts many birds to fishing operations. Birds may then come in contact with fishing gear, either by ingesting bait and hooks, or by contacting gear such as wires during flight or while on the surface of the water. The probability of a bird being caught or injured is a function of many interrelated factors including: type of operation and gear used, length of time gear is at or near the surface, behavior of the bird, water and weather conditions, size of the bird, availability of food (including bait and offal), and physical condition of the bird. Current seabird avoidance measures have greatly reduced the number of seabird takes in Alaska groundfish fisheries, and additional takes from limited trawl activity in the NBSRA is unlikely.

Steller's eiders, Kittlitz's murrelets, and yellow-billed loons do not generally occur in the NBSRA in concentrations, and are therefore unlikely to be affected significantly by potential trawl activity in the NBSRA. However, no directed studies of the effects of trawling on these species have been conducted.

Spectacled eiders may be affected by nonpelagic trawling in the NBSRA, if the volume of trawling is sufficient to reduce the availability of *Nuculana radiata* clams or other species of bottom dwelling invertebrates that SPEI rely on during the winter. However, no studies have been conducted to assess the potential effects of trawling in the NBSRA on SPEI.

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Table 4.7.1. Seabird species in Alaska.

Tubenoses	Northern Fulmar	*Fulmarus glacialis*
	Fork-tailed Storm Petrel	*Oceanodroma furcate*
	Leach's Storm Petrel	*Oceanodroma leucorhoa*
Cormorants	Double-crested Cormorant	*Phalacrocorax auritus*
	Brandt's Cormorant	*Phalacrocorax penicillatus*
	Pelagic Cormorant	*Phalacrocorax pelagicus*
	Red-faced Cormorant	*Phalacrocorax urile*
Waterfowl	Common Eider	*Somateria mollissima*
	King Eider	*Somateria spectabilis*
	Spectacled Eider	*Somateria fischeri*
	Steller's Eider	*Polysticta stelleri*
Jaegers, Gulls, Terns	Pomarine Jaeger	*Stercorarius pomarinus*
	Parasitic Jaeger	*Stercorarius parasiticus*
	Long-tailed Jaeger	*Stercorarius longicaulus*
	Bonaparte's Gull	*Larus philadelphia*
	Mew Gull	*Larus canus*
	Herring Gull	*Larus argentatus*
	Glaucous-winged Gull	*Larus glaucescens*
	Glaucous Gull	*Larus hyperboreus*
	Sabine's Gull	*Xema sabini*
	Black-legged Kittiwake	*Rissa tridactyla*
	Red-legged Kittiwake	*Rissa brevirostris*
	Arctic Tern	*Sterna paradisaea*
	Aleutian Tern	*Onychoprion aleuticus*
Auks & Puffins	Common Murre	*Uria aalge*
	Think-billed Murre	*Uria lomvia*
	Black Guillemot	*Cepphus grylle*
	Pigeon Guillemot	*Cepphus columba*
	Marbled Murrelet	*Brachyramphus marmoratus*
	Kittlitz's Murrelet	*Brachyramphus brevirostris*
	Ancient Murrelet	*Synthliboramphus antiquus*
	Cassin's Auklet	*Ptychoramphus aleuticus*
	Parakeet Auklet	*Aethia psittacula*
	Least Auklet	*Aethia pussila*
	Whiskered Auklet	*Aethia pygmaea*
	Crested Auklet	*Aethia cristatella*
	Rhinoceros Auklet	*Cerorhinca monocerata*
	Tufted Puffin	*Fratercula cirrhata*
	Horned Puffin	*Fratercula corniculata*
Non-breeders		
Tubenoses	Short-tailed Albatross	*Phoebastria albastrus*
	Black-footed Albatross	*Phoebastria negripes*
	Laysan Albatross	*Phoebastria immutabilis*
	Sooty Shearwater	*Puffinus griseus*
	Short-tailed Shearwater	*Puffinus tenuirostris*
Gulls	Ross's Gull	*Rhodostethia rosea*
	Ivory Gull	*Pagophila eburnea*

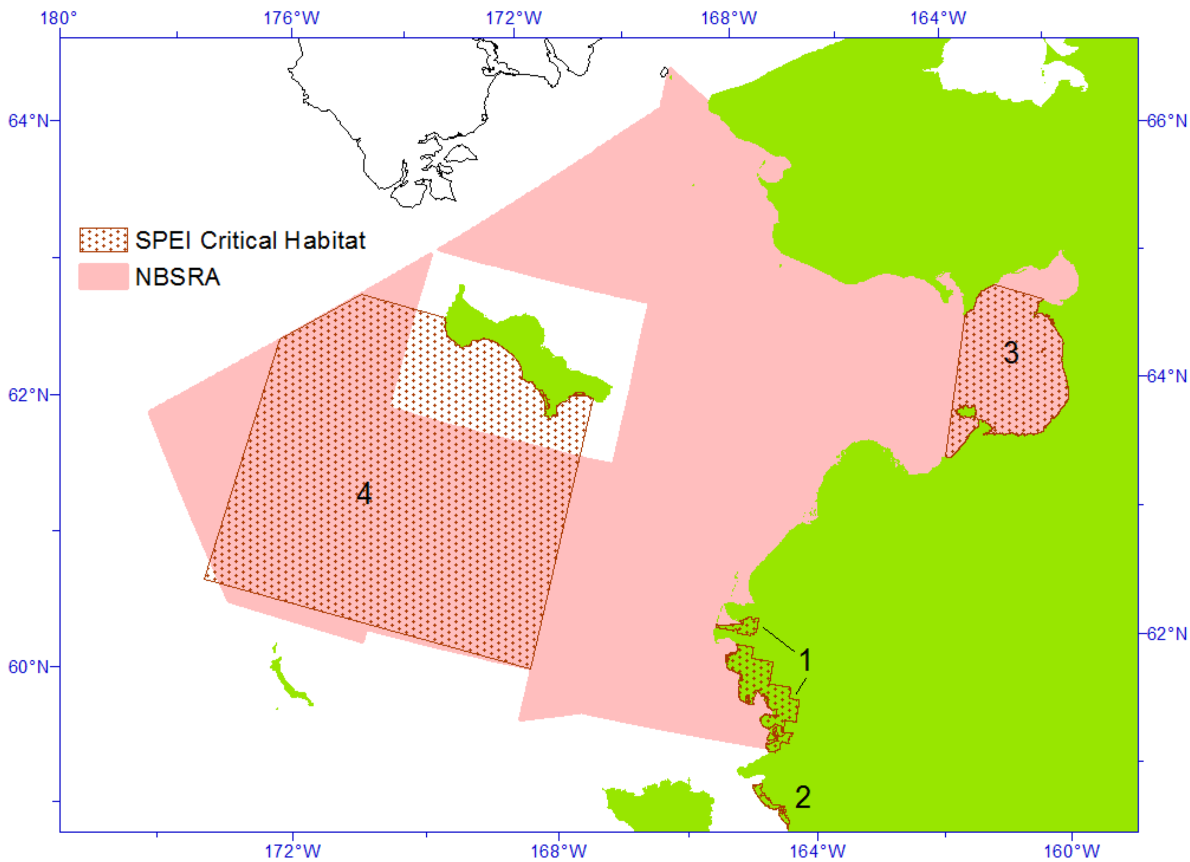

Figure 4.7.1. Spectacled eider Critical Habitat in the NBS. Unit 1 (Yukon-Kuskoswim Delta) is also Steller's eider Critical Habitat.

5. Research

Before 1990

Environmental research in the often ice-bound, remote, and sparsely populated NBS was spurred by strategic, economic and scientific interests to explore marine resources – particularly of hydrocarbon and minerals - and understand ecosystem and pollution dynamics. The U.S. and Russia (formerly U.S.S.R.) are the two nations that possess EEZ within the NBS. The Russian NBS stretches from the Gulf of Anadyr through the Anadyr Strait west of Chirikov Basin to the Bering Strait (Fig. 3.1) on the Siberian coast. The major scientific programs and expeditions undertaken by U.S. and Russia in 1970-1990 that covered the NBS are summarized as follows.

Russia included the part of the NBS to the west and south of St. Lawrence Island in their investigations of new fishing grounds in the northeast Pacific. The early expeditions resulted in information on the physical, biological, and chemical environment (Moiseev 1968).

In 1977, 1984, 1988, and 1993, there were joint U.S. – Russian Bering and Chukchi Seas Expeditions (BERPAC) to investigate the ecosystems (U.S. Fish and Wildlife Service 1982; Izrael and Tsyban 1983, 1990; Roscigno 1990; Nagel 1992; Turner 1992; Tsyban 1995, 1999; Kohl 2010). The major research themes were the oceanographic regime, spatial variability of nutrient concentrations, pollutant dynamics, microbiological, planktonic and benthic communities, and biogeochemical cycles (Grebmeier et al. 1988; Whitledge et al. 1988; Grebmeier et al. 1989; Grebmeier and McRoy 1989; Springer and McRoy 1993; Cooper et al. 2002). The fourth BERPAC in 1993 also focused on the long-term ecological monitoring to establish baseline conditions and early indications of global warming and man-made alterations to the ecosystems.

The Inner Shelf Transfer and Recycling in the Bering and Chukchi Seas (ISHTAR) project studied the interannual variability of physical forcing on the cycle of carbon and nutrients on the shelf. Several oceanographic cruises were conducted between 1983 and 1989 (Peterson and Fry 1987).

The Outer Continental Shelf Environmental Assessment Program (OSCEAP) was initiated by the U.S. Department of the Interior in 1975 (US Dep Commer NOAA 1976). The program funded research from 1975 to 1989 to ensure protection of the marine and coastal environment of the Alaskan outer continental shelf, where hydrocarbon development and production activities were proposed. The NBS from Norton Sound to the north and east of St. Lawrence Island (Norton Basin) was an area of focus for oil and mineral leasing. Diverse scientific information was collected under the program on living resources, environmental processes and relationships, and pollution effects (Hood and Calder 1981). A Comprehensive Bibliography lists the extensive reports and publications associated with OSCEAP. The reports can be accessed through the Alaska Resources Library and Information Services (ARLIS) http://www.arlis.org/resources/ocseap-reports.

NOAA published the Bering, Chukchi, and Beaufort Seas Coastal/Ocean Zones Strategic Assessment Data Atlas (BCB Atlas) on important characteristics of the region by synthesis of the best available published and unpublished information of the time (US Dep Commer NOAA 1988). The BCB Atlas maps and describes: physical and biotic environments, geographic distribution of living resources, economic activities, and jurisdiction (e.g. Fig. 3.2). The information is generally qualitative and non-quantitative, but presents a comprehensive view of the community, economy, environment and natural resources in the region at the time.

Post-1990

Climate change and ecosystem shift in the subarctic and arctic oceans provided new impetus for scientific research in the NBS. Several large scientific programs were initiated with the objectives of understanding ecosystem processes and the effects of climate change. Most relevant to the NBS among them are the Bering Sea Ecosystem Study (BEST, 2007 – present) and Bering Sea Integrated Ecosystem Research Program (BSIERP, 2008 – present) (http://bsierp.nprb.org; http://www.afsc.noaa.gov/Quarterly/amj2009/AMJ09feature.pdf) (Sigler and Harvey 2009). Project results from these two partner programs were collected in the journal *Deep Sea Research Part II* – First Bering Sea Project Special Issue in early 2012 (Wiese et al. 2012), where NBS physical environment (Stabeno et al. 2012a; Wang et al. 2012), nutrients and productivity (Cooper et al. 2012), and trawl species distributions (Stevenson and Lauth 2012) were addressed. A Second Bering Sea Project Special Issue in *Deep Sea Research Part II* is planned for 2013.

The North Pacific Anadromous Fish Commission (NPAFC) initiated the Bering-Aleutian Salmon International Survey (BASIS) to understand the biological response by Pacific salmon during a period of climate change. The Ocean Carrying Capacity Program (OCC) at the Auke Bay Laboratories (http://www.afsc.noaa.gov/ABL/EMA) of the AFSC oversees the development of U.S. BASIS. In the U.S. EEZ, the survey covered the Bering Sea, Bering Strait, and the Chukchi Sea. BASIS addresses research questions concerning how climate change and climate cycles affect anadromous stocks, ecologically related species, available salmon habitat and the Bering Sea ecosystems (North Pacific Anadromous Fish Commission 2009a). BASIS Phase I (2002-2006) collected physical and biological oceanographic data in conjunction with epipelagic trawl sampling (Helle et al. 2007) to investigate growth and life history characteristics of regional salmon stocks (Krueger and Zimmerman 2009; North Pacific Anadromous Fish Commission 2009b). Phase II (2009-2013) continues in the same vein.

Essential Fish Habitat

The EA/RIR/FRFA for Amendment 89 to the BSAI FMP and for Bering Sea Habitat Conservation (NMFS 2010) analyzed environmental information useful for evaluating alternatives of area closure to protecting eastern Bering Sea habitats from potential impacts of fishing. One option was the closure of the NBSRA to nonpelagic trawling until its impacts on crabs, marine mammals, ESA listed species, and subsistence needs of western Alaska coastal communities could be determined and managed.

The main environmental concern for nonpelagic trawling is the potential disturbance to the benthic habitat, which is the basis of food supply for many fish, invertebrates, seabird, and marine mammal species. Western Alaska communities harvest many of these species for cultural and subsistence use. There has yet been little groundfish fishing effort in the NBS area north of St. Matthew Island (~latitude

61°N), and pristine benthic habitat is especially sensitive to disturbance. The EA/RIR/FRFA considered the status of the physical, biological, and socioeconomic environments of the NBS. Information was noted to be sparse in the NBS, and older data sets were drawn upon. The benthic sediment types were described generally as a mix of mud and sand. Biological information of (i) primary target (commercial) stocks: rock sole, yellowfin sole, Alaska plaice, walleye pollock, Pacific cod, blue king crab, and snow crab, (ii) species prohibited in groundfish fishery: Pacific halibut, Pacific herring, Pacific salmon, steelhead, king crab, and Tanner crab *Chionoecetes bairdi*, and (iii) ESA-listed marine mammals and seabirds were summarized. A quantitative mathematical model of fishery impacts on habitat estimated long-term effects on benthic habitat features – particularly of sessile, emergent invertebrates such as sea anemone, sea whips, sponges, etc., but almost no reduction in infaunal and epifaunal prey for managed species.

The EA/RIR/FRFA assessed the potential impacts of the alternatives on the habitat, species, ecosystem and socioeconomics of the BSAI. Based on the best available but limited scientific information and the protection measures already in place, as summarized in the document, there was no evidence to conclude that the NBS would be significantly impacted by bottom fishing. Economic risk to nonpelagic trawling industry and communities is likely to be insignificant or unknown because of uncertainty in future fish and fishing effort distributions. The establishment of the NBSRA would likely maintain the status quo.

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6. Trawl Survey

History of fisheries and trawl survey in the NBS

The NBS has no history of commercial bottom trawling. Small-scale commercial fisheries in the NBS were developed mostly after 1977 and are centered mainly in Norton Sound. Local Alaska Natives have fished for subsistence in the NBS throughout the history of their settlement (Menard et al. 2009). Salmon *Oncorhynchus* spp., herring *Clupea pallasii*, and red king crab *Paralithodes camtschaticus* are the main targets of commercial and subsistence fisheries (http://www.adfg.alaska.gov). Other species potentially present in subsistence and/or sports fisheries include Arctic grayling *Thymallus arcticus*, char *Salvelinus* spp., northern pike *Esox lucius*, burbot *Lota lota*, Arctic lamprey *Lampetra camtschatica*, longnose sucker *Catostomus catostomus*, Alaska blackfish *Dallia pectoralis*, inconnu *Stenodus leucichthys*, and several *Coregonus* species (Menard et al. 2009). None of these fisheries uses bottom trawl gear.

Norton Sound in the eastern part of the NBSRA has been surveyed triennially since 1976 in response to the development of a small red king crab pot fishery (Hamazaki et al. 2005). NMFS conducted the Norton Sound surveys in 1975 and 1979, before standard sampling protocol was established for bottom trawl surveys, and then with the standard protocol in 1982, 1985, 1988, 1991. The Alaska Department of Fish and Game (ADF&G) took over in 1996 and has conducted the Norton Sound bottom trawl surveys approximately triennially from 1996 to the present (1996, 1999, 2002, 2006, 2008, 2011). The NMFS survey was conducted over the entire Norton Sound area, whereas the ADF&G surveys was limited to areas where the commercial crab pot fishery operates (Fig. 6.1).

NMFS AFSC has conducted annual bottom trawl surveys on the eastern Bering Sea shelf (south of 61°N) based on standard sampling protocol since 1982 (Fig. 6.2). In 2010, the AFSC bottom trawl survey expanded northward onto the NBS shelf (Fig. 6.2) as part of the AFSC Loss of Sea Ice (LOSI) Research Plan. The primary purpose of the plan is to study the impacts of climate change and the loss of sea ice on the marine ecosystem and the subsistence fisheries of Alaska fishing communities. A similar survey is planned in the Chukchi Sea for 2012. If LOSI funds continue, surveys in the northern Bering and Chukchi Seas will be conducted every three years. Long-term monitoring is necessary for assessing, quantifying, and predicting effects of climate change and other industrial activities on the distribution, abundance, and ecology of fishes, crabs and marine mammals. A time series of survey data can be used by the Alaska fishing communities to help manage and protect marine resources that are vital to their culture and livelihood.

Results of 2010 NBS trawl survey

The 2010 bottom trawl survey resulted in the most comprehensive coverage of the Bering Sea shelf (approx. 800,000 km^2) since the inception of scientific trawl surveys in Alaska in 1971. The NBS extension of the survey covered much of the NBSRA. Altogether, 156 trawl stations were located in the NBSRA (Fig. 6.2, lower). At each station, about 0.05 km^2 of area was swept by bottom trawl. About 7.8 km^2 of some 29,000 km^2 (0.02%) of the NBSRA seafloor was thus impacted by the bottom trawl survey.

The 2010 survey provides snapshots of the marine environment and the spatial distribution and abundance of trawl species (Figs. 6.3-6.13). The full report for the 2010 eastern and northern Bering Sea shelf bottom trawl survey (Lauth 2011) is available online at: http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-227.pdf. Interactive maps of the catch and temperature data from AFSC bottom trawl surveys of the eastern Bering Sea and northern Bering Sea are also available online at: http://www.afsc.noaa.gov/RACE/ground-sh/survey_data/default.htm.

Overall trawl caught biomass was lower in the NBS than in the EBS. Total fish biomass was 10 times greater in the EBS than in the NBS (Fig. 6.14). In the EBS, walleye pollock *Theragra chalcogramma*, yellowfin sole *Limanda aspera*, rock sole *Lepidopsetta polyxystra*, and Pacific cod *Gadus macrocephalus* together comprised 78% of the total fish biomass compared to the NBS where yellowfin sole *Limanda aspera*, Alaska plaice *Pleuronectes quadrituberlatus*, saffron cod *Eleginus gracilis*, and Arctic cod *Boreogadus saida* comprised 72% of the total fish biomass. There was a high abundance of small, sublegal size (around 70 mm) and sexually immature snow crab of both sexes in the NBS (Fig. 6.12) (Chilton et al. 2011; http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-216.pdf). It is uncertain whether the male will ever reach commercial size in these cold waters.

As latitude increased, the community structure of fishes changed and there were decreases in total biomass, fish biomass, and individual fish weight (Fig. 6.15). Flatfish biomass is lower in the NBS. The relative proportion of gadids, a group that includes commercially important species such as walleye pollock and Pacific cod, becomes greater. The dominant gadids in the NBS, saffron cod and Arctic cod, have much smaller maximum sizes than walleye pollock or Pacific cod. Gadids in the NBS average over 0.8 kg each in the EBS, but less than 0.1 kg in the NBS. A smaller but notable decline in size is evident for flatfish. Conversely, larger sculpins and eelpouts species are encountered in the NBS compared to the EBS. Invertebrate biomass was not significantly different between EBS and NBS.

In the northernmost portion of the NBS (64^{o}N), the catches are dominated by small gadids, which make up about 60% of the fish catch, followed by flatfishes and sculpins. The epibenthic invertebrate fauna is dominated primarily by sea stars (Asteriidae) and oregoniid crabs (*Chionoecetes* snow crab and *Hyas* lyre crab) (Stevenson and Lauth 2012). Other common epibenthic invertebrates are snails (Buccinidae), hermit crabs, and ascidians. In the EBS, fishes make up roughly 70% of the total catch weight, but in the NBS fishes only make up about 30%. The decrease in the NBS is due to epibenthic invertebrates making up a larger proportion of the catch in bottom trawls.

The Bering Sea in the past decade saw a period of low sea ice cover and warm summers (2002-2005), followed by a period of heavy ice cover and cold summers (2006-2009) (Hunt et al. 2010). The region of greatest impact for the 2005-2006 temperature shift is 58-61^{o}N, where mean fish catches were depressed by 20-75% during the cold years (Stevenson and Lauth 2012). In the NBS, interannual near-bottom water temperature is less pronounced than in the EBS. Recent evidence suggests that north of 60^{o}N there is little difference between temperature regime of warm and cold years (Stabeno et al. 2012b). AFSC bottom trawl survey data also suggest that the NBS ecosystem does not fluctuate as dramatically as the EBS.

ADF&G bottom trawl survey data indicate that benthic biomass in Norton Sound increased since 1976. There was little change in benthic epifauna species composition – sea stars remain dominant. Trawl catch of demersal fish and non-crab invertebrates also increased from the late 1970s to the early 1990s, then declined somewhat in the late 1990s. The trends possibly correspond with climatic and oceanographic regime shift in 1977 from cold to warm phase, but not necessarily with bottom water temperature (Hamazaki et al. 2005).

Trawl survey data to date indicate that fishes regularly exploited by bottom trawl in the southeast are not in sufficient quantity in the NBS to support a large-scale commercial fishery, nor are there any common species that reach a large enough maximum size to be commercially desirable.

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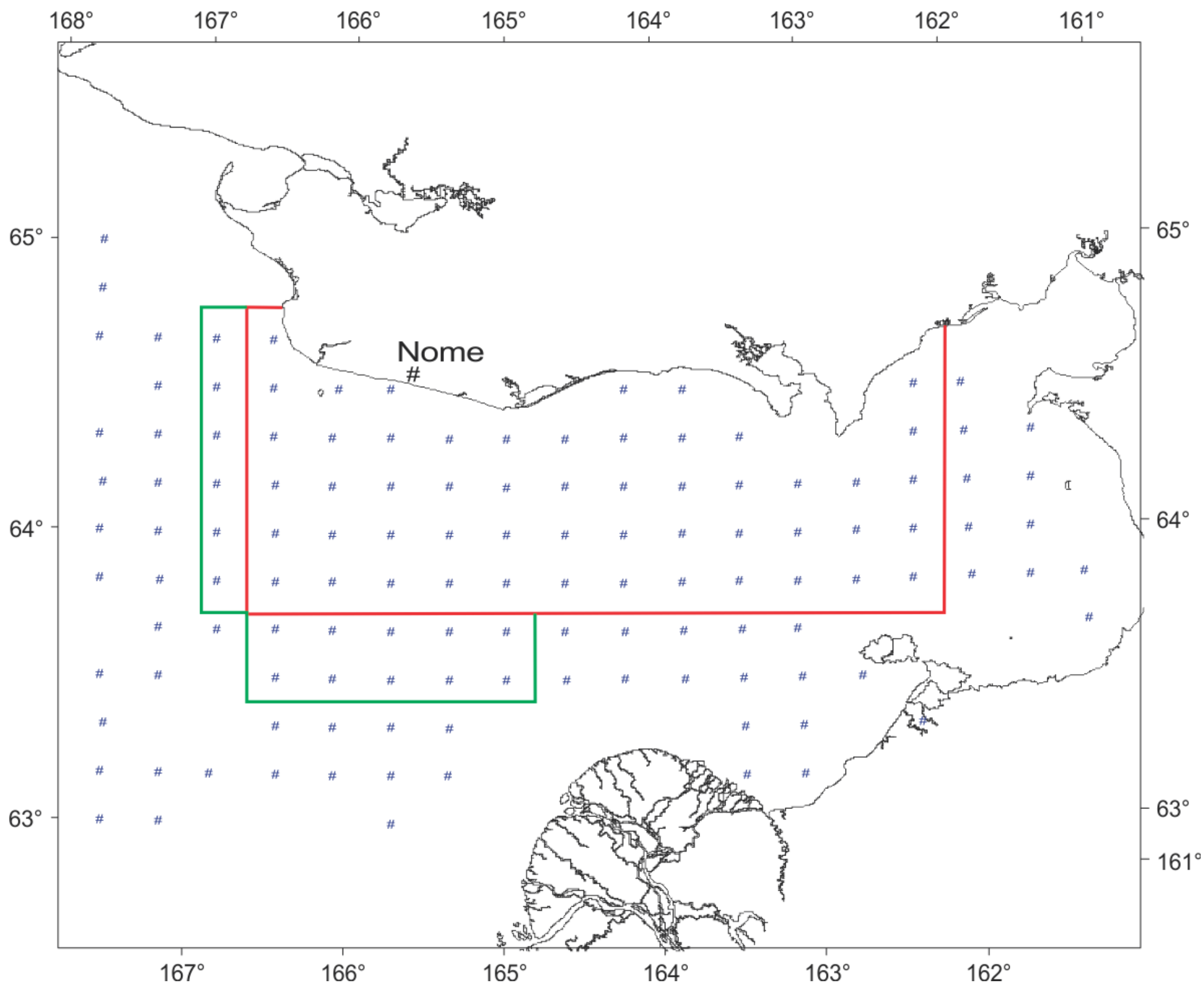

Figure 6.1. Locations of the trawl survey stations in Norton Sound. Stations within the red boundary were continuously surveyed from 1976 to present. Stations in the peripheral green boundaries were surveyed when additional time was available. Stations outside the boundaries were surveyed by NMFS (1976-1991) but discontinued when ADF&G took over the survey in 1996 (adapted from Figure 1, Hamazaki et al. 2005).

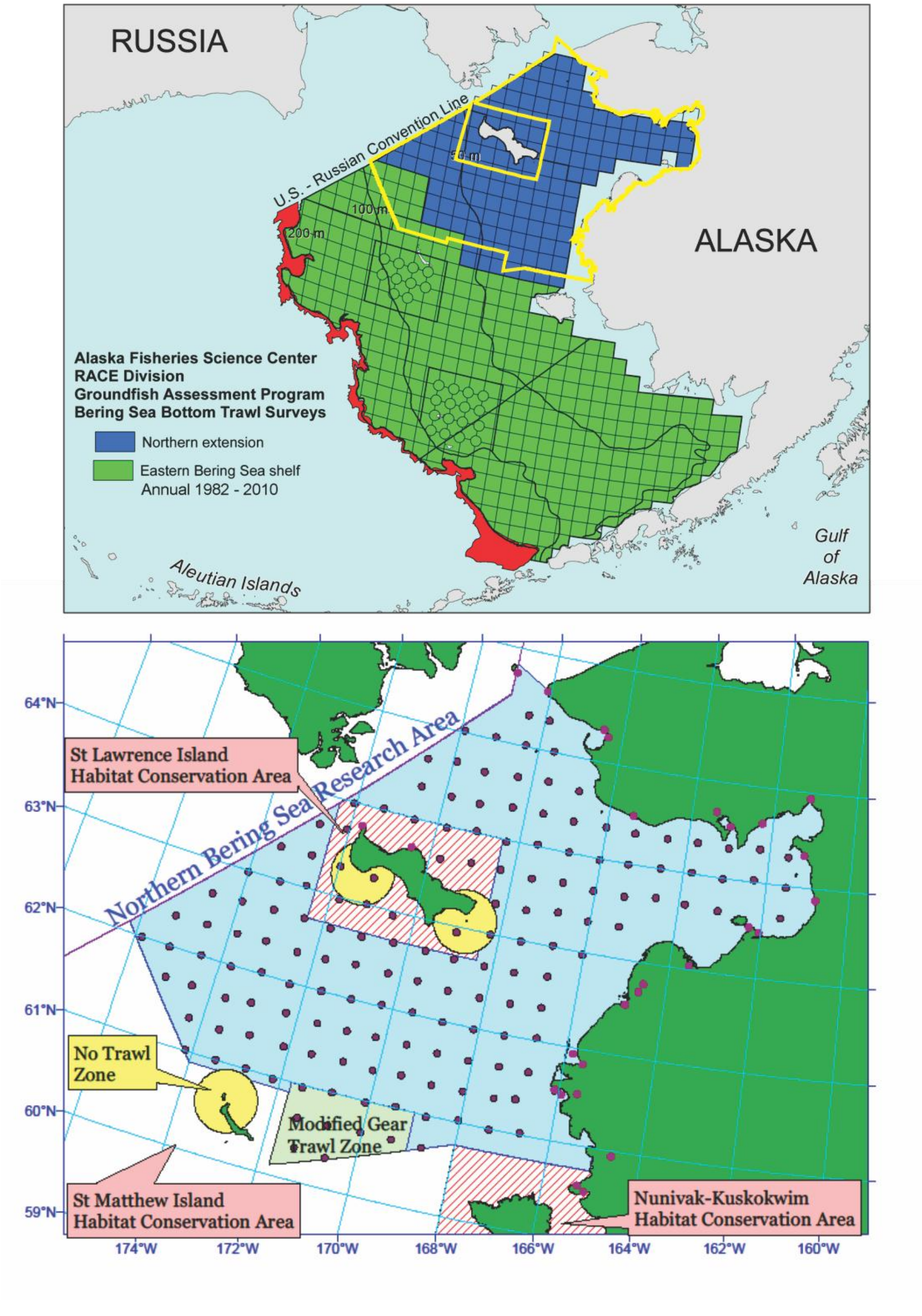

Figure 6.2. (Upper) AFSC Bering Sea bottom trawl survey areas: the eastern Bering Sea shelf (green) is surveyed annually since 1982; the northern Bering Sea shelf (blue) was surveyed in entirety in 2010. Trawl stations are located in the centered of each grid cell. Around St Matthew Island and the Pribilofs, stations are also located at the corners (center of circles) of grid cells. The NBSRA is outlined in yellow. (Lower) Trawl survey station locations within the NBSRA.

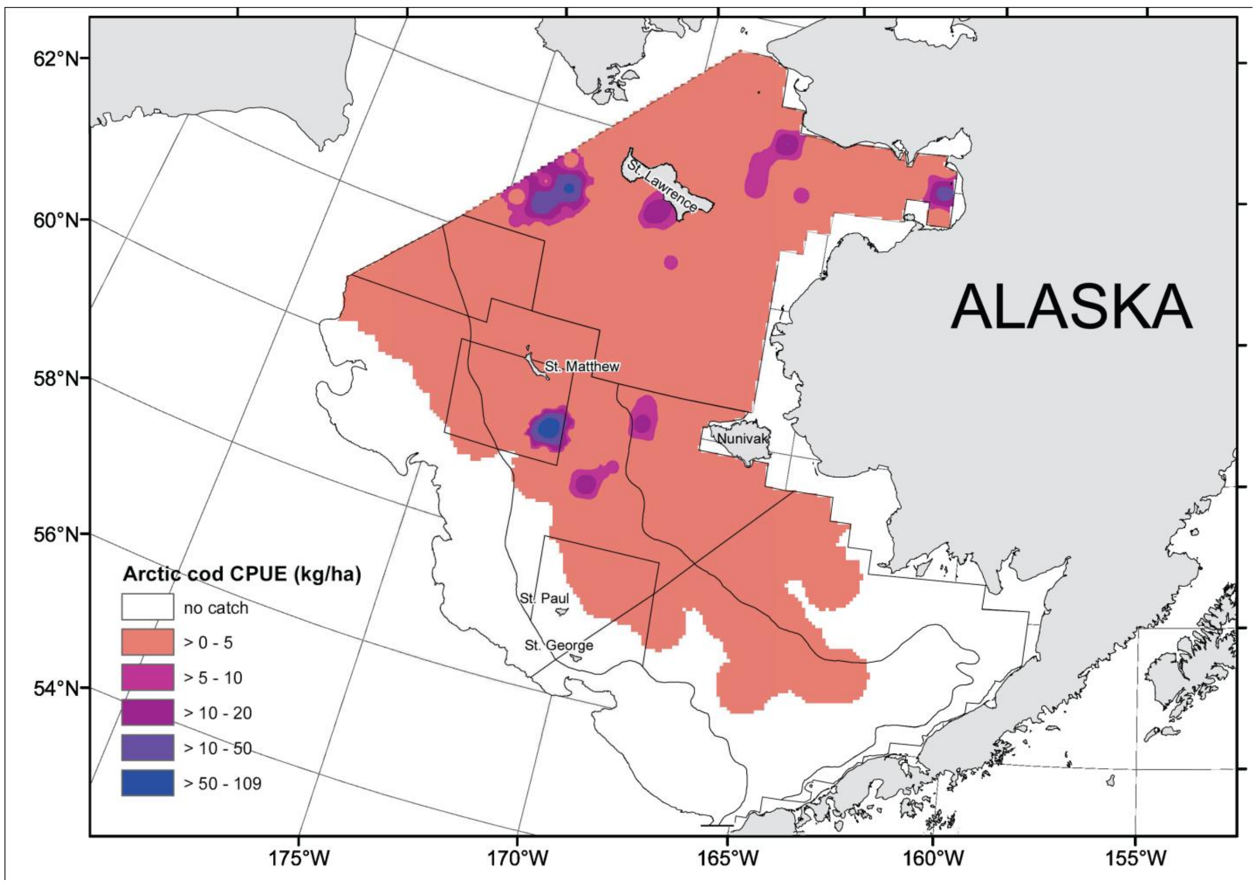

Figure 6.3. Distribution and relative abundance (kg/ha) of Arctic cod *Boreogadus saida* for the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey.

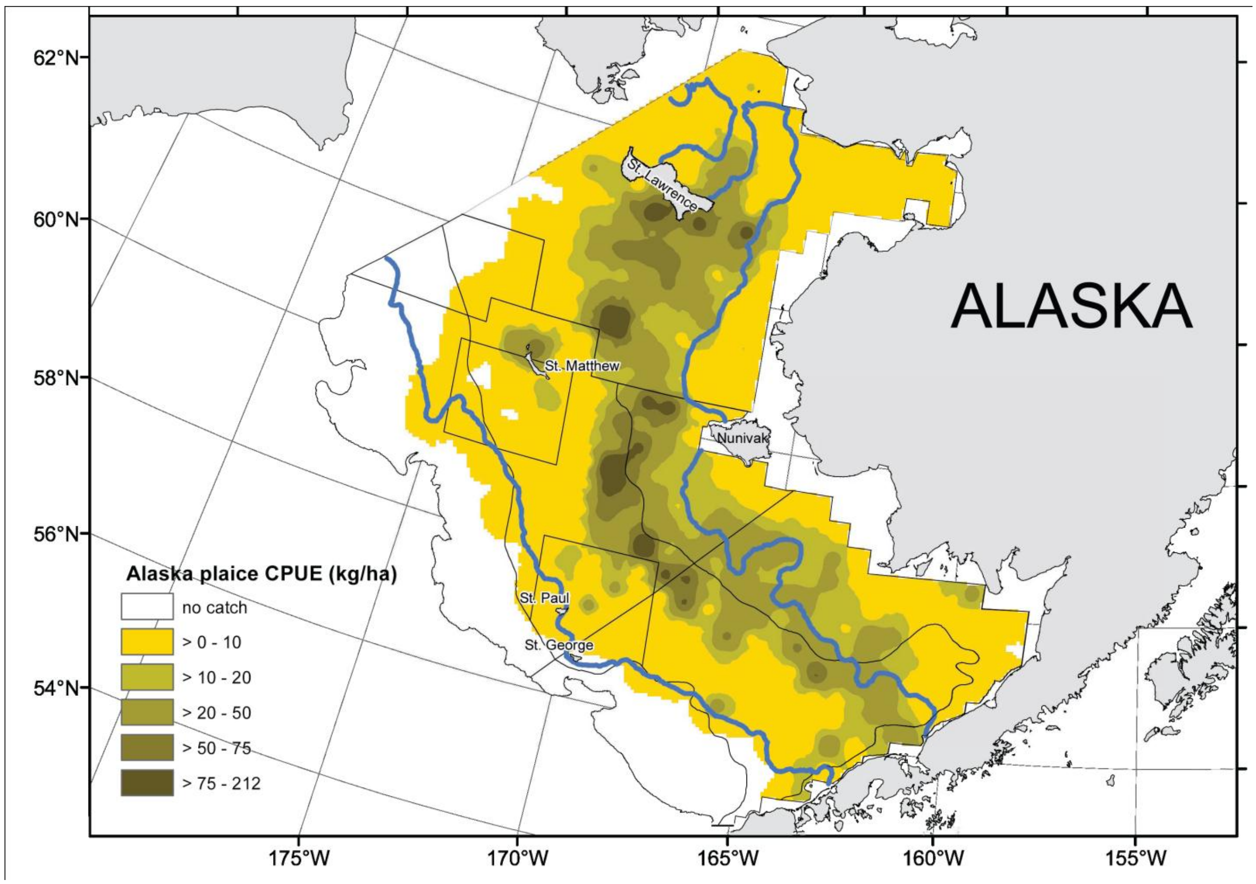

Figure 6.4. Distribution and relative abundance (kg/ha) of Alaska plaice *Pleuronectes quadrituberculatus* for the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey. The 2°C isotherm (blue) delineates the cold pool of bottom water.

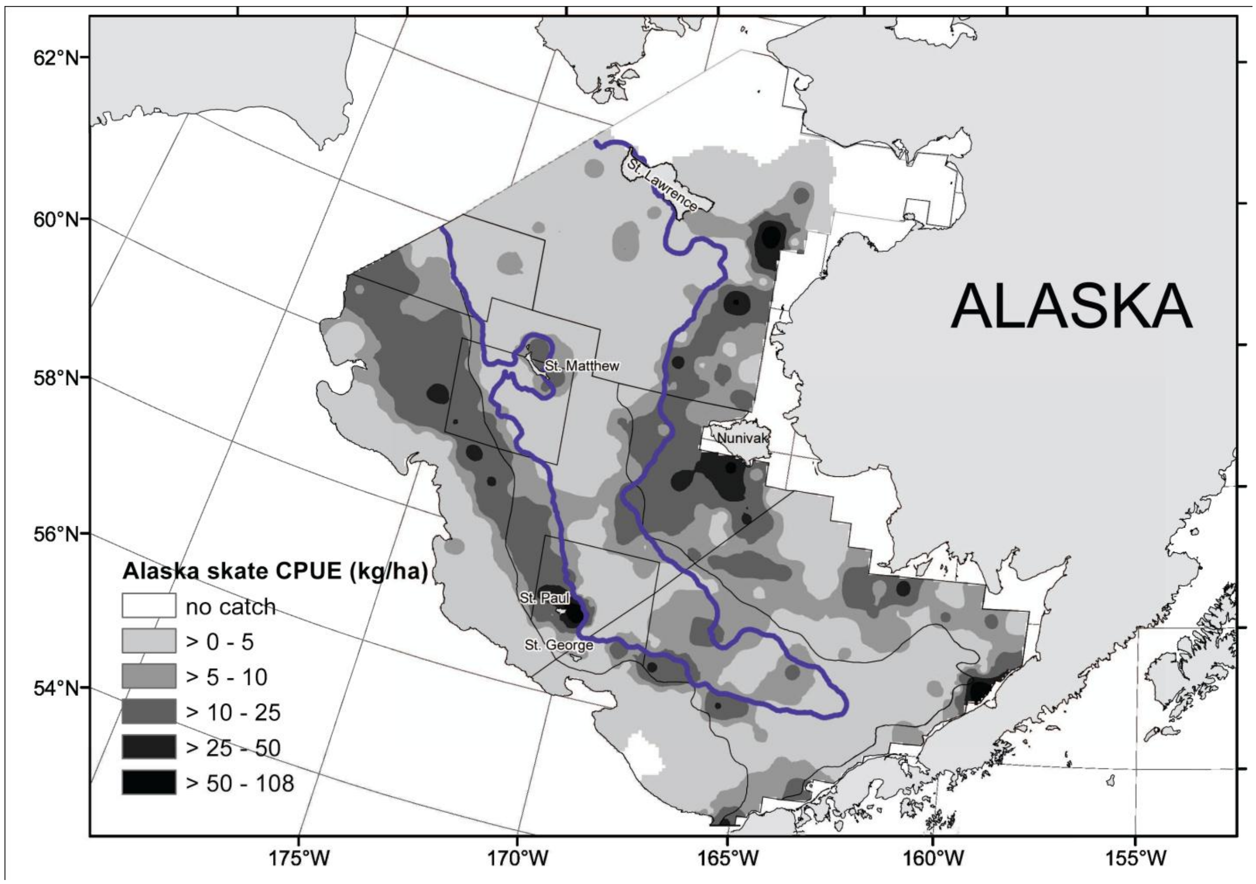

Figure 6.5. Distribution and relative abundance (kg/ha) of Alaska skate *Bathyraja parmifera* for the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey. The 2°C isotherm (blue) delineates the cold pool of bottom water.

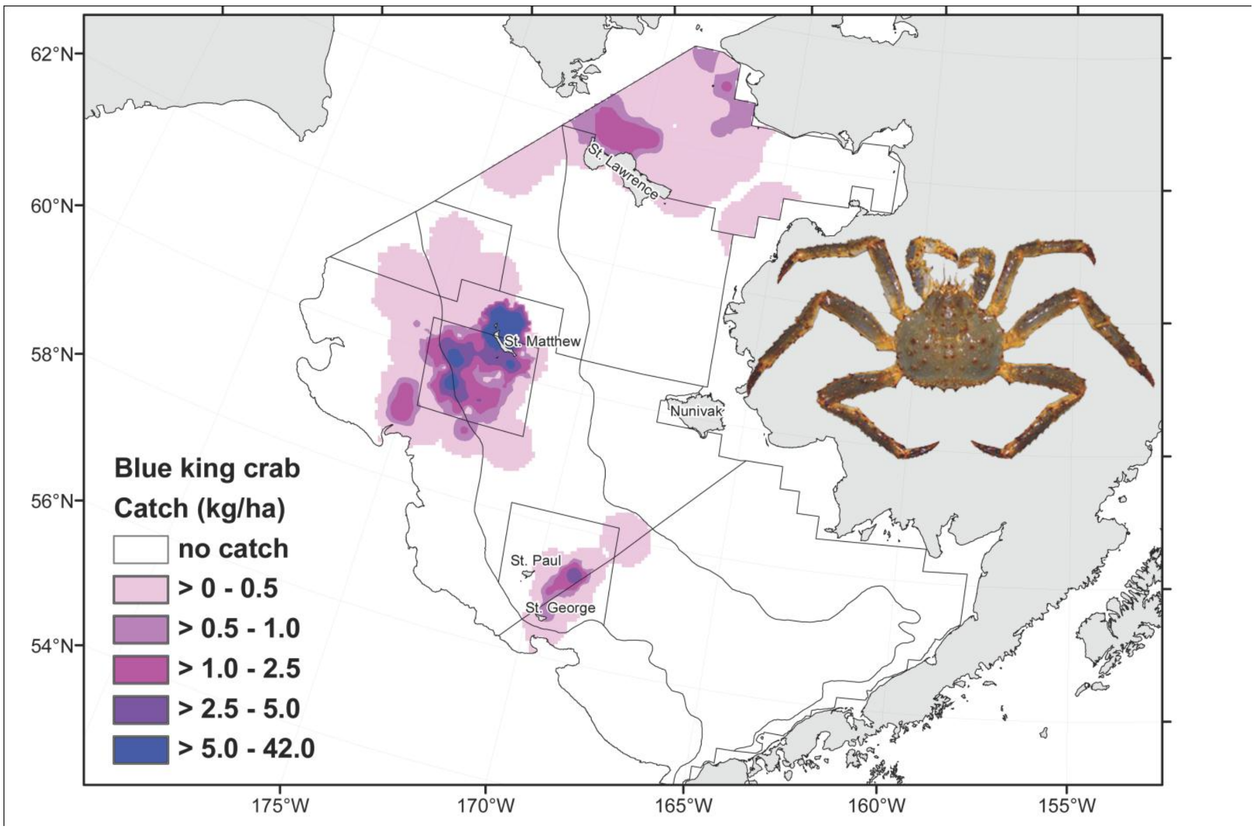

Figure 6.6. Distribution and relative abundance (kg/ha) of blue king crab *Paralithodes platypus* for the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey.

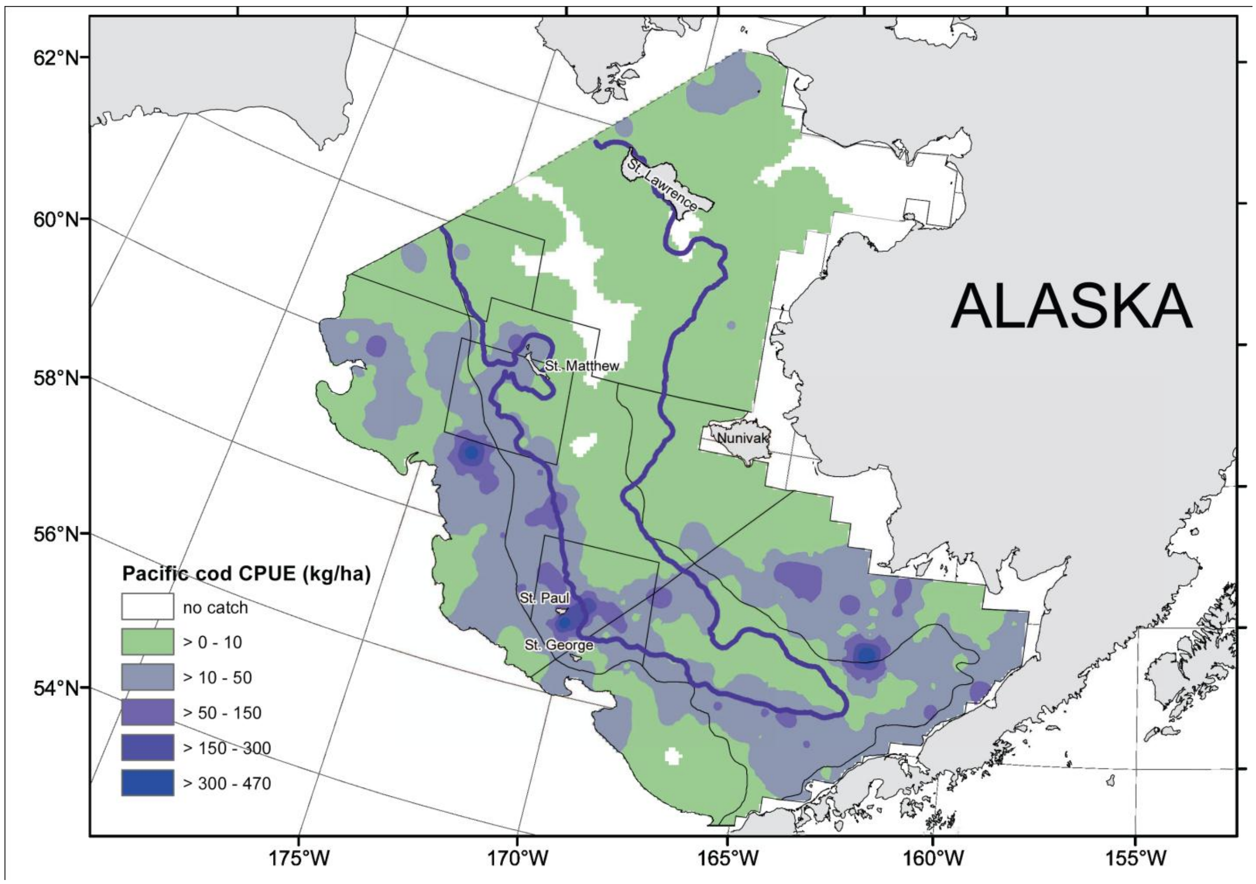

Figure 6.7. Distribution and relative abundance (kg/ha) of Pacific cod *Gadus macrocephalus* for the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey. The 2°C isotherm (blue) delineates the cold pool of bottom water.

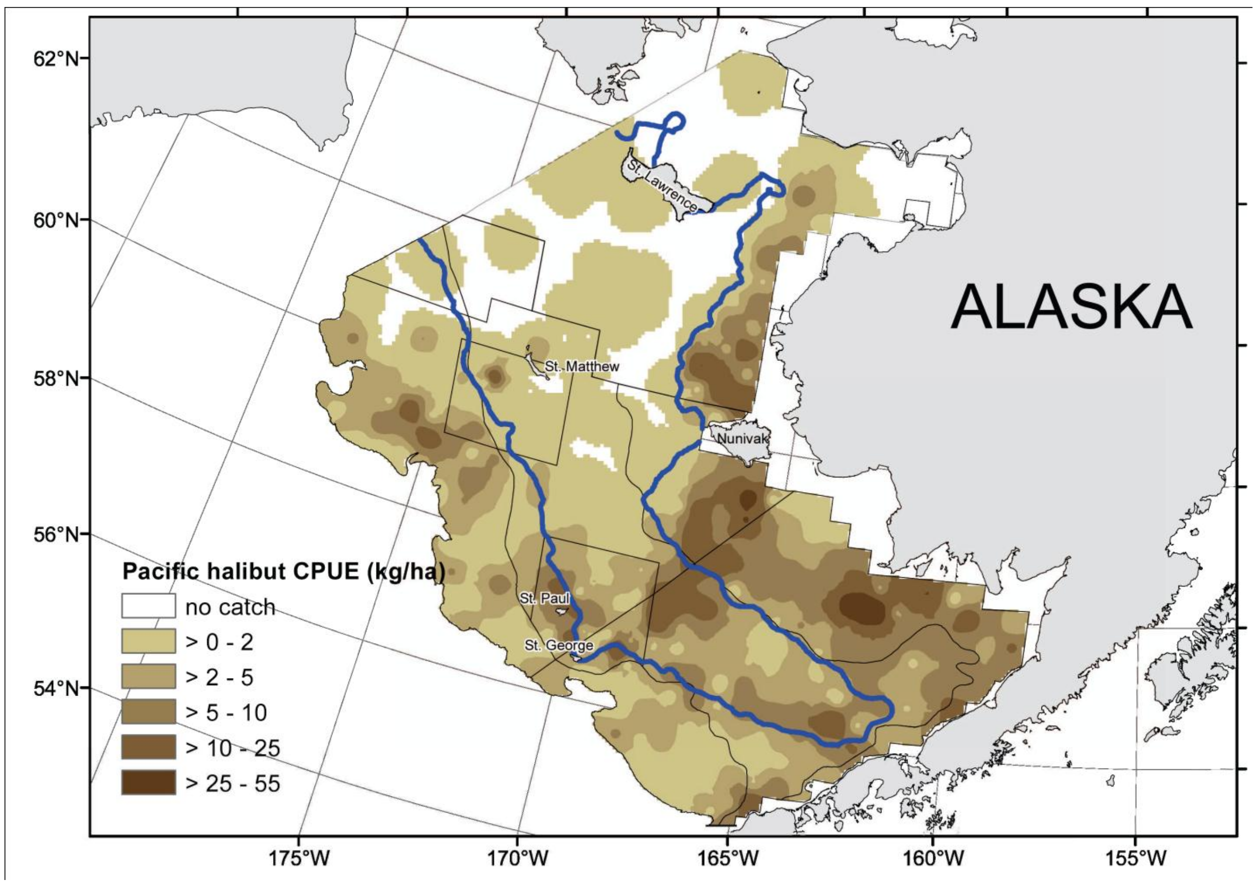

Figure 6.8. Distribution and relative abundance (kg/ha) of Pacific halibut *Hippoglossus stenolepis* for the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey. The 2^{o}C isotherm (blue) delineates the cold pool of bottom water.

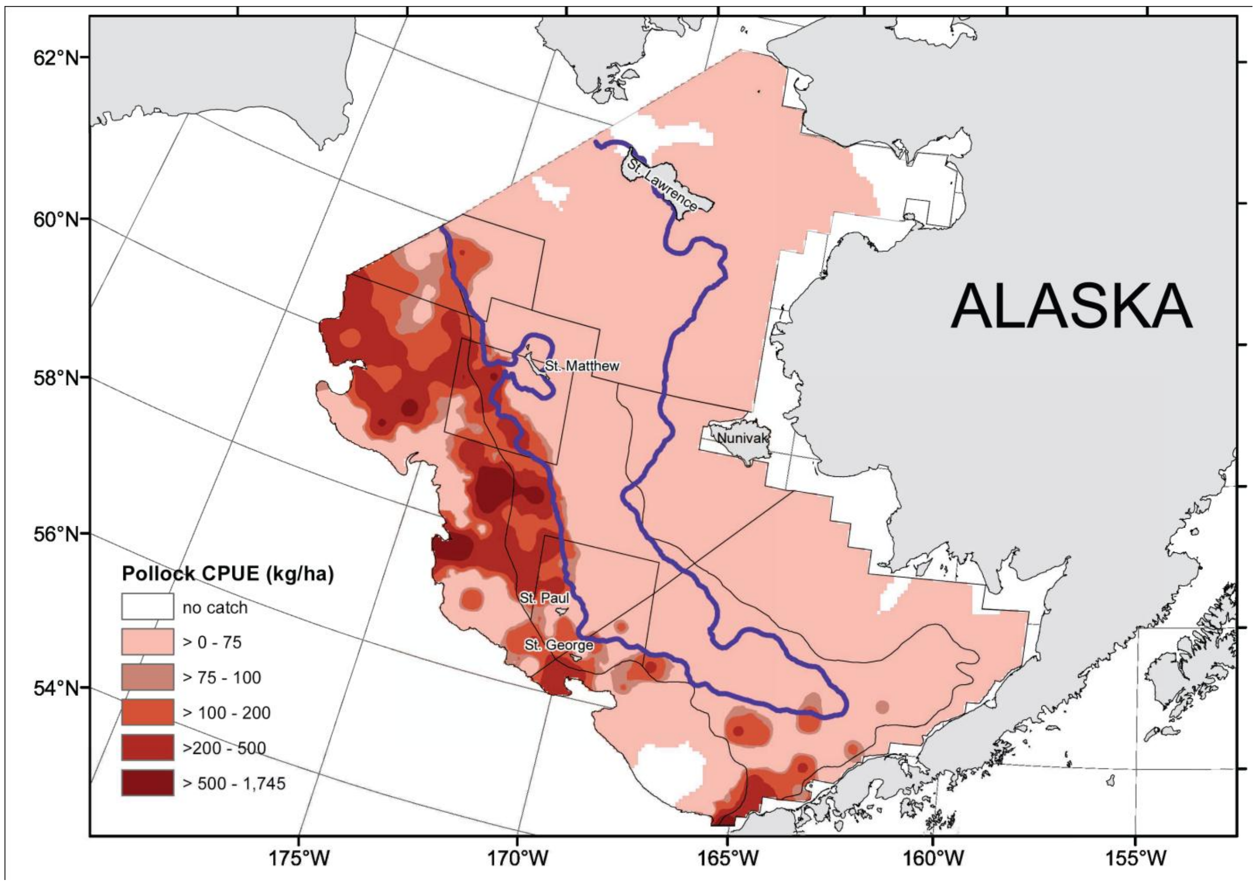

Figure 6.9. Distribution and relative abundance (kg/ha) of walleye pollock *Theragra chalcogramma* for the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey. The 2°C isotherm (blue) delineates the cold pool of bottom water.

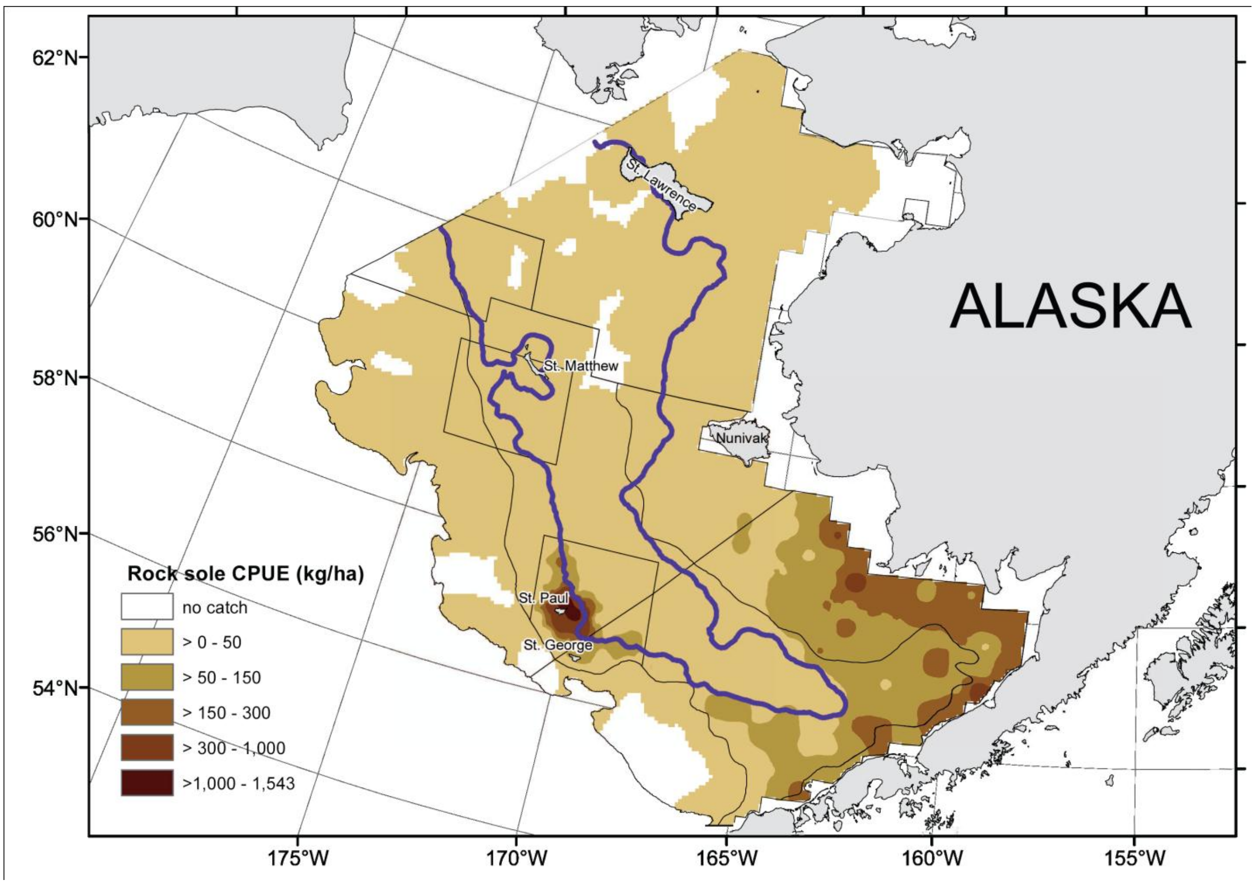

Figure 6.10. Distribution and relative abundance (kg/ha) of rock sole *Lepidopsetta polyxystra* for the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey. The 2°C isotherm (blue) delineates the cold pool of bottom water.

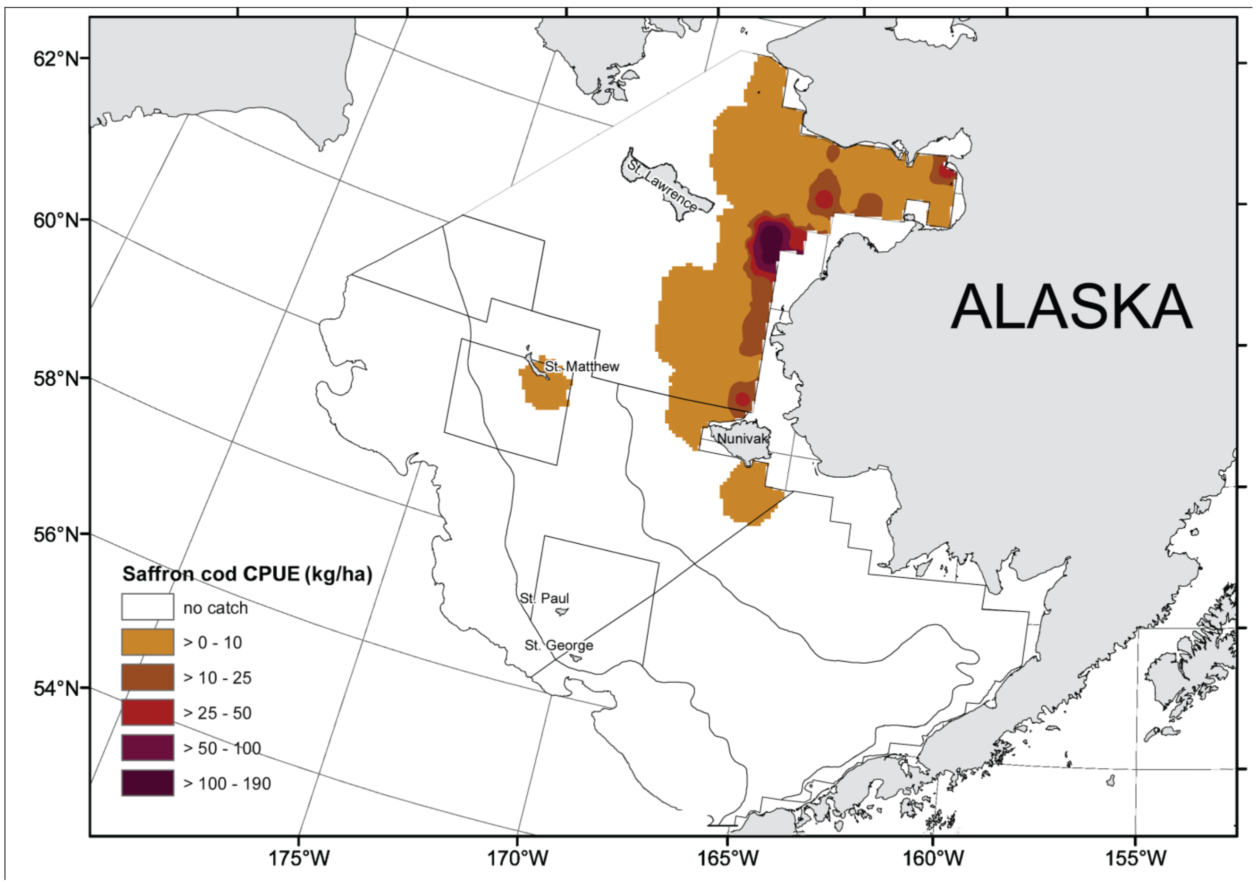

Figure 6.11. Distribution and relative abundance (kg/ha) of saffron cod *Eleginus gracilis* for the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey.

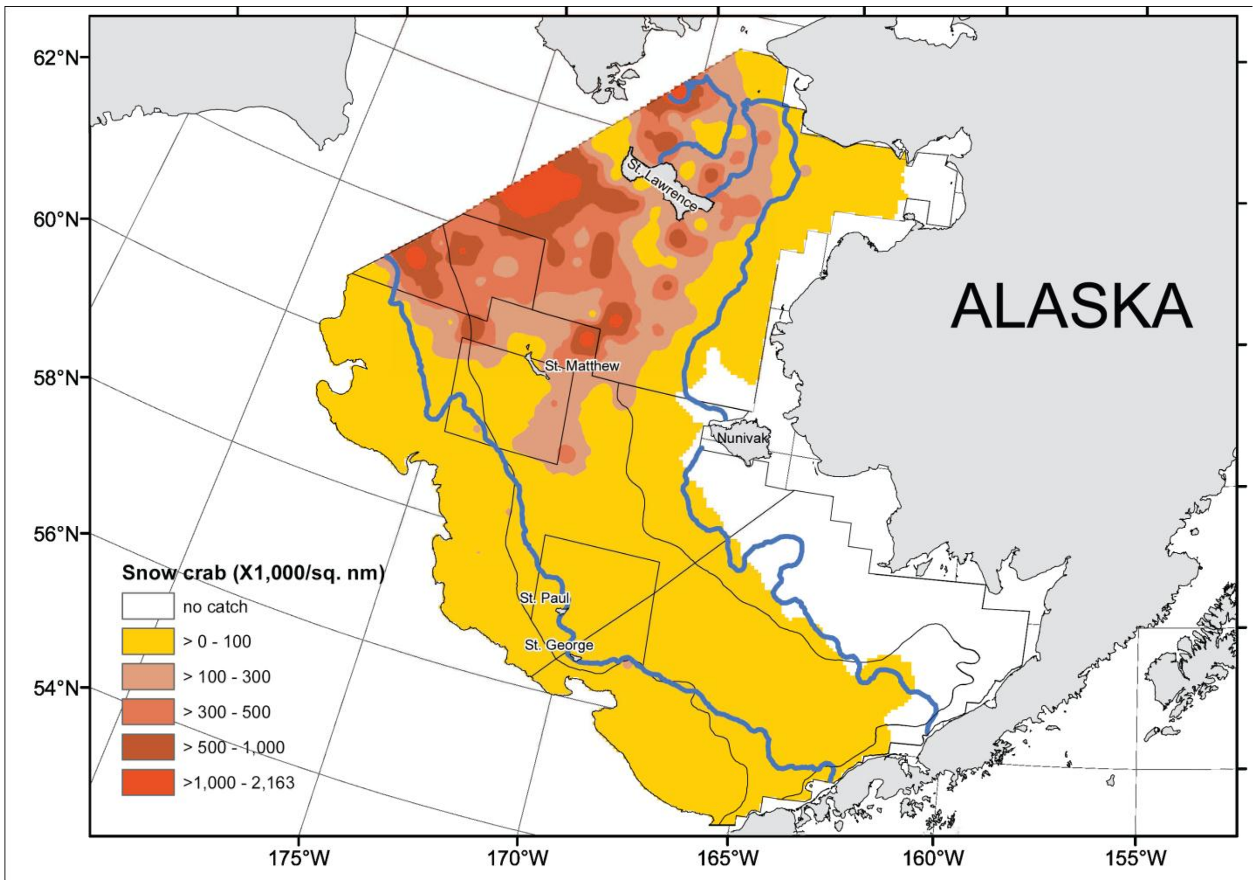

Figure 6.12. Distribution and relative abundance (kg/ha) of snow crab *Chionoecetes opilio* for the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey. The 2°C isotherm (blue) delineates the cold pool of bottom water.

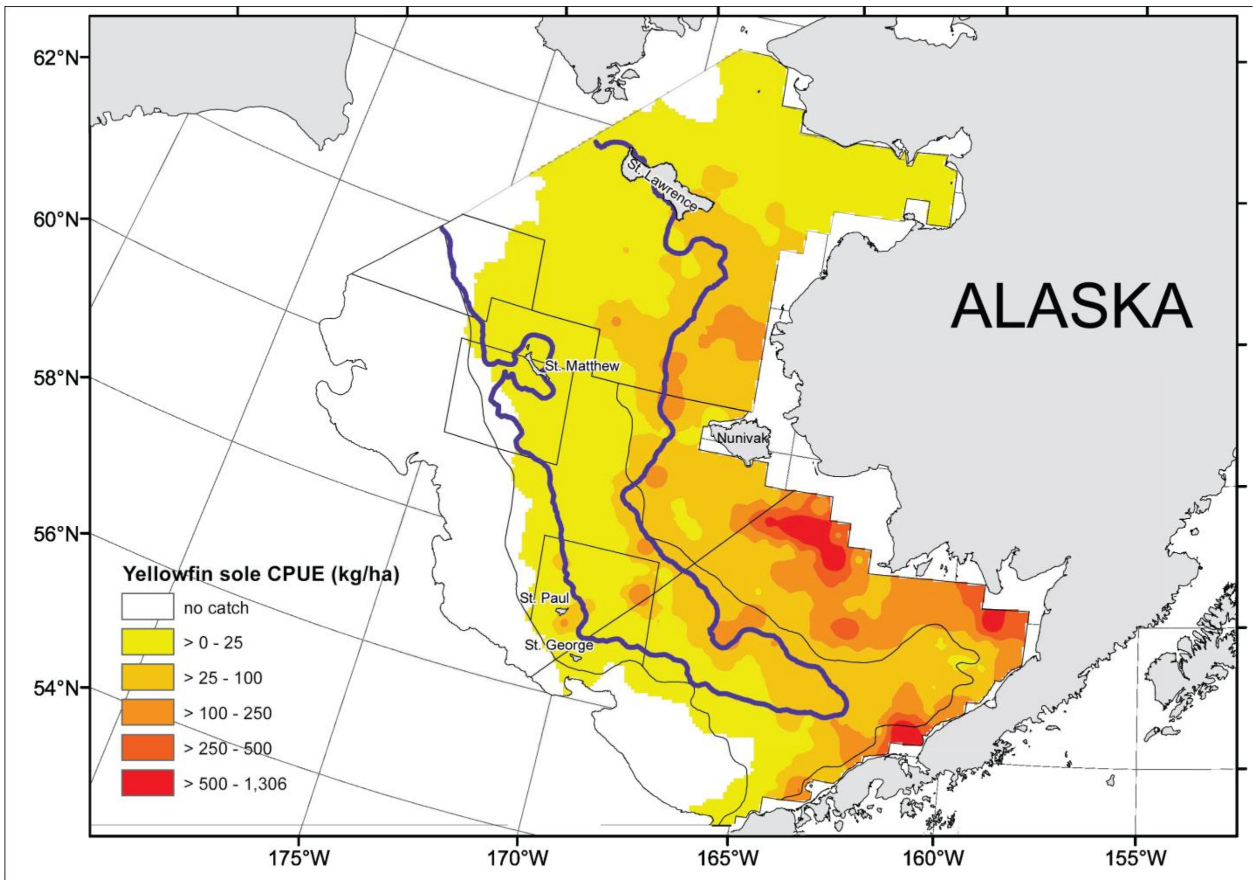

Figure 6.13. Distribution and relative abundance (kg/ha) of yellowfin sole *Limanda aspera* for the 2010 eastern and northern Bering Sea continental shelf bottom trawl survey. The 2°C isotherm (blue) delineates the cold pool of bottom water.

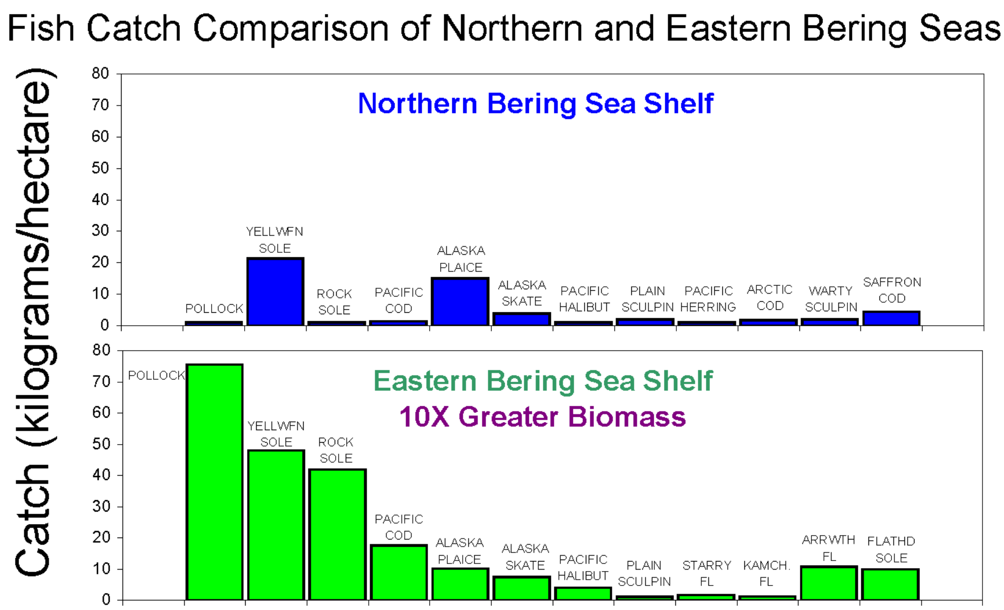

Figure 6.14. Fish catch comparison of northern and eastern Bering Seas.

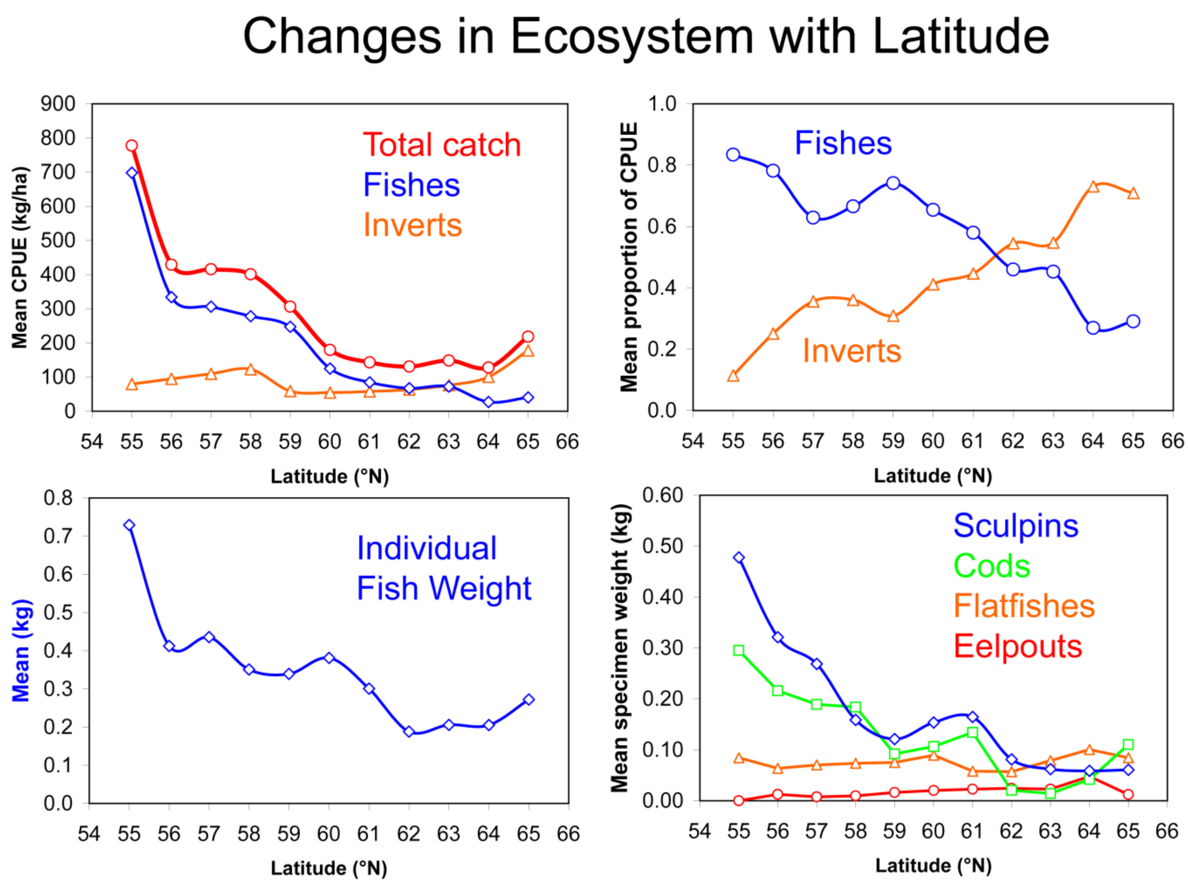

Figure 6.15. Changes in ecosystem with latitude.

7. Trawl Impact Studies

Nonpelagic (bottom) trawls are a class of mobile fishing gear that is highly adaptable for use in diverse habitat types. These trawls are designed to maintain direct contact with the seabed and to efficiently remove organisms in their path. As such, they are capable of affecting large areas of the seabed and represent a widespread, recurring, spatially variable and (importantly) a manageable form of disturbance.

In general, the process of understanding mobile gear effects has three distinct phases: (1) controlled experiments to identify changes caused by gear contact, (2) ecological studies to determine the consequences of these changes, and (3) decision-making based on a comprehensive cost-benefit analysis. Nearly all of the experiments to date have focused on benthic invertebrates and the specific changes that occur after mobile fishing gear, particularly bottom trawls, contact the seabed. This worldwide emphasis on benthic invertebrates reflects their limited mobility and high vulnerability to bottom-tending gear, and observations that structurally complex seabeds are an important element of healthy and productive ecosystems. The effects are typically measured as changes in community structure, abundance or biomass of populations, or the mean size of organisms. Although generalizations about the effects are possible, site-specific responses are likely, given variation in the composition of the benthos and differences in the intensity, severity and frequency of both natural and anthropogenic disturbances. Moreover, the frequently non-random selection of study areas makes it extremely tenuous to apply research findings from one geographic area to another. As such, the eventual management of bottom-trawling activity in the NBSRA by the Council should be based on a rigorous experiment designed specifically for the area.

Investigating the effects of bottom trawls

Research to understand and quantify the effects of bottom trawls has occurred throughout the world in a variety of benthic marine habitats (National Research Council 2002; Barnes and Thomas 2005). Most of these studies have used methods based on one of two experimental approaches. Short-term (acute) effects are studied in previously untrawled areas by comparing conditions in experimental corridors before and after a single pass or repeated passes of the gear. Occasionally, the recovery process is examined by re-sampling at a later date; these studies incorporate untrawled control corridors into the sampling program in order to account for systematic change during the study period (a Before-After-Control-Impact, or BACI, experimental design; (Green 1979)). Multiple trawled and control corridors are preferred for statistical reasons. This approach provides insights about the process of trawl disturbance and is the basis for most knowledge about trawling effects. Longer-term (chronic) effects are studied by comparing conditions in heavily fished and lightly fished or unfished areas and, as such, measure the cumulative effects of fishing. These experiments are relatively uncommon because high-quality historical fishing-effort data are frequently unavailable, and their designs are often flawed because the (unfished) “control” areas have previously been fished or they are fundamentally different than the corresponding experimental units (National Research Council 2002).

Previous research in the Bering Sea

Since 1996, the TRAWLEX project[2] has been investigating potential adverse effects of bottom trawls at sites in the Bristol Bay region of the EBS. These sites are relatively shallow (44-57 m), have sandy substrates, show a high level of natural disturbance, and support a rich invertebrate assemblage. Both chronic and short-term effects on the benthos have been studied.

Chronic effects of bottom trawls

The well-documented development of commercial trawl fisheries in the EBS since 1954 presented a unique opportunity to investigate the chronic effects of bottom trawling on soft-bottom benthos (McConnaughey et al. 2000; McConnaughey et al. 2005). Using detailed accounts of closures and fishing activity, it was possible to reconstruct historical effort and identify untrawled (UT) areas immediately adjacent to areas that had been heavily trawled (HT) over many years. For most of the benthic invertebrate species examined, it was determined that biomass and mean body size were reduced as a result of heavy trawling, suggesting a general population decline. In a few cases, greater overall biomass accompanied the observed body-size reduction, suggesting a proliferation of relatively small individuals in the HT area. The only exception to the pattern of smaller individuals in the HT area was red king crab (*Paralithodes camtchaticus*). In this case, mean body size was greater in the HT area, due to substantially fewer small crabs in the HT area than in the UT area. Since biomass in the HT area was lower than that in the UT area, the red king crab response to chronic bottom trawling was fewer individuals of greater mean size. Overall, these effects on body size were relatively small when compared with natural variability in a large, adjacent area closed to commercial trawling. From a community perspective, the HT benthos was less diverse, was dominated by the purple-orange sea star (*Asterias amurensis*), had less emergent epifauna and less biogenic substrate (shell) resulting in reduced structural complexity, and was more patchy overall.

Short-term effects of bottom trawls and recovery

Another TRAWLEX study investigated short-term effects of bottom trawling and recovery using a BACI experimental design (McConnaughey and Syrjala, in prep.). This project was located inside the same closure area used for the chronic effects study. The primary research questions were: (1) Do bottom trawls have measurable and statistically significant effects on soft-bottom habitat in the EBS and, if impacts are identified, (2) does the affected area recover to its original condition in the absence of fishing (if so, how quickly), or does it become fundamentally different as a result of the disturbance? In general, this study addresses management issues related to the need for and efficacy of bottom-trawl prohibitions, as well as operational considerations related to management of closed areas. Six pairs of experimental and control trawl corridors (statistical blocks) were established adjacent to one another in a previously untrawled area (Fig. 7.1). Each corridor was 20 km long, based on the average length of

[2] Point of contact for TRAWLEX research is Dr. Robert A. McConnaughey, RACE Division, Alaska Fisheries Science Center, Seattle, WA; 206-526-4150; bob.mcconnaughey@noaa.gov.

commercial bottom-trawl hauls in the area and on operational considerations; each corridor was 100 m wide so that it could contain all components of the commercial gear that was used. The number of corridors was based on a statistical power analysis that estimated the required number of samples for the anticipated number of sampling events. Three of the corridor pairs were oriented north-south and three were oriented east-west, to account for strong currents in the study area and possible directional effects. Overall, this study was designed to accommodate one sampling event before the experimental trawling disturbance and three events after the disturbance.

Potential impacts were investigated with biological and geological sampling before and after four passes with a typical commercial bottom trawl (Nor'eastern Trawl System Inc. 91/140 two-seam Aleutian combination otter trawl with a 0.36 m footrope diameter). Invertebrates that live on the seafloor (epifauna) were sampled with 15 min tows at a speed of 3 kts, using a standard AFSC 83/112 bottom trawl that was modified to improve capture and retention of small organisms. At each of these locations, the invertebrates that live in the seabed (infauna) and the physical-chemical properties of the surficial sediments were characterized with two pairs of grab samples collected prior to trawling for epifauna. Changes in seabed morphology were assessed with side scan sonar surveys that were conducted both before and after the commercial-trawl disturbance. The sampling locations were randomly selected from uniform grids superimposed on the corridors (Fig. 7.2), and an ultra-short baseline (USBL) system provided precise positioning of the commercial trawl and all sampling gear. During the first year of the experiment (2001; 35 days at sea), a total of 36 epifauna samples and 144 grab samples were collected before the commercial trawling disturbance, and all 12 corridors were surveyed with side scan sonar; with the same sampling effort after the trawling disturbance. Analysis of these data indicated statistically significant effects on biomass in three of the 24 invertebrate groups examined; however, 2.4 significant results were expected due to nothing more than random variation in the data (for $\alpha = 0.10$). The study area was revisited one year later (21 days at sea) and the after-disturbance-sampling protocol was repeated to assess whether longer-term (lagged) effects on the benthos had occurred. Once again, only minimal effects that could not be differentiated from random variation were observed. As such, it was concluded that the bottom trawl did not substantially affect biomass in the invertebrate populations studied. Analysis of the side scan sonar imagery also revealed negligible changes in the generally firm and featureless seabed, although trawl-door tracks were visible in the corridors. Trawling effects on ~160 infauna taxa are still being evaluated.

Scenario for an NBSRA BACI experiment

The environmental and biological characteristics of the NBSRA are largely unknown and, because there is no history of commercial bottom trawling, it represents a very rare opportunity to study short-term trawling effects and recovery. Many of the handicaps that have constrained the design or interpretation of previous experimental work (e.g. uncertain disturbance history) are non-existent because of the historical ice cover. Thus, one or more carefully designed BACI experiments (with directed use of the commercial trawl, as above) should be randomly placed according to resource-management needs for the area. Although an investigation involving more realistic fishing behavior is conceivable (e.g. Brown et al. 2005), it is unlikely that there would be sufficient pattern in the intensity and distribution of fishing effort to permit a statistical analysis with an acceptable level of Type II error (i.e. failure to reject a false hypothesis of no effect). Ultimately, the proven design and methods for the BACI experiment in the EBS can be adapted to conditions in the NBSRA. With fishing industry input, corridor dimensions (length, width) could be adjusted to match the best estimates of tow length and total gear width. Similarly, gear design and the intensity of disturbance (number of passes) with the commercial trawl could be set based on relevant observations from the EBS, anticipated changes in fishery practices, and other resource management considerations. If commercial trawl fisheries do develop as a result of less sea ice and more harvestable biomass, the cumulative effects of bottom-trawling disturbances could eventually be examined through a judicious use of closed-area boundaries (e.g. the MGTZ) and effort information as was done in the EBS.

Interpretation of research findings

Statistical analysis of the experimental results will test for species-specific differences before versus after disturbance with the commercial bottom trawl, while adjusting for temporal variability observed in the associated untrawled (control) areas. If no statistically significant effects are detected, it can be concluded that bottom trawling did not cause detectable changes in the benthic-invertebrate community within the time-scale of the study. As such, it is unlikely that bottom trawling will impact animals and subsistence activities that are dependent on this type of benthic habitat. If, on the other hand, statistically significant effects are detected, the impacts to managed and subsistence resources related to changes in the invertebrate community will need to be interpreted based on knowledge of ecological linkages. However, worldwide success at interpreting the ecological effects of trawling is quite limited because relatively little is known about the ecology of individual benthic invertebrate species (Smith et al. 2011), let alone the complex linkages and dependencies that exist with managed populations. A mathematical model has been developed to evaluate the effects of fishing on benthic habitat in Alaska (Fujioka 2006), however the results are expressed in terms of equilibrium levels of specific habitat types rather than the direct effects on managed populations. More recent modeling for the prawn-trawl fishery in Australia illustrates a more direct application of experimental results for management purposes (Pitcher et al. 2009). To this same end, basin-scale habitat-utilization models already developed for managed populations in the EBS (e.g. McConnaughey and Syrjala 2009) could be extended to include benthic invertebrate predictors thereby providing a means to estimate population-level responses to the observed effects of trawling. Ultimately, the statistical and ecological analyses, combined with an understanding of the local recovery dynamics, will provide the information basis for the Council to consider management actions.

Recommendations to facilitate research planning and management decision making

Precursory scientific investigations and targeted discussions with knowledgeable stakeholders should be undertaken to address specific design and execution details affecting the utility of the NBSRA experimental results. Early consensus on the interpretive scheme will also facilitate the decision-making process based on results of the study. In particular:

(1) It is important to maximize the relevance of the study by carefully specifying the gear type and intensity of disturbance, based on expected practices of the fishing industry. Whereas it is possible to incorporate multiple gear types and disturbance intensities into the experimental design and thus broaden the scope of the investigation, this would significantly multiply the effort and expense required to complete the work.

(2) The Type II error level should be minimized to the extent practical, so as to reduce the possibility of an incorrect conclusion of no trawling effect(s). A statistical power analysis based on NBSRA trawl-survey data can be used to estimate appropriate samples sizes for specified levels of uncertainty. Because the results of this analysis will vary by species according to their unique population characteristics, it is very important to identify the species of particular interest at the beginning of the experimental design effort.

(3) A systematic approach to study site selection is needed to produce representative and broadly applicable results. The usual non-random selection of study sites for trawl-impact experiments produces case-study results that are strictly limited to the location studied. However, study sites that are randomly selected from areas of similar sensitivity (i.e. those with distinct benthic invertebrate assemblages, or strata) would constitute replicated experiments that legitimately represent the entire stratum of interest. Such distinct and persistent benthic invertebrate assemblages have been described in the EBS using bottom-trawl-survey data (Fig. 7.3). In order to avoid the case-study limitation, a similar assemblage analysis using recently acquired NBSRA data should be undertaken prior to random selection of BACI experimental sites. Potential study sites within a stratum that are considered to be extremely sensitive, of significant cultural/scientific value or simply are not trawlable can be purposely excluded from consideration, recognizing that experimental results may not be applicable to areas so excluded. These exclusions could be identified with a formal public process resembling the one used to nominate and designate Alaska's Habitat Areas of Particular Concern (HAPC).

(4) Because it is necessary to isolate the effect of experimental trawling in the BACI experimental design, it may be necessary to impose temporary restrictions on pelagic trawling and other potentially disruptive activities in order to protect the integrity of the NBSRA study sites.

(5) Finally, early consideration of predictable issues would probably facilitate the Council's decision-making process. For example, it may be useful to reach consensus on acceptable levels of change (e.g. % increase/decrease in biomass of invertebrates or managed species) due to trawling, recognizing that such changes are inevitable. It might also be useful to identify a "common currency" for summarizing the various positive and negative changes in invertebrate/fish populations and other seabed properties that will be documented by the experiment.

NBSRA research summary and timeline scenario

Design and execution of experiments to study the effects of bottom trawling in the NBSRA would entail the following:

(1) Preliminary surveys (years 1-2+). Conduct two or more bottom trawl surveys to establish biological and environmental baselines (i.e. characterize pre-disturbance conditions and variability). The first such survey was completed in 2010 and is summarized in Section 6 of this report.

(2) Precursory analyses (years 2-3). Use the trawl survey data: (1) in a statistical power analysis for designing the BACI experiment and (2) to examine the spatial structure of the benthic invertebrate communities, as a basis for stratifying the NBSRA for systematic trawl impact studies. Obtain input from stakeholders to identify priority species and the trawl-impact parameters.

(3) Trawl impact experiments (years 4-5+). Initiate a replicated set of Before-After Control-Impact (BACI) investigations of bottom-trawl effects in distinct invertebrate communities (strata), preferably using contracted F/Vs and directed fishing with relevant commercial gear.

(4) Ecological studies (subsequent years). Conduct interpretive research on the ecology of the affected benthic invertebrates and their linkages to managed fish stocks.

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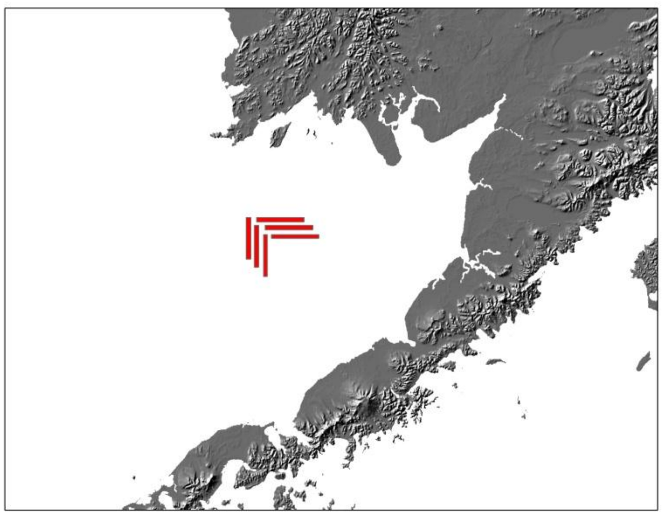

Figure 7.1. Layout of research corridors for the Before-After-Control-Impact bottom trawl impact experiment conducted in the eastern Bering Sea. Each of the six blocks represents a pair of Experimental (trawled) and Control (untrawled) corridors separated by 100 meters (enlarged for clarity).

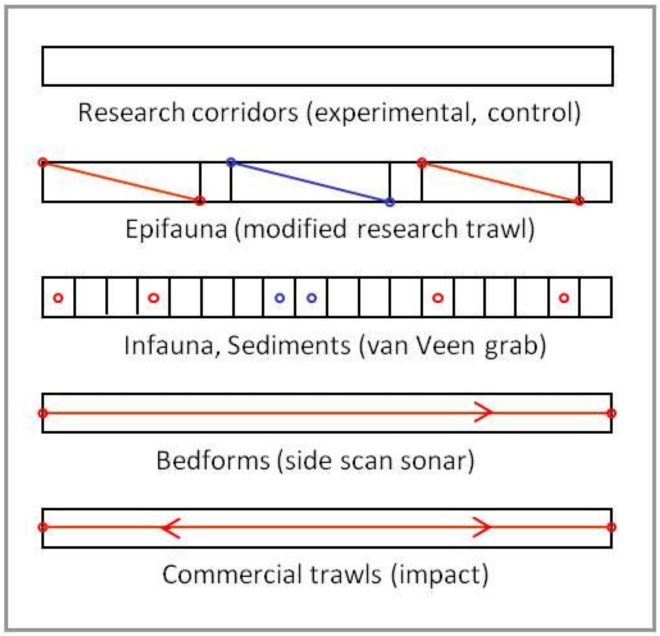

Figure 7.2. Schematic of the random sampling plan for the Before-After Control-Impact bottom trawl impact experiment in the eastern Bering Sea. Different colors represent different sampling events (times) during the course of the experiment. Each grid cell is sampled only once.

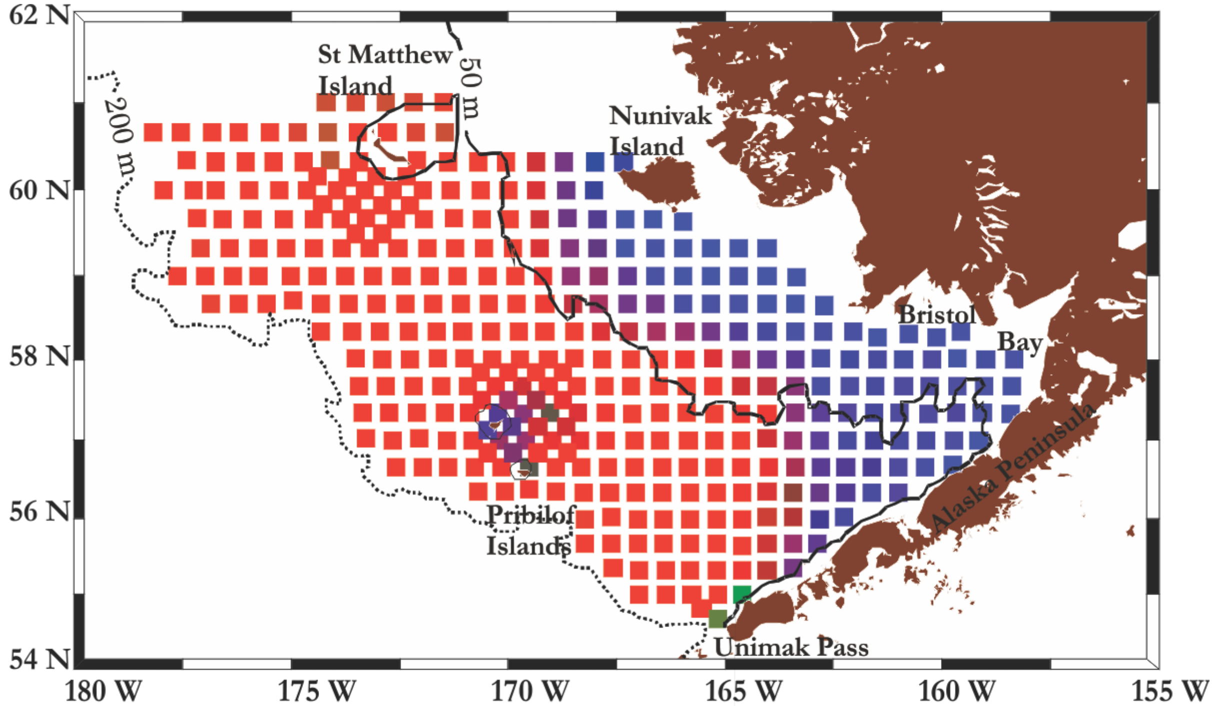

Figure 7.3. The structure of benthic invertebrate assemblages in the eastern Bering Sea based on a cluster analysis of bottom-trawl survey data from 1982-2002. Two distinct assemblages (offshore, inshore) were identified and two stations were undefined. The probability of cluster membership for a station over the study period is indicated with an RGB color scale where red corresponds to the offshore group (1:0:0), green corresponds to the undefined group (0:1:0) and blue corresponds to the inshore group (0:0:1). For example, a probability of 0.3 for an inshore station is represented by a symbol colored with a mix of red, green, and blue in the proportion (0.2:0.5:0.3). (adapted from Figure 1, Yeung and McConnaughey 2006).

8. Trawl Gear

Flatfishes, principally yellowfin sole and Alaska plaice, are the only commercially trawled species distributed broadly within the NBSRA. Pacific cod and walleye pollock are mainly limited to its southwestern margins. Based on the possible target fish species**,** the following are descriptions of the trawl gear (NPFMC 2012) most likely applicable in the NBSRA if nonpelagic trawling is allowed.

Flatfish and/or Pacific cod

The flatfish fishery uses two-seam or four-seam trawls with relatively low vertical openings. Vertical distance between headrope and seafloor is typically 1 to 3 fathoms (Fig. 8.1). Nets are made of polyethylene netting, with codends and intermediates using 5.5" to 8" mesh in square or diamond configuration. Steel trawl doors ranging in size from 5 m^2 to 11 m^2 spread the nets horizontally. Some vessels use off-bottom doors. The door spread varies with fishing depth and rigging style, but generally ranges from 40 m to 200 m (131' to 656'). The rigging between the net and the doors includes bridles and sweeps (mudgear), ranging in length from 30 m to 400 m (98' to 1,312'), which herd fish into the path of the trawl. Sweeps are made of steel cable or synthetic combination rope with bobbins to lift the sweep off the bottom. Footropes keep the front of the net off the bottom to protect it from damage. They are made of rubber disks or bobbins strung on chain or wire, with large diameter (12"-24") disks or bobbins separated by 18"-48" long sections of smaller disks (4"-8" diameter). Bobbins are mostly rubber, but sometimes are hollow steel balls designed to roll along the seabed. A design objective for flatfish nets is to herd fish into the net with minimum bottom contact, reducing gear damage and drag and maintaining fish quality by keeping sand out of the catch.

All vessels participating in the Bering Sea flatfish fisheries, as well as vessels fishing for groundfish with bottom trawls in the Modified Gear Trawl Zone, are required to use elevating devices on trawl sweeps to reduce habitat impacts. The fleet commonly uses rollers as elevating devices to achieve the minimum clearance of 2.5" off the bottom (Fig. 8.2). Elevating devices are required to be a minimum of 30' to 95' apart, depending upon the clearance achieved. As the sweeps are the gear component that contact up to 90% of the seafloor area from which fish are captured, this requirement is aimed at reducing trawl impact on the bottom habitat and benthic invertebrates. Research showed that this gear modification generally reduced impact on benthic invertebrates, specifically reducing crab injury rates to <5% (Rose et al. Submitted; Hammond 2009; Rose et al. 2010). The study is detailed in the Amendment 94 analysis (http://www.fakr.noaa.gov/sustainablefisheries/amds/94/bsaiamd94_earirfrfa0910.pdf, pp. 18-27).

Pacific cod

Bottom trawls are also used by American Fisheries Act (AFA) and non-AFA trawl fleets to target Pacific cod. Typical distance between headrope and seafloor is 1 fathom to 5 fathoms (6' to 30') (Fig. 8.1). Steel doors range in size from 4 m to 10 m. Door spread in most fishing depths is typically 100 m (328'), and the trawl warp/scope to depth ratio is typically 4 to 1. Sweeps are made of combination rope or wire threaded with rubber disks ranging from 3 to 8 inches in diameter. Footropes, constructed of chain or steel cable, typically extend 100’ to 200’ and are threaded with rubber discs and larger bobbins, which are 8” to 18” in diameter and are designed to roll along the bottom to limit contact with the bottom and protect the net. The larger diameter bobbins are spaced at intervals of 12” to 48”.

Walleye pollock

All vessels in the AFA fleet target pollock with pelagic otter trawls (Fig. 8.1). To achieve large net openings with a minimum of drag, the mesh sizes are very large, and twine size is relatively small. The trawl nets have meshes in the front end as large as 32 m to 64 m (105’ to 210’) and typically have a headrope to footrope vertical distance rise of 10 fathoms to 30 fathoms (60’ to 180’). The size of the gear used is dependent on the size and horsepower of the vessel, such that the larger and more powerful vessels tow the larger trawls. Net mesh gets smaller towards the intermediate and codend, with the codend typically having 4” to 4.5” stretched mesh. Otter boards (or doors) are made of steel and range in size from 5 m^2 to 14 m^2. In the pelagic fishery the doors do not come in contact with the seafloor. Door spread in most fishing depths ranges from 100 m to 180 m (328’ to 590’), and trawl warp/scope to depth ratio is typically 3 to 1. Contact with the seafloor is from weight clumps and the footrope. Long wire rope bridles attach the net to the doors. Unlike other groundfish trawl fisheries, there are no discs attached to the footropes on these trawls. Footropes typically are built of bare chain and extend 180 m to 450 m (590’ to 1,475’). Tow duration in this fishery ranges from 20 minutes to 10 hours (depending upon catch rates), at a speed of 3.5 to 4.5 knots. Tows may be in a straight line, or they may be adjusted to curve around depth contours or to avoid location of hangs and fixed gear. Vessels may turn around while towing and make several passes over the same general area.

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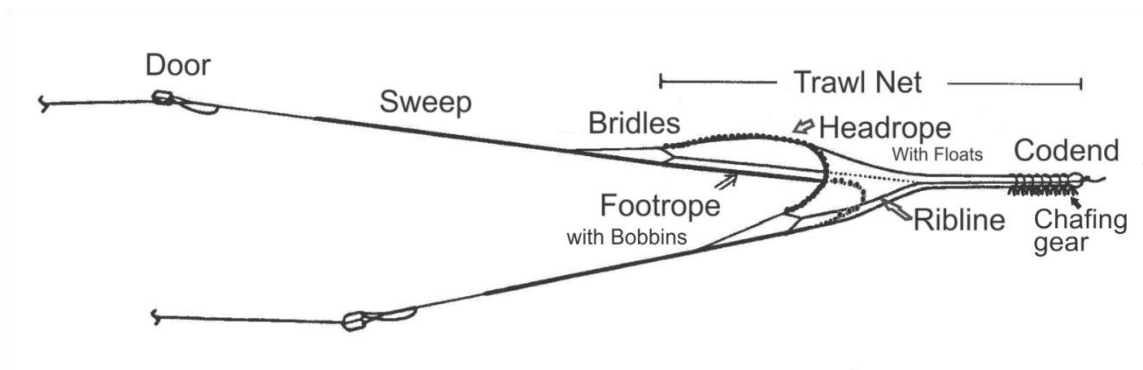

Figure 8.1. Diagram of trawl gear commonly used in the Bering Sea.

Figure 8.2. Example of an elevating device - 10 inch elevating bobbin connected to 2-inch (52-mm) combination wire with hammerlocks (coupling links). (Figure 3-6, Amendment 94 EARIRFRFA September 2010, http://www.fakr.noaa.gov/sustainablefisheries/amds/94/bsaiamd94_earirfrfa0910.pdf).

9. Public Input

NBSRA Research Plan - Community and Subsistence Workshop

The AFSC hosted the NBSRA Research Plan Community and Subsistence Workshop at the Anchorage Chamber of Commerce in Anchorage, Alaska, on 24-25 February 2010. The objectives of the workshop were to communicate the intent of the NBSRA to western Alaska communities, solicit their input for a research plan to study the impacts of nonpelagic trawling in the NBSRA, gather existing local and traditional knowledge from the communities, and register their concerns. The subsistence and culture of the communities are closely tied to the environment and animals of the NBS. Their knowledge of the area is of great value to science and resource management, while management actions and policies in the area may greatly impact their lives.

The Alaska Regional Office (AKR) and the North Pacific Research Board (NPRB) provided funding to the Rural Alaska Community Action Program, Inc. (RurAL CAP) to facilitate the workshop and to support travel for the invitees identified by RurAL CAP. The invitees include community leaders, elders and hunters. Over twenty communities along the eastern Bering Sea coast from Kuskokwim Bay to the Bering Straits were represented at the workshop. Also in attendance were representatives from conservation groups, the trawl fishing industry, and the Anchorage community (Appendix A).

Pat Livingston (SSC Chair and AFSC Resource Ecology and Fisheries Management (REFM) Division Director) opened the workshop by emphasizing the objectives of the workshop. Staff from the AKR, AFSC and the U.S. Fish and Wildlife Service (USFWS) presented information on the policies, research planning, subsistence species, and proposed research in the NBSRA. Melanie Brown (AKR) presented the history of the establishment of the NBSRA and the protected areas within, and clarified the current rules and regulations. Cynthia Yeung (AFSC) explained the process for development of the NBSRA Research Plan, which was only then at the initiation stage. She urged for community input in the planning process. Jonathan Snyder (USFWS), Dan Urban (AFSC), Michael Cameron (NMML), and Tamara Zeller (USFWS) respectively presented biological information on the Pacific walrus, crabs, ice-associated seals, seabirds. Bob McConnaughey (AFSC) explained the general design of nonpelagic trawl impact studies. Craig Rose (AFSC) reported findings from recent studies in nonpelagic trawl gear modifications and discuss regulated trial use in the Bering Sea. The Bering Sea Elders Advisory Group together with the Alaska Marine Conservation Council (AMCC) presented maps of some critical areas of subsistence usage in the Nunivak Island, Etolin Strait, and Kuskokwim Bay region. Community participants raised questions and commented on each presentation. Discussion ensued on a broad array of issues pertaining to their subsistence and socioeconomic interests. Livingston closed the workshop with a summary of main concerns raised by the communities to be considered in the research planning and management of the NBSRA:

Science considerations -

(1) Take ecosystem approach
(2) Do not solely focus on climate effects
(3) Consider seasonal distribution and habitat of species

(4) Understand fish spawning and rearing habitat
(5) Consider critical habitats of polar bears and ice-associated seals
(6) Rely on previous studies to greatest extent possible (instead of initiating new trawl studies)
(7) Incorporate Local and Traditional Knowledge into study plan
(8) Add cultural component to plan
(9) Include Native communities in research effort
(10) Nearshore research is also important
(11) Research salmon genetics and rivers of origin

Management Aspects -
(1) Prohibit bottom trawling, or allow the least amount of disturbance possible
(2) Create buffer areas
(3) Impose seasonal restrictions
(4) Strong monitoring and enforcement
(5) Proceed slowly with planning
(6) Conserve and respect environment and resources
(7) Stewardship for future generations

Communication and Process -
(1) Develop process to involve Native communities in planning and implementation
(2) Add rural outreach component to the plan
(3) Increase active communication between communities and agencies

Additional Points -
(1) Consult with communities regarding 2010 AFSC research survey in the NBS
(2) Observe AFN Resolution 0935 Trawling Moratorium
(3) Consider effect of commercial fisheries on subsistence
(4) NMFS and NPFMC should consult often with communities
(5) Community representation on NPFMC
(6) Maintain the boundaries prohibiting commercial nonpelagic trawling
(7) Visit and stay in communities to foster understanding
(8) Commit financial support for group meetings
(9) Reconvene to follow-up on this workshop within a year

Ultimately, the workshop became a forum for the communities to raise questions and voice concerns. The communities were wary that the NBSRA Research Plan to study nonpelagic trawl impacts was a veiled attempt to sanction commercial nonpelagic trawling in the NBS, which most of them opposed. Another contention was the lack of tribal consultation by federal government on the entire issue of establishing the NBSRA and initiating research planning. The workshop was an important starting point in building an understanding between resource management /research agencies and NBS communities. The key outcome was the realization that the communities were highly sensitive to the NBSRA issue, and dialogue must continue to build trust and collaboration.

NBSRA Research Plan - Science Workshop

The AFSC hosted the NBSRA Research Plan Science Workshop at the Alaska Marine Science Symposium (AMSS) on January 17, 2011, in Anchorage, Alaska. The objective of the workshop was to gather information from scientists and local communities on what areas and species within the NBSRA warrant protection under this plan. More than sixty people attended, representing state and federal agencies, non-government organizations, academia, native corporations, and the fishing industry (Appendix B).

Russ Nelson, Director of the Resource Assessment and Conservation Engineering (RACE) Division, AFSC, opened the workshop with the introduction of participants and an overview of the NBSRA. He emphasized the goal of the workshop, and that of the Research Plan: to investigate the effects of bottom trawling on bottom habitats, and provide information to assist the Council in protecting crabs, marine mammals, endangered species, and the subsistence needs of western Alaskan communities. Bob McConnaughey (AFSC) presented on how to study the effects of bottom trawls based on his research in Bristol Bay. Sue Moore (NOAA Office of Science and Technology) presented for Jackie Grebmeier and Lee Cooper (University of Maryland, Center for Environmental Sciences, Chesapeake Biological Laboratory), providing insights on the variability in the NBS ecosystem from decades of research, especially on benthic-pelagic production and linkages to the food web of marine mammals and seabirds. Jim Lovvorn (Southern Illinois University, Carbondale) presented on the threatened spectacled eider and its critical habitats in the NBS, expounding on ecosystem linkages. Questions and discussions followed each presentation.

After the final open discussion period, Pat Livingston summarized the main concerns for study design raised during the workshop:

Type of study -
An acute effects study seems most appropriate, but it is important to separate natural variability from trawl effects. There is the need to look at existing data to understand benthic community types and their variability on different temporal and spatial scales. There are questions as to what kinds of existing data are available for use in designing the study, what type of gear should be used, and the size of the area and the duration of the study.

Species considerations -
Walrus and bearded seals are important subsistence species that feed mostly on the benthos. Their prey dwell deeper than can be reached by a van Veen sediment grab sampler. Sampling for their prey is problematic. There are decadal-scale changes in prey and predator feeding patterns, so it is difficult to predict what areas are or will be important to mobile predators. The occurrence of phytoplankton blooms that drive benthic productivity can vary in location and timing. Ice cover also dictates where mobile predators can gain access to prey. Given all the variability, it is difficult to predict where benthic production will be favorable and where fisheries may be likely to occur.

Spatial and temporal considerations -
Given the variability of the ecosystem on a decadal scale, the duration of the study is an important consideration. The study design needs to account for seasonal and decadal signals. The frequency

of trawling is a factor in the effects generated. The design also needs to address the exclusion or inclusion of the habitats for key predators - on one hand, to avoid adversely affecting the animals; on the other, to increase the understanding of them. Inshore areas are important for study for its importance to subsistence fisheries. Data mining is useful for research planning. There are existing data available from ADF&G on subsistence activities. Also, Russian data on the NBS are important to consider. Regarding the scope of the study, the debate is whether it should be confined to the effects of fishing, or expanded to broader issues, such as the human dimension.

Feasibility -
How feasible is it to conduct the study as will be proposed in the Research Plan? Where flatfish, primarily yellowfin sole, are concentrated now and where they might move to in the future are candidate areas for study. The present distribution and abundance of the fish are not attractive to commercial fisheries, and the future state is unpredictable. Federal resources are lacking for conducting a fishery-independent study, so an Exempted Fishing Permit (EFP) process may have to be employed. Monitoring gear will need to be added to commercial vessels under the EFP process. Finally, it is still unclear how the study that will be proposed is linked to regulatory outcomes, e.g., whether area opens if the study concludes that no adverse effects of trawling can be detected.

Nelson closed the workshop thanking the participants and urging for more information on species, habitat, and activities helpful for planning the research. He acknowledged that more basic ecological research is necessary, but it is not in the purview of the Research Plan as AFSC is tasked. He believed that the December 2011 timeline for completing the draft of the Research Plan may be optimistic. Between now and the completion of the draft Research Plan, there will ample opportunity for public input and comment, including possibly another Subsistence and Community Workshop.

Appendix A. NBSRA Research Plan Community and Subsistence Workshop - participants

Participant	Affiliation
Angelique Anderson	CVRF
Jason Anderson	Best Use Cooperative
Karl Ashenfelter	White Mountain
Allen Atchak	Stebbins
Reggie Barr	Brevig Mission/NSEDC
Julia Beaty	AMCC
David Bill Sr.	Toksook Bay
Aggie Blandford	NSEDC
William Brown	Eek Traditional Council
Keith Bruton	O’Hara Corporation
David Carl	Kipnuk
Dorothy Childers	AMCC
David O. David	Kwigillingok
Jack Fagerstrom	Golovin
Andrew Hartsig	Ocean Conservancy
Jennifer Hooper	AVCP
Larson Hunter	CVRF
Art Ivanoff	Unalakleet
Weaver Ivanoff	Unalakleet
Axel Jackson	Native Village of Shaktoolik
John Jemewouk	Elim
Kenneth Kingeekuk	Native Village of Savoonga
Charlie Lean	NSEDC
Laurie McNicholas	Nome
Vera Metcalf	Kawerak
Eva Mendalook	Diomede
Peter M. Moore	Emmonak
Muriel Morse	AMCC
Erik O‟Brien	State of Alaska Commission
Ukallaysaaq Tom Okleasik	NWAB
Frank K. Oxereok Jr.	Wales
Christine Perkins	Kawerak
Vince Pikonganna	King Island
Fred Phillip	Kwigillingok
John A. Phillip, Sr.	Kongiganak
George Pletnikoff	Greenpeace/AITC
Julie Raymond-Yakoubian	Kawerak
Charles Saccheus	Native Village of Elim
Glenn Seaman	Homer

Participant	Affiliation
Stewart Tocktoo	Brevig Mission Native Village
Stanley Tom	Newtok
Deborah Vo	CVRF
Jon Warrenchuk	Oceana
Gregg Williams	IPHC
Heather Kinzie	A Leading Solution (Moderator)
Rebekah Lührs	RurAL CAP
A. J. Salkoski	RurAL CAP
Sarah Scanlan	RurAL CAP
Melanie Brown	NMFS AKR
Mike Cameron	NMFS AFSC
Diana Evans	NPFMC
Nicole Kimball	NPFMC
Bob Lauth	NMFS AFSC
Pat Livingston	NMFS AFSC
Bob McConnaughey	NMFS AFSC
Eric Olson	NPFMC
John Olson	NMFS AKR
Craig Rose	NMFS AFSC
Jonathan Snyder	USFWS
Dan Urban	NMFS AFSC
Cynthia Yeung	NMFS AFSC
Tamara Zeller	USFWS

Appendix B. NBSRA Research Plan Science Workshop - participants.

Participant	Affiliation	Participant	Affiliation
Vera Alexander	U. Alaska Fairbanks	Jim MacCracken	USFWS
Jason Anderson	Alaska Seafood Cooperative	Paul MacGregor	NPRB
Tim Andrew	AVCP	Bob McConnaughey	NMFS AFSC
Alex Andrews	NMFS AFSC	Vera Metcalf	Eskimo Walrus Commission/Kawerak
Robyn Angliss	NMFS NMML	Sue Moore	NMFS S&T
Julia Beaty	AMCC	Muriel Morse	AMCC
John Bengtson	NMFS AFSC	Phil Mundy	NMFS AFSC
Sally Bibb	NMFS AKR	Jim Murphy	NMFS AFSC
Peter Boveng	NMFS AFSC	Russ Nelson	NMFS AFSC
Ron Britton	USFWS	Art Nelson	Bering Sea Fisherman's Association
Melanie Brown	NMFS AKR	John Olson	NMFS AKR
John Burns	Living Resources, Inc.	Ed Richardson	AtSea Processors Assoc.
Mike Cameron	NMFS NMML	Kim Rivera	NMFS AKR
Dorothy Childers	AMCC	Glenn Seaman	Homer
Phil Clapham	NMFS NMML	Gay Sheffield	ADF&G
Paula Cullenberg	Alaska Sea Grant Marine Advisory Program	Mike Sigler	NMFS AFSC
Erin Dougherty	Native American Rights Fund	Laura Slater	ADF&G
Lisa Eisner	NMFS AFSC	Stephanie A. Smith	Battelle
Sarah Ellgen	NMFS AKR	Alan Tilstone	Battelle
Diana Evans	NPFMC	Dan Urban	NMFS AFSC
Anthony Fischbach	USGS	Tom van Pelt	NPRB
Geoffrey Glennon	Alaska Pacific University	Vicki Vanek	ADF&G Kodiak
John Goodwin	Kotzebue IRA	Jon Warrenchuck	Oceana
Pearl Goodwin	Kotzebue IRA	Tom Weingartner	U. Alaska Fairbanks
Tuula Hullmen	U. Alaska Fairbanks	Julie Yakoubian-Raymond	Kawerak
Meg Inokuma	ADF&G Kodiak	Cynthia Yeung	NMFS AFSC
Frank Kelty	City of Unakaska		
Earl Krygie	Marine Conservation Alliance Foundation		
Natalie Landreth	Native American Rights Fund		
Bob Lauth	NMFS AFSC		
Charlie Lean	NSEDC		
Gary Lester	EcoAnalysts, Inc.		
Pat Livingston	NMFS AFSC		
Jim Lovvorn	Southern Illinois U. Carbondale		

Appendix C. Abbreviations

ADF&G	Alaska Department of Fish and Game
AFA	American Fisheries Act
AFSC	Alaska Fisheries Science Center (NMFS)
AITC	Alaska Inter-Tribal Council
AK	Alaska
AKR	Alaska Region (NMFS)
AMCC	Alaska Marine Conservation Council
AMSS	Alaska Marine Science Symposium
AP	Advisory Panel (NPFMC)
ARLIS	Alaska Resources Library and Information Services
AVCP	Association of Village Council Presidents
BACI	Before-After-Control-Impact
BASIS	Bering-Aleutian Salmon International Survey
BERPAC	Bering and Chukchi Seas Expeditions
BEST	Bering Sea Ecosystem Study
BSAI	Bering Sea and Aleutian Islands
BSIERP	Bering Sea Integrated Ecosystem Research Program
CFR	Code of Federal Regulations
CVOA	Catcher-Vessel Operational Area
CVRF	Coastal Villages Region Fund
DPS	District Population Segment
EA/RIR/FRFA	Environmental Assessment/Regulatory Impact Review/Final Regulatory Flexibility Analysis
EBS	Eastern Bering Sea
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FMP	Fishery Management Plan
FR	Federal Register
GOA	Gulf of Alaska
HAPC	Habitat Areas of Particular Concern
IPHC	International Pacific Halibut Commission
IRA	Indian Reorganization Act
ISHTAR	Inner Shelf Transfer and Recycling in the Bering and Chukchi Seas
ITR	Incidental Take Regulations
LOSI	Loss of Sea Ice research
MGTZ	Modified Gear Trawl Zone
MMPA	Marine Mammal Protection Act
MSA	Magnuson-Stevens Fishery Management and Conservation Act
NBS	Northern Bering Sea

NBSRA	Northern Bering Sea Research Area
NMFS	National Marine Fisheries Service (NOAA)
NMML	National Marine Mammal Laboratory
NOAA	National Oceanic and Atmospheric Administration
NPAFC	North Pacific Anadromous Fish Commission
NPFMC/Council	North Pacific Fishery Management Council
NPRB	North Pacific Research Board
NSEDC	Norton Sound Economic Development Corporation
NWAB	Northwest Arctic Borough
OCC	Ocean Carrying Capacity Program
OSCEAP	Outer Continental Shelf Environmental Assessment Program
PBR	Potential Biological Removal
PR	Protected Resources Division (NMFS)
RACE	Resource Assessment and Conservation Engineering Division (AFSC)
REFM	Resource Ecology and Fisheries Management Division (AFSC)
RurAL CAP	Rural Alaska Community Action Program, Inc.
S&T	Office of Science and Technology (NMFS)
SAR	Stock Assessment Report
SF	Sustainable Fisheries Division (NMFS)
SPEI	Spectacled eider
SSC	Scientific and Statistical Committee (NPFMC)
STAL	Short-tailed albatross
STEI	Steller's eider
U.S.	United States (of America)
U.S.S.R.	Union of the Soviet States of Russia
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Service
Y-K	Yukon-Kuskokwim