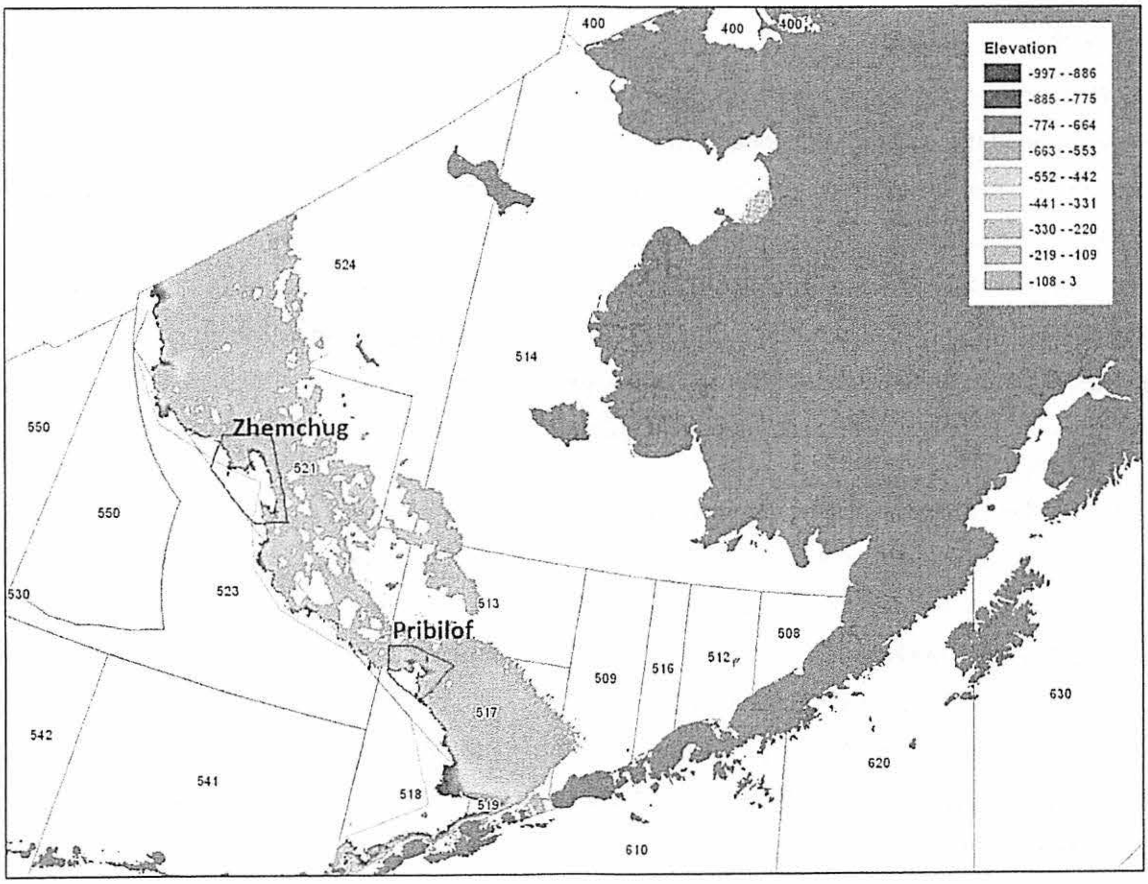
AGENDA C-7
Supplemental
JUNE 2013

PRIBILOF AND ZHEMCHUG CANYON HABITAT CONSERVATION AREAS: AN UPDATED REVIEW WITH IMPLICATIONS FOR MANAGEMENT



SUBMITTED TO THE NORTH PACIFIC FISHERY MANAGEMENT COUNCIL
IN REFERENCE TO AGENDA ITEM D-2

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For Greenpeace

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1.1 Problem Statement

The eastern Bering Sea is one of the most biologically productive large marine ecosystems in the world, and also one of the biggest fishing grounds in the world (NRC 1996, 2002). Some of the most intensive fishing has occurred along the 1,200 km margin of the outer continental shelf and slope in the eastern Bering Sea (Fritz *et al.* 1998, NMFS 2004), referred to as the "Green Belt" because of its elevated primary and secondary productivity (Springer *et al.* 1996, NRC 1996, Macklin and Hunt 2004, Okkonen *et al.* 2004, Buck and Bruland 2007, Hunt *et al.* 2008). Groundfish target fisheries in this ecoregion have included walleye pollock, Pacific cod, Greenland turbot, sablefish and rockfish (Fritz et al. 1998). The vast majority of the groundfish catch is taken with trawl gear, although fixed gears account for a significant portion of the Pacific cod and Greenland turbot catch as well as all of the directed fishery catch of sablefish and halibut.

Historical management actions that addressed fishing gear impacts on habitat in the Bering Sea were focused on protection of nearshore crab and sea lion habitat, consisting mainly of closures to trawling in relatively shallow waters with sand substrates along the coasts (NMFS 2004). Until very recently there were no habitat protections of any kind in the deeper waters that encompass the continental shelf break and upper slope of the eastern Bering Sea, Aleutian Islands or the Gulf of Alaska. As part of essential fish habitat (EFH) plan amendments in 2005 and 2007, the Council adopted new measures to mitigate the adverse impacts of bottom trawling in the deeper slope and basin waters of Aleutian Islands and Gulf of Alaska and to "freeze the footprint" of bottom trawling in the eastern Bering Sea, but other bottom-tending gear types (including pelagic pollock nets)[1] were not addressed in the Bering Sea and the shelf break/slope habitat along the Green Belt remains unprotected – no year-round or seasonal benthic habitat protection or other protection from fishing has been provided to date.

This ecoregion is unique in having some of the largest submarine canyons in the world, which play a major role in ocean circulation to the shelf and serve as vital habitat for a diverse assemblage of benthic and pelagic fauna. In 2006-2007, the Council considered HAPC designation for submarine canyons but delayed action pending more information. Currently the Council is considering designation of six areas of known skate egg concentration situated within a number of deepwater canyons along the Green Belt as skate HAPC. The localized nature of these skate egg concentrations within the canyons and their vulnerability to fishing disturbance makes them logical choices for HAPC designation and protection,[2] but the limited, site-specific approach to HAPC is not designed to address the wider impacts of fishing on this vulnerable deep-sea ecosystem and the diverse fauna that inhabit its complex system of submarine canyons, valleys and slopes.

The absence of habitat protections for representative areas of the deepwater benthic and pelagic zone along the 1,200 km extent of the Green Belt is difficult to justify given its ecological importance to the region's diverse fish, mammal and bird fauna, its value as a source of replenishment that sustains fisheries, and its cultural significance to indigenous communities. A wider, ecosystem-based approach to habitat protection is needed to address all the important features of the Bering Sea Greenbelt, including representative canyon habitats.

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[1] Although the massive pollock fishery has exclusively deployed pelagic trawl nets since 1999, there is a strong incentive for

[2] See NPFMC Agenda Item C4(a), *Skate HAPC Initial Review*, February 2012.

1.2 Need and Purpose

Numerous proposals have been made to NMFS and the Council since 2001 to establish Habitat Conservation Areas (HCAs) in representative portions of the Green Belt. These proposals have focused on Pribilof and Zhemchug canyons as candidates for measures to provide EFH protection for deep-sea corals, sponges and other benthic habitat important to managed species as well as refuges from directed fishing and/or bycatch of deepwater species whose life history, habitat preferences and reliance on the stable, relatively unchanging environment afforded by these canyons make them especially vulnerable to the impacts of fishing. In 2006-2007, the Council reviewed information from the Alaska Fisheries Science Center summarizing current knowledge of Pribilof, Pervenets and Zhemchug canyons and considered HAPC designation for submarine canyons but ultimately postponed action, pending more information.

Since then, new information has become available from several sources that merit re-examination of possible habitat measures for the Green Belt canyons. In 2007, a research expedition to Pribilof Canyon and Zhemchug Canyon conducted video surveys of seafloor habitat in the canyons and provided new information on their coral and sponge fauna, including new species records and northern range extensions for a number of corals and sponges as well as discovery of a new sponge species, *Aaptos kanuux* (Lehnert *et al.* 2008, Miller *et al.* 2012). In addition, new research describes the importance of Zhemchug and Pribilof canyons in the circulation exchange between the Bering Sea shelf and basin (Hunt *et al.* 2008, Kinney *et al.* 2009) and provides new details on the diversity, stock structure, and ecology of deepwater fish fauna typically found in the canyons (e.g., Stevenson *et al.* 2008, Hoff 2009, Heifetz *et al.* 2009, Hoff 2010, Stevenson and Lewis 2010, Stone *et al.* 2011, Palof *et al.* 2011). In 2009, the first comprehensive mapping of Pribilof Canyon was also completed using high-resolution multibeam echosounders, providing a clearer picture of the canyon environment and its important features (AFSC 2009). Finally, the 2006 amendments to the Magnuson-Stevens Act give Councils new authority to protect deep-sea corals[3]and other species and habitats, considering the variety of ecological factors affecting fishery populations.[4]

Taken together, these new sources of information and strengthened legislative mandates compel a fresh look at options for protecting representative portions of the shelf break and slope canyon habitats that have, until now, received no protection. Although the importance of these canyons as EFH of commercially important managed species is clear, they play a larger role in the eastern Bering Sea ecosystem. The absence of habitat protection measures for this distinct ecoregion and the rare and unique fauna found within it calls for remedial action designed to avoid long-term or irreversible environmental damage while research continues. Protections afforded to representative canyons within this ecoregion would achieve multiple goals for habitat conservation and ecosystem-based management under the BSAI FMP, and are critical to the long-term sustainability of the fisheries.

[3]MSA § 303(b)(2)(B) (16 U.S.C. § 1853(b)(2)(B)).
[4] MSA § 303(b)(12) (16 U.S.C. § 1853(b)(12)).

2. Description of the Concept: Pribilof and Zhemchug Canyon HCAs

The 1,200 km upwelling and mixing zone along the margins of the outer continental shelf and slope of the eastern Bering Sea has been widely referred to as the "Green Belt" because it is an area of greatly enhanced primary and secondary productivity. The outer continental shelf break and slope of the Bering Sea is also unique in having several of the largest submarine canyons in the world, which play crucial roles in the physical transport of nutrients from deep basin waters to the eastern Bering Sea shelf and provide essential habitat to vulnerable deep-sea fauna as well as many top predator fish, seabirds and marine mammals that utilize the pelagic zone associated with the canyons. For purposes of delineating the boundaries of this ecoregion, the area encompassing the outer shelf and slope between the 100 and 1000 m isobaths is used as a first approximation, encompassing a total area of 191,648 km^2(Fig. 1).

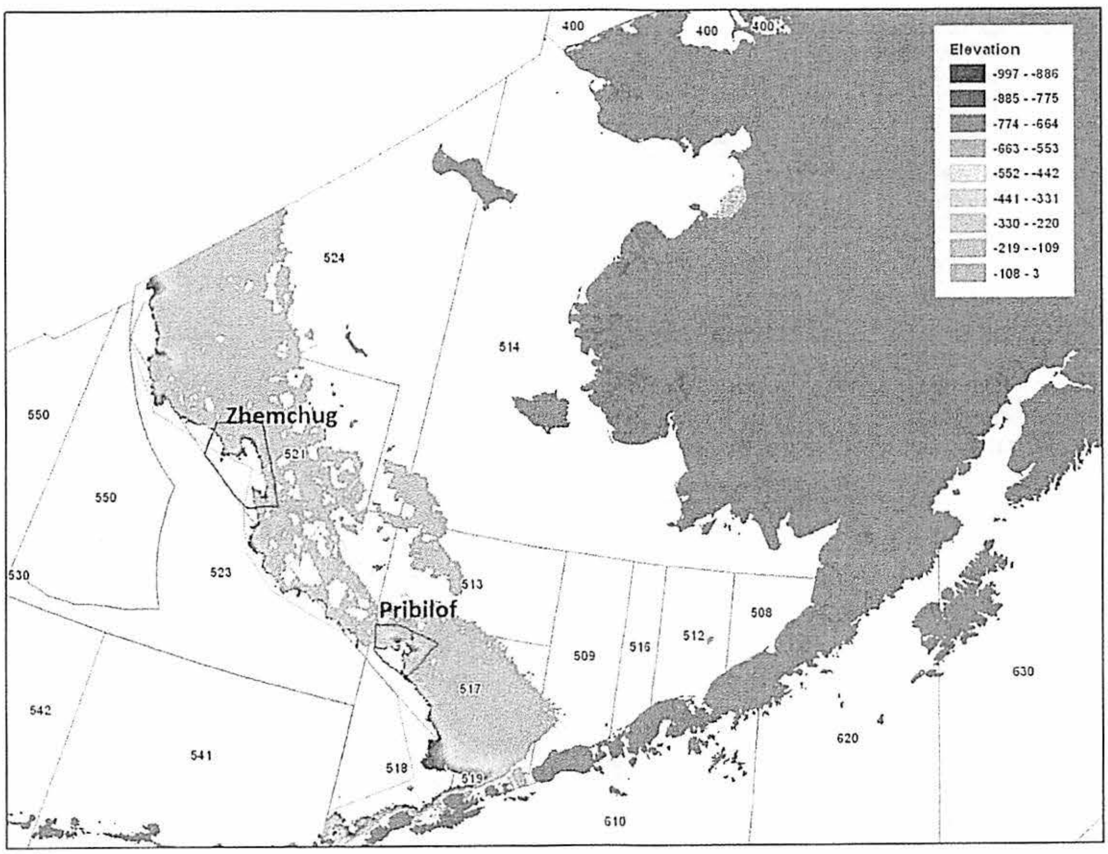


Figure 1. Area encompassing the outer shelf and slope between the 100 and 1000 m isobaths, courtesy of NMFS AKRO.

To remedy the absence of habitat protection measures for this vital ecoregion, this paper reviews the benefits of establishing habitat conservation areas (HCAs) encompassing the full extent of Pribilof Canyon and Zhemchug Canyon, which occupy positions in the central-southern and central-northern sections of the Green Belt.

2.1 Example Boundaries for Pribilof and Zhemchug Canyon HCAs

To illustrate this concept, example boundaries were drawn for canyon HCAs. The Pribilof Canyon HCA encompasses an area of 5,974 km^2 and the Zhemchug Canyon HCA encompasses an area of 12,999 km^2, for a combined area of 18,973 km^2. To put this in context, Table 1 and Fig. 2 provides a comparison of the proposed HCA areas to other management units. Overall, the combined area of the proposed canyon HCAs is **1.9%** of Bering Sea subarea (including the Bering Sea HCA but not the international waters of the Donut Hole), **2.3%** of EBS Shelf subarea (0-1000 m, excluding the Bering Sea HCA), and **9.9%** of Outer Shelf/Slope (100-1000 m).

Table 1. Comparative scale of example canyon HCAs in relation to other management units.

Units	Area (km^2)	% Bering Sea Subarea	% EBS Shelf (0-1000 m)	% Outer Shelf/ Slope (100-1000 m)
Bering Sea Subarea/a	1,002,076 km^2			
EBS Shelf (0-1000 m)/b	815,547 km^2	81%		
Outer Shelf/Slope (100-1000 m)	191,648 km^2	19%	23%	
Pribilof Canyon HCA	5,974 km^2	<1%	<1%	3.1%
Zhemchug Canyon HCA	12,999 km^2	1.3%	1.5%	6.8%
Pribilof/ Zhemchug Combined	18,973 km^2	1.9%	2.3%	9.9%

a/ Includes the Bering Sea HCA (159,119 km^2) but not international waters of the Donut Hole.
b/ Does not include the Bering Sea HCA.

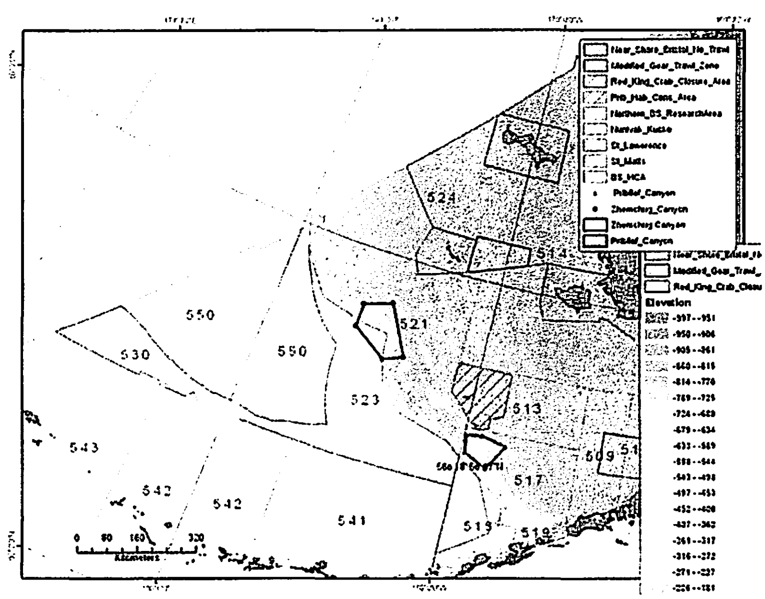


Figure 2. Example canyon HCAs in relation to other management units, courtesy of NMFS AKRO.

2.2 Unique Importance of the Deepwater Canyons Within the Bering Sea Green Belt

From a global perspective, submarine canyons are considered rare habitats, occupying less than four percent of the earth's seafloor and containing unique assemblages of species (McConnaughey and McGovern 2009). In the Bering Sea, there are reported to be at least 15 distinct canyon systems along the continental shelf, including three of the largest in the world (NMFS 2006). Zhemchug Canyon, 80 miles northwest of the Pribilof Islands, *is* the largest submarine canyon in the world, spanning some 60 miles in width and reaching depths of 2,730 m (9,000 ft.) with a volume of 8,500 cubic kilometers (km^3) (Scholl *et al.* 1970). Pribilof Canyon, whose canyon head starts just 20 miles south of the Pribilof Islands, is much smaller but still far larger than most and it is one of the world's longest at 90 miles in length, reaching depths of 1,800 m (6,ooo ft.) with a volume of 1,300 km^3. By contrast, the better-known Monterey Canyon off central California has a volume of only 450 km^3 (Scholl et al. 1970).

These shelf-edge canyons play a crucial role in circulation and transport of nutrients in the eastern Bering Sea as the northwestward-flowing Bering Slope Current interacts with canyon topography (Napp et al. 1998, Macklin and Hunt 2004, Okkonen *et al.* 2004, Kinney *et al.* 2009).Because they intersect the shelf break, the canyons act as conduits for organic nutrients moving between deep basins and the continental shelf, and the resulting fluxes support diverse communities with high biomass compared to non-canyon regions at similar depths (NMFS 2006, McConnaughey and McGovern 2009). A recent study indicates that the largest on-shelf flux of warmer, saltier oceanic water from the Bering Slope Current passes through Zhemchug Canyon (Kinney *et al.* 2009).The interaction of nutrient- and plankton-rich slope waters from the slope with the submarine topography of the canyons generates eddies and frontal zones on either side of the shelf break. These hydrographic features concentrate zooplankton and prey fish such as squids and juvenile walleye pollock and support a diverse assemblage of higher trophic level predators (Springer et al. 1996, Brodeur *et al.* 1997, Stabeno *et al.* 1999, Moore *et al.* 2002, Macklin and Hunt 2004, Okkonen *et al.* 2004, Hunt *et al.* 2008, Call *et al.* 2008).

The Pribilof Island Archipelago is known as the "Galapagos of the North" because the islands have supported some of the largest breeding colonies of marine birds and mammals in North America historically (Macklin *et al.* 2008).The largest colonies of fish-eating kittiwakes (*Rissa* spp.), murres (*Uria* spp.) and puffins (*Fratercula* spp.) in Alaska are found on the Pribilof Islands, drawn to the productive shelf-edge habitat where squids, juvenile pollock and other forage fish are most often found in high concentrations. More than half of the northern fur seal population gathers on the Pribilof Islands breeding and pupping grounds during the summer half of the year, feeding over a wide area of the shelf break, canyons and slope on pollock, squids, and deepsea smelts (Lowry *et al.* 1982; Kajimura *et al.* 1984; Sinclair *et al.* 1994; Springer *et al.* 1996, NRC 1996, Robson *et al.* 2004, Call *et al.* 2008, Call and Ream 2012). The major reason for this abundance is close proximity to the shelf break where slope waters are transported through Pribilof Canyon, providing a steady supply of new nutrients to the Pribilof Islands that sustain high productivity throughout the summer months (Napp *et al.* 1998, Hunt *et al.* 2008). Based on these distinctive bathymetric, hydrographic and ecological features, Hunt *et al.* (2008) defined a unique "Pribilof Domain" in the southeastern Bering Sea.

The canyons are also spawning, nursery and foraging habitats for commercially important species such as pollock and halibut, among many others. Pollock are known to spawn in predictable locations such as sea valleys and canyons along the outer margin of the continental shelf (Bailey 1998, Bailey *et al.* 2000), including areas in Pribilof Canyon and Zhemchug Canyon (Bacheler *et al.* 2010, Quinn *et al.* 2011).Tagging studies have shown that adult halibut migrate from summer feeding grounds on the Bering Sea shelf to winter spawning grounds that are concentrated near the edge of the southeastern Bering Sea shelf between 180-550 m depth, and spawning is known to occur as far north as the Pribilof Canyon(Gilbert St-Pierre 1984, Andrew C. Seitz *et al.* 2007).The canyons almost certainly serve as spawning habitat for other groundfish species that frequent the canyons, including Pacific cod, Greenland turbot, and sablefish. They are EFH for all life stages of resident rockfish from birth to adulthood. They harbor a diverse but poorly understood assemblage of deepwater skates and grenadiers, and they are preferred egg-nesting sites for skates (Hoff 2009, Hoff 2010). They provide important foraging habitat for managed groundfish species such as cod, pollock, flounders, rockfish, and sablefish as well as State-managed salmon and herring stocks that feed on the euphausiids, squids, smelts, and juvenile pollock that are found in the Bering Sea Canyons.

Lastly, new research and *in situ* observations indicate that Pribilof and Zhemchug canyons harbor a much more diverse community of deep-sea corals, sponges and other epibenthic fauna than was previously believed. The Bering Sea Canyons expedition documented the presence of previously unknown coral habitat in the canyons and includes new species records, northern range extensions, and possibly the discovery of coral species new to science as well as a new sponge species, *Aaptos kanuux* (Lehnert et al. 2008, Miller *et al.* 2012).Studies of submarine canyon sponge fauna elsewhere have found that canyons harbor a rich diversity of species and unique species assemblages that may rival the diversity of sponges found on seamounts (Schlacher *et al.* 2007). Given the enormous size of these canyons and the lack of systematic surveys, it is likely that many species and concentrations of coral and sponge habitat are still unknown to science in Pribilof and Zhemchug canyons.

In summary, the Pribilof and Zhemchug canyons are major bathymetric features of the Green Belt seascape with persistent and predictable hydrographic properties that have great ecological, economic and cultural significance. The fact that the long-term effects and consequences of fishing in the canyons is highly uncertain is all the more reason to provide comprehensive protection to representative portions of these vulnerable canyon habitats and species *now*, while research continues, in order to avoid unintended or irreversible harm and ensure that that there will be a multiplicity of options available with respect to future uses of these resources.[5]

2.3 Canyon HCAs as Tools to Accomplish Multiple Management Objectives and Promote the Application of Ecosystem Principles in Fisheries

The final report to Congress of the U.S. Commission on Ocean Policy (USCOP 2004) noted that the offshore area of the U.S. Exclusive Economic Zone (EEZ) is the largest in the world and larger than the combined land area of all fifty states. In managing the public trust resources of this vast territory for the benefit of all Americans, the USCOP called for a coordinated national ocean policy guided by overarching principles of stewardship for present and future generations based on an ecosystem-based approach to management of activities and uses (USCOP 2004).

An ecosystem-based approach to fisheries involves considering not only a relative handful of commercially important species but addressing how fishing activities affect biodiversity, food web interactions, and habitats in order to maintain the health of the ecosystems on which sustainable fisheries (NMFS 1999, Pikitch *et al.* 2004, Heltzel *et al.* 2011). Addressing the need for effective, meaningful habitat protections along the Bering Sea Green Belt requires consideration not only of the EFH of single species or interactions with individual protected species but a wider, ecosystem-based perspective that reflects the ecological, economic and cultural importance of this ecoregion and achieves multiple management objectives. Habitat Conservation Areas (HCAs), also known as marine protected areas (MPAs), provide the most effective tool for achieving that goal.

By *building in* refuges from fishing, the Council could provide buffers against the considerable scientific and management uncertainties associated with managing these resources sustainably for present and future

[5]MSA 3(5) (16 U.S.C. § 1802(5)).

generations. A system of fully protected canyon HCAs along the as-yet unprotected Bering Sea Green Belt would accomplish multiple objectives for conservation and management under the MSA, ESA, and MMPA, including:

- Minimizing adverse effects on benthic and pelagic EFH.
- Protecting deep-sea corals and other structure-forming benthic epifauna.
- Conserving ecologically important non-target species and habitats.
- Reducing bycatch of ecologically and economically important benthic and pelagic species.
- Protecting marine mammal and seabird foraging habitat.
- Providing buffers against scientific and management uncertainty.
- Establishing control areas to foster adaptive learning.
- Achieving of the MSA's ultimate goal, Optimum Yield (OY).

Pacific ocean perch (*Sebastes alutus*) and fan coral (*Plumarella sp.)*,Greenpeace

3. Overview of Fishing Impacts in the Proposed Pribilof and Zhemchug Canyon HCAs

In the 2010 Eastern Bering Sea Slope trawl survey, approximately 145 fish species and 334 invertebrate species were identified along the continental slope and canyons from 200-1200 m (Hoff and Britt 2011). The giant grenadier (*Albatrossia pectoralis*) represented the largest biomass, followed by Pacific ocean perch (*Sebastes alutus*) and arrowtooth flounder (*Atheresthes stomias*). The most abundant fish species was the popeye grenadier (*Coryphaenoides cinereus*). The deep-sea papillate cucumber (*Pannychia moseleyi*) had the largest estimated biomass for invertebrates and the brittle star (*Ophiacantha normani*) was the most abundant. In Pribilof Canyon and Zhemchug Canyon, significant concentrations of managed groundfish species included walleye pollock, Pacific cod, rockfish, sablefish, halibut, turbot, and other flounders), crabs (Tanner, snow, and golden king crab), as well as diverse species of squids, octopods, eelpouts, skates, sculpins, grenadiers and sleeper sharks.

Nearly all of these species or families also appeared in the observer-reported catch data for groundfish vessels fishing within the boundaries of the proposed Pribilof and Zhemchug canyon HCAs during 1990-2011. Catch records for a subset of representative target and non-target fish species were analyzed to evaluate the overall magnitude of commercial fishing in the canyons as well as the potential for adverse impacts to the benthic and pelagic habitats and fauna found within the canyons.[6] Detailed spatial, temporal and depth distributions of fishing were not provided, but this information should be evaluated by the Council. Overall, the North Pacific Groundfish Observer Program catch database indicates that nearly 1.2 million tons of observed catch of groundfish and other marine life were reported within the proposed canyon HCA boundaries from 1990 to the present, representing about 3.3% of the total EBS groundfish catch of all species for the same period. Pribilof Canyon catches totaled 785,908 mt (66% of the combined catch from both canyons), while Zhemchug totaled 412,711 mt (34%). Although Pribilof Canyon catches were nearly double the amount for Zhemchug Canyon over the period, the amount of observed fishing effort was considerably higher in Zhemchug Canyon (Table 2).

Table 2. Observed commercial groundfish fisheries catch from vessels fishing in the proposed closure areas of Pribilof and Zhemchug Canyons, summed for each area, all gear types, 1990-2011./a

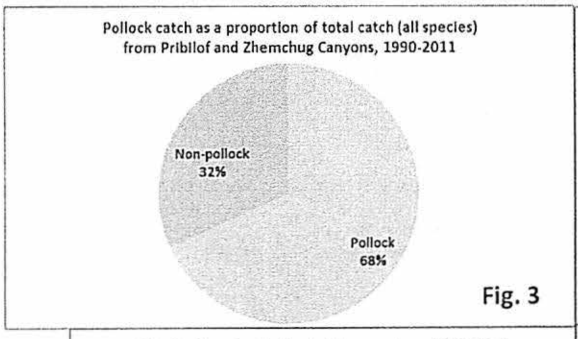
Area	Total Observed Catch (metric tons)	Duration Gear Deployed (minutes)	Number of Observed Hooks/Pots	Number of Observed Hauls/Sets
Pribilof Canyon (all observed hauls/sets)	785,908	7,544,655	46,289,920	16,211
Zhemchug Canyon (all observed hauls/sets)	412,711	16,640,970	171,803,085	23,027

a/ Data provided by the NOAA/NMFS North Pacific Groundfish Observer Program (NPGOP). Data were aggregated by area, calendar year, and gear type for the period 1990-2011. For confidentiality purposes, data were provided only for observed hauls/sets within statistical cells with more than three fishing vessels. Fishing location data were omitted.

Overall, pollock and cod catches accounted for more than two-thirds of the total observer-reported catch from both canyons during 1990-2011:

[6] Data provided by the North Pacific Groundfish Observer Program (NPGOP). Extrapolated numbers (n) and or weight (kg) were used. The values represent the expansion from the sampled catch to the total catch (effort in the case of longliners) for that haul or set. They do not account for any unsampled sets or vessels which were unobserved. Official estimates of the catch in the Catch Accounting System (CAS) may be higher in some cases due to accounting for unobserved catches.

- Combined pollock catches of 818,348 mt accounted for 68% of all observed catches from both canyons (Fig. 3) but only about 3% of the EBS-wide pollock catch. Pollock catches accounted for 80% of all observed groundfish catches in Pribilof Canyon, but only 46% of all groundfish catches in Zhemchug Canyon (Fig. 4). Nearly all pollock was caught with pelagic trawls (Fig. 5) and 81% of the catch came from Pribilof Canyon during 2000-2011 (Fig. 6).
- Combined Pacific cod catches totaled nearly 101,000 mt, representing ~8% of the total catch within both canyons but less than 3% of the EBS-wide cod catch. 82% of the cod was taken from Zhemchug Canyon (Fig. 7) and 81% of that catch was taken with longline gear (Fig. 8).
- Combined catches of skates, sculpins, grenadiers, rockfishes, sablefish, halibut, Greenland turbot, sleeper sharks, and squids accounted for 56,611 mt, nearly 5% of the total observed catch from both canyons.
- Observer-reported bycatch of benthic invertebrates was rarely identified to the species level and was mainly informative in documenting presence and identifying relative contribution from each gear type. Bycatch of benthic infauna and epifauna occurred in all gears, although a quantitative analysis of the relative contribution of each gear type has not been completed. Clearly there is extensive interaction with the seafloor by all gear types, including pelagic trawls.



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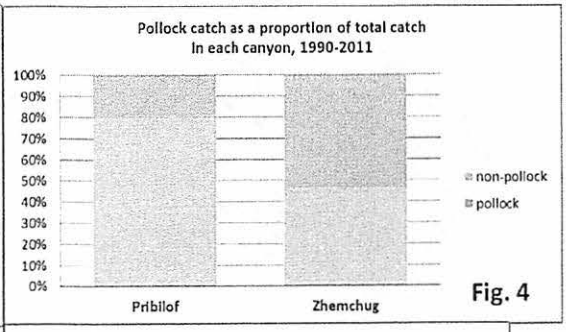

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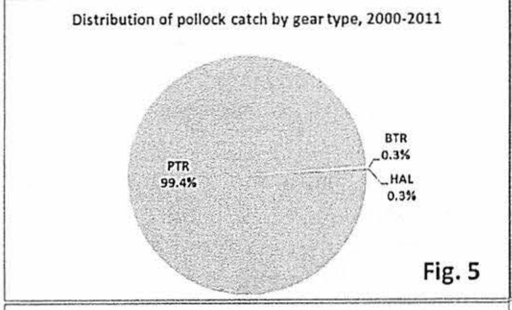

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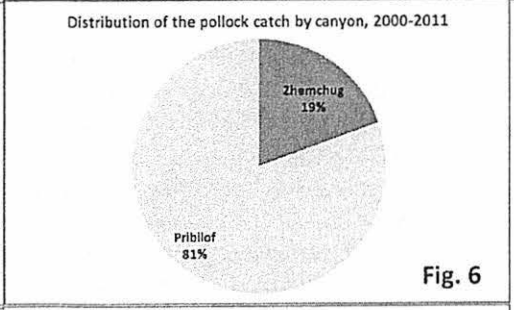

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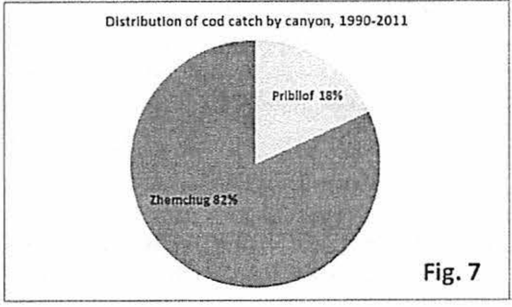

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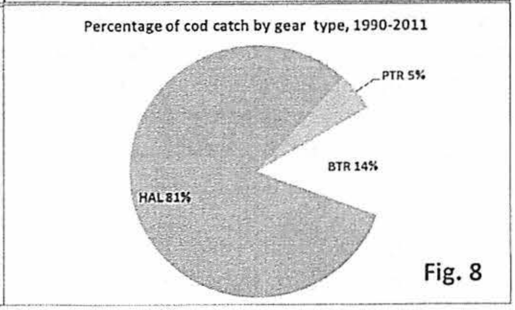
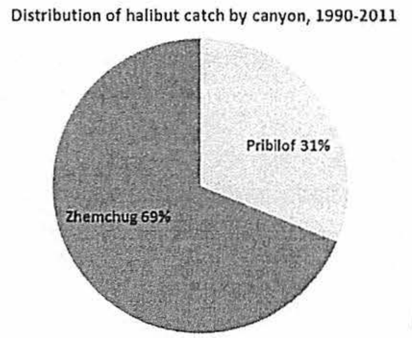


Fig. 8

- Combined halibut and Greenland turbot catches totaled 14,546 mt, representing 1.2% of the total catch from both canyons. 69% of the halibut catch and 64% of the turbot catch came from Zhemchug Canyon (Figs. 9, 10). Longline gear accounted for slightly more than 90% of the catch of both species, with bottom trawl and pelagic trawl gears accounting for the remainder (Figs. 11, 12). The 2010 halibut catch in the canyons (273 mt) was about 10% of the 2010 commercial catch of halibut in the Bering Sea (5.892 million lb., ~2,707 mt).



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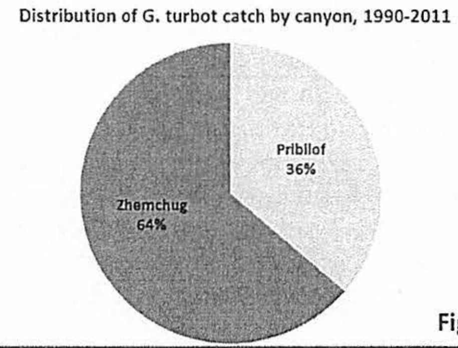

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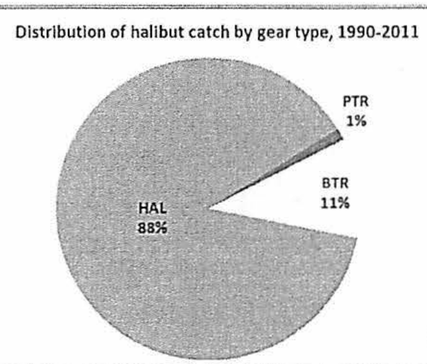

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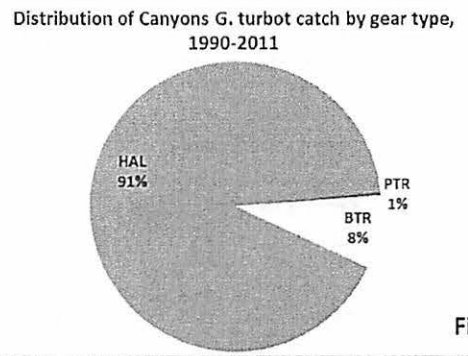


Fig. 12

Although the catches of skates and other non-target species associated with the outer shelf and slope are small in comparison to the pollock catch, they represent a diverse assemblage of poorly understood deepwater and pelagic species with life histories and habitat preferences that make them highly vulnerable to fishing mortality and associated habitat damage or disturbance from fishing. A number of them were previously managed together as the "Other Species" stock complex, including skates, sculpins, sharks, squids and octopus. Skates and sculpins comprised the vast bulk of the estimated bycatch of Other Species in the BSAI, mainly in trawl fisheries for yellowfin sole, Pacific cod, walleye pollock, Atka mackerel and flathead sole, and in the Pacific cod longline fishery (Ormseth and TenBrink 2010). In addition, grenadiers are ecologically important deepwater species associated with the continental slope that occur frequently in some fisheries, and concerns about their vulnerability to fishing impacts has prompted efforts to document bycatch in the fisheries since 2003 (Tribuzio *et al.* 2008). In 2010, the Council passed amendments to the BSAI and GOA FMPs which separated the "Other Species" stock complex into its constituent species groups and removed grenadiers from the FMP. The fishery observer data indicate that all of these species and their habitats are significantly affected by fishing in Pribilof and Zhemchug canyons:

- Skates were vulnerable to all fishing gears but longlines accounted for the vast majority (97%) of skate bycatch in the canyons (Fig. 13 below) and 79% of the bycatch occurred in Zhemchug Canyon (Fig. 14).

Deepwater species (e.g., Commander, roughtail, and whitebrow skates) occurred almost exclusively in longline gear. Significant quantities of skate egg cases (weighing tens to hundreds of kilograms) were reported in all gears and in nearly all years, but fishing effort distribution data were not available to determine their locations within the canyons.

- Grenadier bycatch occurred mainly in longline gear (Fig. 15) and 91% of it was taken in Zhemchug Canyon (Fig. 16). For the period 2004-2011, when observers began reporting grenadiers to the species level, the only species reported was giant grenadier. Giant grenadier accounted for the bulk of grenadier bycatch in most years, but "grenadier unidentified" accounted for a larger portion share of the bycatch in most years.
- Sculpin bycatch was divided almost evenly among longline and bottom trawl gears (Fig. 17), and more than three-quarters of the bycatch (78%) came from Zhemchug canyon (Fig. 18)
- Squids, smelts, and herring occurred primarily caught in pelagic trawl gear, although bycatch in bottom trawl gear was sometimes significant. Squids were the dominant biomass of forage fish other than pollock reported in pelagic trawls and most of it was taken from Pribilof Canyon in most years, but the combined catch of 2,843 mt during 1991-2011 was <1% of the total catch of all species from the canyons over the entire period. Eulachon was the most commonly reported smelt species in most years but was reported in far lower quantities than squids, while herring rarely occurred at more than trace levels.
- Significant numbers of chinook and chum salmon were reported as bycatch in some years (mainly in pelagic trawls), but their occurrence was highly variable. In some years, the combined canyons chinook bycatch represented a large percentage of the total number of fish taken as bycatch in the EBS-wide pollock fishery – *as much as 20-30% of all observer-reported chinook in 1999-2000 and 12% in 2003, but generally <10% in other years.*

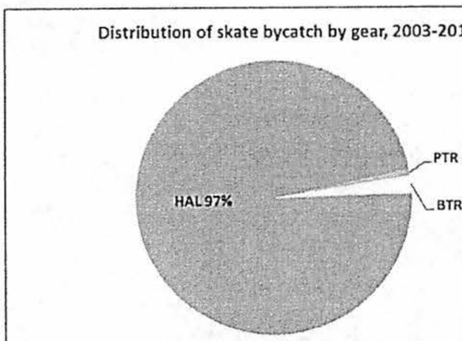
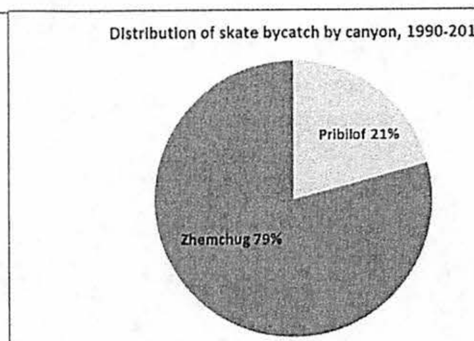


Fig. 13



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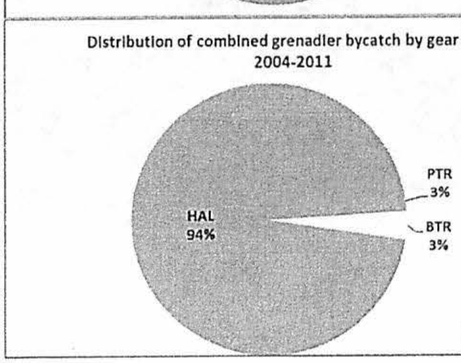
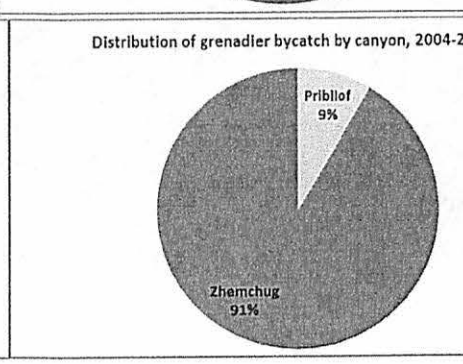


Fig. 15



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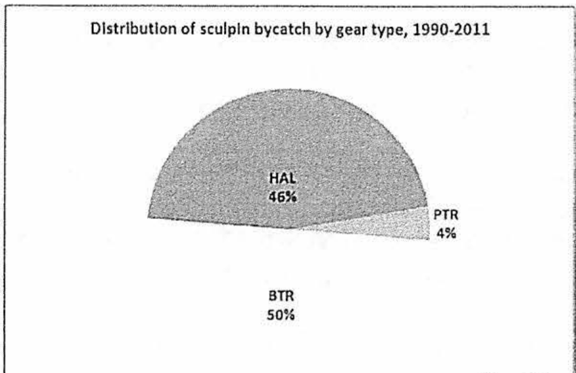

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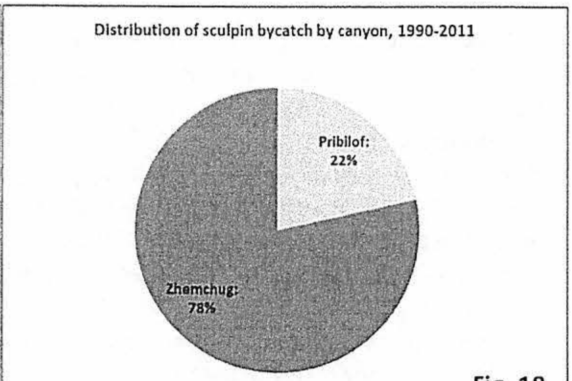

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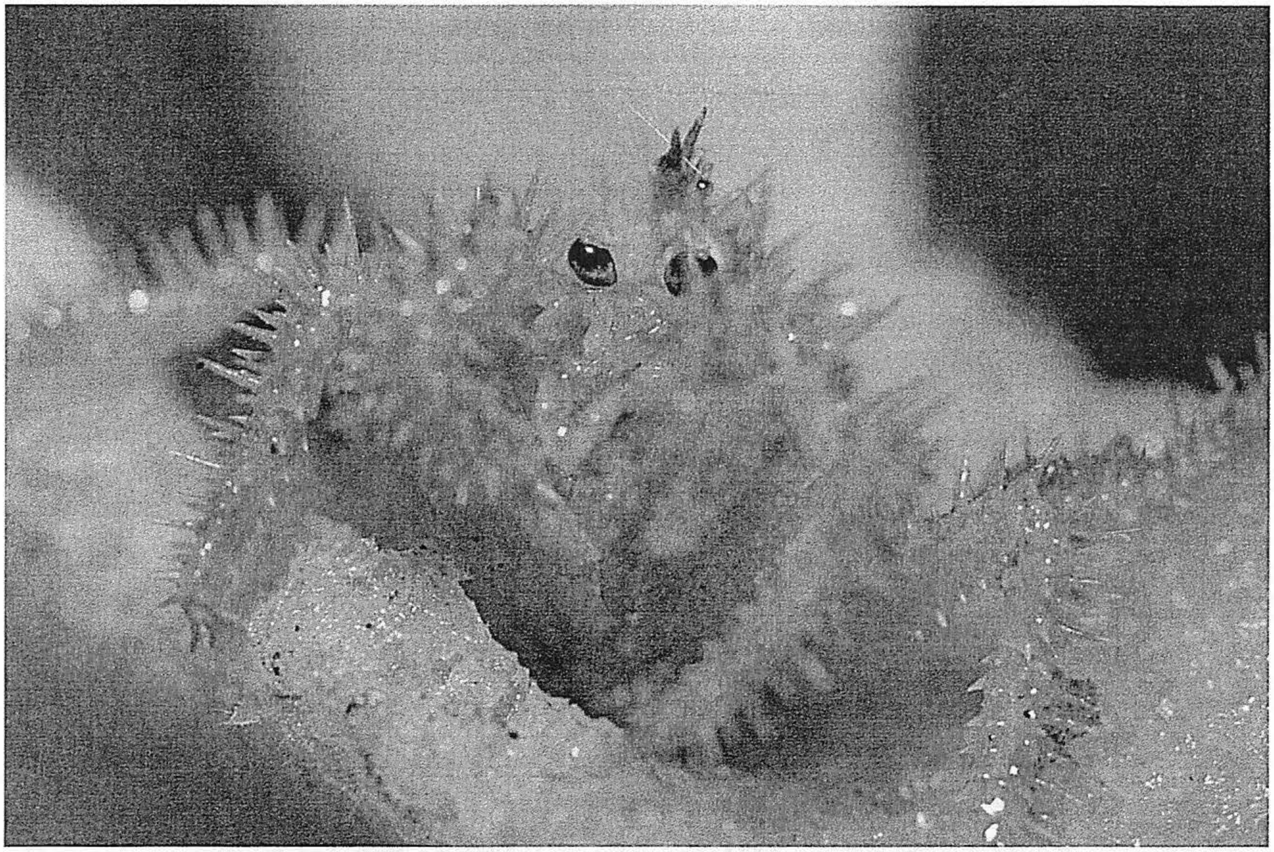

Juvenile golden king crab (*Lithodes aequispinus*), Todd Warshaw/Greenpeace USA

4. Benthic Habitats: Deep-Sea Corals, Sponges and Other Benthic Epifauna

Epibenthic organisms that create habitat structure in Alaska waters include soft and stony corals, sponges, bryozoans, sea pens, anemones, and tunicates (NPFMC 2010). Analyses of NOAA trawl survey data and *in situ* observations have found that most FMP species in the Alaska groundfish fishery (approximately 85%) are associated with these living substrates during some or all of their lives, including many rockfish (*Sebastes, Sebastolobus* spp.), greenlings such as Atka mackerel (*Pleurogrammus monopterygius*), various flatfish (*Pleuronectidae* spp.), cod and pollock (*Gadidae* spp.), sculpins and crabs (Heifetz 2002, Krieger and Wing 2002, Stone 2006, Stone and Shotwell 2007, Stone *et al.* 2011). *In situ* observations by Krieger and Wing (2002) further subdivided faunal groups that associate with deepwater corals into predators (sea stars, sea snails, nudibranchs), suspension-feeders (crinoids, basket stars, anemones, and sponges), and protection seekers (rockfish, crab, shrimp). The Council has identified deep-sea corals as EFH habitat areas of particular concern (HAPC) because they are important habitat for many managed fish species, and because they are long-lived, slow-growing and highly vulnerable to damage by fishing gear.

4.1. Deep-Sea Corals (Alyconacea, Antipatharia, Gorgonacea, Pennatulacea, Scleractinia, Stolonifera)

Deepwater corals are widespread throughout Alaska, but most information on coral distribution has been based on observer-reported fisheries bycatch and analyses of NOAA trawl surveys. Major taxonomic groups of corals found off Alaska include Alyconacea (soft corals), Gorgonacea (tree corals, sea fans, bamboo corals), Scleractinia (cup corals, stony corals), Stylasterina (hydrocorals), Stolonifera (stoloniferan corals) and Antipatharia (black corals) (Heifetz 2002), representing 141 unique coral taxa (Stone and Shotwell 2007). Common gorgonian corals off Alaska include red tree coral (*Primnoa willeyi* and *P. resedaeformis*), bubblegum coral (*Paragorgia arborea*), bamboo corals (Family Isididae) and sea fans (*Calligorgia sp.* and *Plumarella* sp.). Large *Primnoa* colonies may be many hundreds of years old and analysis of growth rings of red tree coral specimens from Southeast Alaska indicated that growth occurs very slowly (mm/year), meaning that recovery from damage by fishing gear could take many decades or centuries (Heifetz 2002, Andrews et al. 2002). Removal and disturbance of these slow-growing corals could have lasting impacts on associated deepwater fauna, including many commercially important managed species (Krieger and Wing 2002).

In general, coral fauna have been poorly documented in the Bering Sea (Stone and Shotwell 2007). Based on fishery bycatch data, trawl survey data and a single ROV study of the upper reaches of Pribilof Canyon, deepsea corals are known to be patchily distributed along the shelf and slope, representing sixteen species or subspecies: three species of soft corals, six species of gorgonians, four species of pennatulaceans, and three species of stylasterids (Stone and Shotwell 2007). In 2007, a collaborative research expedition to Pribilof Canyon and Zhemchug Canyon conducted video surveys of seafloor habitat in the canyons and provided the most extensive *in situ* observations of the seafloor habitat along the Bering Sea slope to date. The Bering Sea Canyons expedition documented the presence of coral habitat in the canyons and includes new species records, northern range extensions, and possibly the discovery of coral species new to science as well as a new sponge species, *Aaptos kanuux* (Lehnert et al. 2008, Miller et al. 2012). Several fish species, including rockfish, sculpins and poachers, were commonly associated with corals and sponges in both canyons. The expedition's findings on coral taxa are summarized in Table 3.

Table 3. Taxonomic groups and species of deep-sea corals identified in Pribilof and Zhemchug canyons during the 2007 Bering Sea Canyons expedition.

Taxa	Pribilof Canyon	Zhemchug Canyon
Order Scleractinia *Caryophyllia alaskensis*		Present; new record depth and range extension
Order Antipatharia *Lillipathes wingi*		Present; range extension
Order Alcyonacea *Anthomastus* sp.		Present; possible range extension
Suborder Stolonifera *Clavularia* sp.		Present; new record
Order Gorgonacea *Plumarella superba* sp.	Common; range extension	
Isidella sp.		Present; range extension
Paragorgia arborea.		Present; possible range extension
Plumarella echinata	Common; range extension	
Primnoa pacifica		Present; possible range extension
Primnoa wingi		Present; new record
Swiftia pacifica	Present; new record	Common; new record
Order Pennatulacea *Anthoptilum* sp.	Present	Present; possible range extension
Halipteris willemoesi	Locally abundant	Present
cf. *Pennatula* sp.		Present; possible new species (not collected)
Protoptilum sp.	Common	Common

4.2 Deep-Sea Sponges (Calcarea, Demospongiae, and Hexactinellida)

Sponges (Porifera) also play a critical role in shaping benthic habitats and new research in the Aleutian Islands indicates that sponges often play a dominant role, providing important habitat refuges for many species of fish and invertebrates including juvenile rockfish (*Sebastes* spp.) and king crabs (*Lithodes* sp.) (Stone *et al.* 2011). At least 125 species or subspecies of sponges have been identified in the Aleutian Islands and examination of video footage from submersible observations indicate that there are likely hundreds of species still uncollected, many as yet unknown to science.

In the Bering Sea, even less is known about the extent of sponge diversity. Twenty different sponge specimens were collected during the Canyons Expedition's *in situ* exploration of Pribilof and Zhemchug in 2007, representing all three classes of Porifera (Calcarea, Demospongiae, and Hexactinellida). Many were new records for the Bering Sea – two-thirds of the species identified were reported for the first time, including a new sponge species, *Aaptos kanuux* (Lehnert *et al.* 2008, Miller *et al.* in press). Studies of submarine canyon sponge fauna elsewhere have found that canyons harbor a rich diversity of species and unique species assemblages that may rival the diversity of sponges found on seamounts (Schlacher *et al.* 2007), and it is likely that many sponge species are still uncollected and unknown to science in Pribilof and Zhemchug canyons.

4.3 Fishing Gear Impacts to Benthic Habitats

Disturbance from fishing activities is the greatest present threat to deepwater coral and sponge habitats in Alaska, particularly (but not only) from bottom trawl gear (Stone and Shotwell 2007). The National Marine Fisheries Service (NMFS) has estimated that 82 metric tons of coral is removed by commercial groundfish fisheries each year (NMFS 2004), and more than 90% of this incidental bycatch is reported in the waters of the Aleutian Islands and Bering Sea (Stone 2006). This bycatch undoubtedly understates the true magnitude of fishing impacts because it does not account for damaged benthic organisms that were not retrieved with the gear and it does not account for the unseen damage and loss of habitat due to scraping and plowing of seafloor habitat (NMFS 2004).

4.3.1 Bottom trawl impacts to the benthos

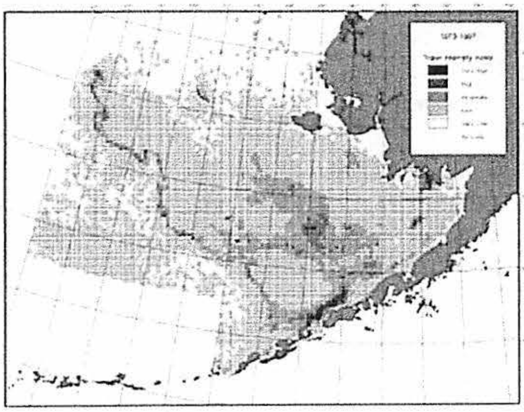

Fig. 19. Location and intensity of bottom effort in the Bering Sea, 1973-1997. Source: http://www.afsc.noaa.gov/groundfish/hist.trawldata.htm.

Three main fishing gears used in the Alaska groundfish fisheries: otter trawls, longlines, and pots (NMFS 2004). The vast majority of the Bering Sea groundfish catch (~90%) is taken with pelagic and bottom trawl gear, although fixed gears account for a significant portion of the Pacific cod catch as well as all of the directed catch of sablefish and halibut. Bottom trawling is considered the highest threat to coral habitat in Alaska (Stone and Shotwell 2007). Virtually all areas of the Bering Sea have experienced some degree of exposure to bottom trawls. However, the intensity of exposure varies, reflecting the non-random behavior of fishing fleets, which is based on historical patterns of effort and regulatory restrictions. Relatively heavy trawling has concentrated in several regions, including the highly productive upwelling zone along the western edge of the continental shelf and slope in the Green Belt (Fig. 19) (NRC 1996 Fritz *et al.* 1998, NMFS 2004). Studies have shown that chronic bottom trawling reduces structural complexity and diversity of benthic species in the soft-bottom habitats of the eastern Bering Sea (McConnaughey *et al.* 2000), and a single pass of bottom trawl gear over structurally complex seabed habitats comprised of deep-sea corals and sponges can inflict extensive and long-lasting damage (Freese *et al.* 1999, Krieger 2001, Andrews *et al.* 2002, Stone and Shotwell 2007, Heifetz *et al.* 2009, Stone *et al.* 2011). Krieger (2001) used a submersible to observe the effects of bottom trawl gear on *Primnoa* coral during a resource trawl survey and found that 27% of the original volume of coral was removed by a single pass of trawl gear in a site that was closed to commercial trawling. These findings were used in the 2005 EFH EIS to conduct the analysis of coral sensitivity to fishing gear impacts, with a range of 22-35% (NPFMC 2011). Sponges are also easily damaged by contact with bottom fishing gear, and high rates of fishery bycatch as well as *in situ* observations indicate that interaction with the existing fisheries is extensive and disturbance is widespread (Heifetz *et al.* 2009, Stone 2006, Stone *et al.* 2011).

Despite Council actions to limit the expansion of the bottom trawl footprint and set six small areas off-limits to bottom-tending gear in central Aleutian Island coral gardens (377 km^2 total), new research indicates that disturbance and damage to corals and sponges is widespread in open areas of the central Aleutians where bottom fisheries still operate. Video surveys with the *Delta* submersible and *Jason* ROV found that 14% of corals and 21% of sponges were damaged overall. Disturbance was widespread on most video transects (Heifetz et al. 2009). The Bering Sea Canyons expedition also found evidence of fishing disturbance on 13 occasions (nine in Pribilof Canyon, four in Zhemchug Canyon) at depths ranging from 154-966 meters. Most observations were trawl scars caused by gouging of soft sediment, but damage to corals was also evident. In Pribilof Canyon, at 280 m depth, researchers observed trawl scars on the seafloor and numerous gorgonians and sea pens were toppled and lying in the same direction on the seafloor.

4.3.2 Pelagic trawl impacts on the benthos

Although the massive pollock fishery has exclusively deployed pelagic trawl nets since 1999, there is a strong incentive for fishing pelagic nets near or on bottom (NPFMC 2012).[7] Bycatch of benthic species in pelagic nets confirms that pelagic trawl nets regularly come in contact with, or very close to, the seabed (Stevenson and Lewis 2010). Observer-reported bycatch data for Pribilof and Zhemchug canyons indicates that pelagic gear regularly hauled up benthic infauna as well as epifauna, including corals, sponges, bryozoans, tunicates, sea urchins, sand dollars, crinoids, bivalves, sea snails, anemones, nudibranchs, polychaete worms, sea cucumbers, brittle and basket stars, cephalopods and crabs. The reported quantities of these species generally appear to be much less than for bottom trawls, but they appeared consistently over time and they are consistent with the findings of the North Pacific groundfish EFH EIS (NMFS 2005), which estimated that pollock "pelagic" trawl gear contacts the seafloor approximately 44% of the time it is deployed.[8] Because many benthic organisms will drop out of the large mesh panels in the forward sections of the pelagic net before it is hauled up (NPFMC 2011),[9] whatever comes up in the net likely understates the true extent of interaction with the seafloor and benthic organisms. Like bottom trawls, pelagic trawl nets that come in contact with the seabed are capable of inflicting extensive damage to benthic substrates and epibenthic structures such as deep-sea corals.

4.3.3 Longline impacts on the benthos

Longline gear is fished on bottom in Alaska, mainly for Pacific cod, Pacific halibut, Greenland turbot, sablefish and some rockfish. In the Bering Sea, bottom longlining (principally targeting cod) has been intensely concentrated along the western edge of the continental shelf and slope, including Pribilof and Zhemchug canyons. Average set length ranges from 4-10 miles depending on the fishery (NMFS 2004). Longlines are often deployed in habitats that are too rough for trawling and some vessels attach weights to the groundline, especially on rough or steep bottoms so that the gear stays in place on the bottom. During the retrieval process, the groundline sweeps the bottom for considerable distances before ascending and can snag objects in its path, dislodging rocks and breaking off upright corals (NMFS 2004, Stone 2006, Stone and Shotwell 2007). In addition, observations of halibut gear during submersible dives off Southeast Alaska have shown that hooked fish can move the groundline for distances of 50 feet or more on either side as they attempt to free themselves, which can disturb objects in their path (NMFS 2004). Although longlines are considered a moderate threat to coral habitat in Alaska, there have been no directed studies of the effects of bottom longline gear on benthic habitat in Alaska and bycatch of corals and other benthic fauna are common in some areas (Stone and Shotwell 2007). During the 2007 Bering Sea Canyons Expedition, researchers also observed evidence of bottom longline damage and derelict fishing gear, including tangles of line and netting (Miller *et al.* 2012). Observer data for Pribilof and Zhemchug canyons indicates that longline gear often accounted for significant quantities of benthic invertebrates, including unidentified corals, bryozoans, sea pens or sea whips, anemones, and crabs, in addition to sometimes large quantities of skate egg cases. Longline gear was responsible for the majority of skate and grenadier bycatch in the canyons as well as a variety of lesser-known deepwater fish species from eelpouts to sleeper sharks.

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[7] See NPFMC Agenda Item C4(a), *HAPC Initial Review*, February 2012, p. 10.
[8] NMFS (2005), Final Environmental Impact Statement (EIS) for Essential Fish Habitat (EFH) Identification and Conservation in Alaska, Appendix B, Table B.2-4.
[9] NPFMC (2011), FMP for the Bering Sea and Aleutian Islands, Appendix F.

4.4 Measures to Address Fishing Gear Impacts on Benthic Habitat

While bottom trawl gear has the most extensive and destructive impacts on deep-sea corals, sponges and other epibenthic structures in the canyons, the evidence clearly indicates that measures aimed at prohibiting bottom trawling in sensitive benthic habitats do not address the potential for widespread and lasting impacts of other fishing gears that frequently make contact with the seabed, including pelagic nets.

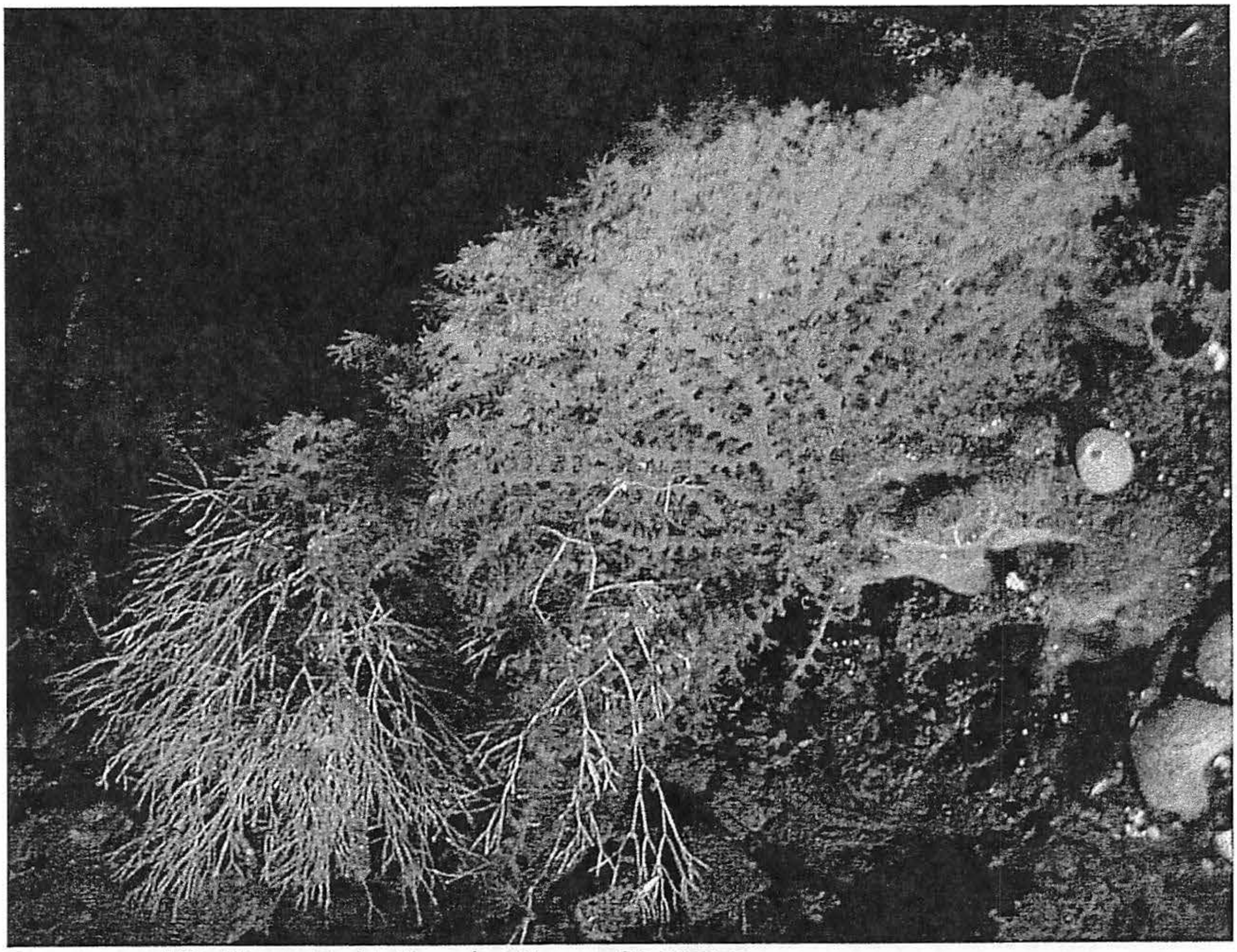
Observer data from Pribilof and Zhemchug canyons corroborates the extensive interaction with the seafloor by *all* gear types, as evidenced by the benthic invertebrates retrieved in each gear type, including: corals, sponges, bryozoans, tunicates, sea urchins, sand dollars, crinoids, bivalves, sea snails, anemones, nudibranchs, polychaete worms, sea cucumbers, brittle and basket stars, cephalopods and crabs. Observer-reported bycatch of corals and other benthic invertebrates was rarely identified to the species level and detailed information on locations and depth distributions of fishing was lacking, therefore the observer data are mainly informative in documenting presence and identifying relative impact of each gear type. The Bering Sea Expedition's *in situ* exploration of the canyons with submersibles and ROVs sheds additional light on the taxonomic groups that are likely to be impacted by bottom-tending fishing gears, including deepwater corals in six taxonomic Orders (Alyconacea, Antipatharia, Gorgonacea, Pennatulacea, Scleractinia, Stolonifera) and species from all three classes of sponges (Calcarea, Demospongiae, Hexactinosida) (Miller *et al.* 2012).

The benthic and pelagic species taken as bycatch by each gear type in the fishery represent the collateral damage of fishing in the canyons, but the reported bycatch does not account for the unseen habitat damage to fauna and structures on the seafloor that are not retrieved with the gear. The observer-reported bycatch of benthic fauna in longlines and pelagic trawl nets probably understates their full impacts considerably. In general, the analysis of the fishery observer data for Zhemchug and Pribilof canyons shows that each of the gears in the fishery contributes significantly to the overall impact of fishing on the canyon seabed habitats and epifauna.

Given how little is known about the true extent of the biodiversity in the Bering Sea Canyons or the cumulative, long-terms impacts of fishing on deepwater corals, sponges and other epibenthic fauna in the canyons, the Council's policy should be to manage explicitly for habitat diversity and complexity *now*, while research on "essential" habitats continues:

> *"Management for habitat complexity and diversity is an alternative to species-based management for 'essential' habitat. It is a precautionary approach that takes into account our limited knowledge of fishing gear impacts and the ecology of recently settled fishes. It allows for variable timing and location of settlement. Its premise is that maintaining habitat complexity increases the survivorship of all species. Numerous uncertainties surround fisheries management, and managers should accompany their calls for more data with precautionary measures that will prevent long-term damage to ecosystems while scientific theories are being tested"* (Auster *et al.* 1997).

This habitat policy should encompass representative habitat types in all ecoregions, including the outer continental shelf and slope of the Bering Sea Green Belt. Designation of habitat conservation areas (HCAs) for Pribilof and Zhemchug canyons that prohibit fishing with bottom-tending gears would be consistent with the stated intent of NMFS and the Council to reduce and avoid impacts to essential fish habitat of managed species by the use of management tools that include marine protected areas and no-take marine reserves in order to maintain the abundance, diversity and productivity of these habitats (NMFS 2004, NPFMC 2010).[10]HCAs that prohibit the use of all bottom-tending fishing gears (including pelagic trawls) would provide significant protection to representative areas of this ecoregion that are currently unprotected while research continues to expand our understanding of the true extent, diversity and ecological importance of coral and sponge habitats in the Bering Sea Canyons.



Deep-sea coral (*Swiftia pacifica*) in Zhemchug Canyon, Greenpeace

[10] See: NMFS (2004), Alaska Groundfish Fisheries Final Programmatic Supplemental EIS, Executive Summary, and NPFMC (2011), Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area, Executive Summary and Chapter 2.

5. Benthic Fish Species: Rockfish, Skates, Grenadiers, and Sculpins

Many deepwater fish species that are found along the outer continental shelf and slope of the eastern Bering Sea are highly vulnerable to fishing disturbances and mortality as a consequence of life history traits that include slow growth, delayed maturation, low fecundity and extreme longevity (Koslow *et al.* 2000, Devine *et al.* 2006, Garcia *et al.* 2008, Norse *et al.* 2012). Rockfish (*Sebastes, Sebastolubus* spp.), sablefish (*Anoplopoma fimbria*), deepwater skates (*Bathyraja* spp.), grenadiers (*Albatrossia, Coryphaenoides* spp.), sculpins (*Hemilepidotus* spp., *Myoxocephalus* spp., *Hemitripterus* spp.), sleeper sharks (*Somniosus pacificus*) and deepwater flatfishes such as Greenland turbot (*Reinhardtius hippoglossoides*) are just some of the inhabitants of the Bering Sea canyons whose life histories and habitat preferences make them especially vulnerable to fishing mortality and associated habitat disturbance from fishing gears. Most are considered "data-poor" stocks and their status with respect to overfishing and overfished thresholds is unknown or highly uncertain. The great diversity of species found in some of these families of deepwater fishes (e.g., Sebastidae, Cottidae, Rajidae, Macrouridae) further compounds the difficulty of managing a relative handful of commercially important species so as not to overfish and deplete the less abundant or less productive members of these deepwater communities. A system of canyon HCAs along the Bering Sea Green Belt that provides refuges from fishing would provide buffers against all these uncertainties by reducing bycatch mortality, minimizing the risk of inadvertent overfishing, and protecting sensitive deep-sea habitats on which these species rely.

5.1 Rockfish (Scorpaenidae)

Shortraker rockfish (*Sebastes borealis*), caught at 2,100 ft. depth in Pribilof Canyon by the pelagic pollock trawler Kodiak Enterprise.

At least 41 rockfish species in 2 genera (*Sebastes, Sebastolobus*) are known in the North Pacific. Pacific ocean perch (*Sebastes alutus*) is the dominant species along the outer continental shelf and upper slope regions of Bering Sea and Aleutian Islands and is widely distributed at depths of 100-500 m, but the highest concentrations of fish are found in patchy, localized aggregations. Four other species of slope rockfish are commonly found together with POP – northern rockfish (*S. polyspinis*), shortraker rockfish (*S. borealis*), rougheye rockfish (*S. aleutianus*), and sharpchin rockfish (*S. zacentrus*), although sharpchin is not as common in the eastern Bering Sea. Many of the species in the slope rockfish assemblage are of limited economic value and catches of "other slope rockfish" are frequently discarded by fishermen. All have life history characteristics typical of other deepwater species: slow growth, late maturity, low fecundity, extreme longevity. POP can live up to 100 years, shortraker to 120-140 years, and rougheye to more than 200 years (Love *et al.* 2002).

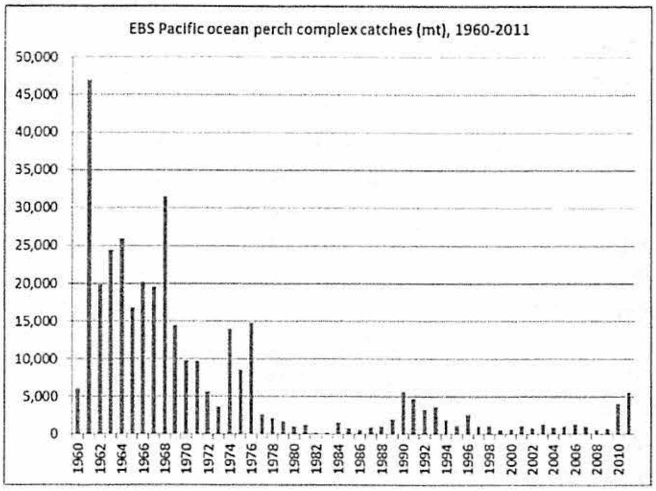


Fig. 20. Historical catches of Pacific ocean perch (POP) and other slope rockfish in the eastern Bering Sea, 1960-2011. Source: NPFMC BS/AI SAFE 2011.

All these species were managed as a single stock complex until 1991, when POP was separated for management purposes in recognition of the fact that POP is the largest rockfish biomass in this assemblage and the prime fishing target. Historically, Soviet and Japanese trawlers rapidly depleted the POP/red rockfish complex in the 1960s, when some 236,000 tons of POP catch were mined from the eastern Bering Sea slope (in addition to even larger rockfish catches in the Aleutians and Gulf of Alaska). POP abundance rapidly plummeted under this fishing pressure and the fishery crashed (Fig. 20). As a slow-growing, long-lived species that bears live young, POP recovery has been slow over the past three decades, but with limited fishing and strong recruitment from 1990s year classes the population is beginning to show signs of rebuilding in recent years (Spencer and Ianelli 2010).

In Pribilof and Zhemchug canyon over the period 1990-2011, POP and other slope rockfish comprised 98% of the observed catch (dominated by POP),with small contributions coming from pelagic shelf rockfish such as dusky (S. *variabilis*, commonly found at depths of 100-200 m) as well as thornyheads (*Sebastolobus* spp.), and trace amounts (10s to 100s of kg) of rarer rockfish species: harlequin (*S. variegatus*), red-banded (*S. babcocki*), red-striped (*S. proriger*), dark (*S. ciliatus*), darkblotched (*S. crameri*), yelloweye (*Sebastes ruberrimus*)and Bocaccio(*S. paucispinis*) (Fig. 21). Although the frequency of occurrence of less abundant or rare species in the assemblage may be low overall, the number of individuals caught when the species is encountered may be quite high relative to local abundance (Sinclair *et al.* 1999). Most (90%) of the observed rockfish catch from Pribilof and Zhemchug canyon was taken in bottom trawls (Fig. 22), but much of the catch was simply discarded – discard rates of EBS rockfish averaged 33% during 1990-2009, far higher than in the Aleutians fishery (Spencer and Ianelli 2010).

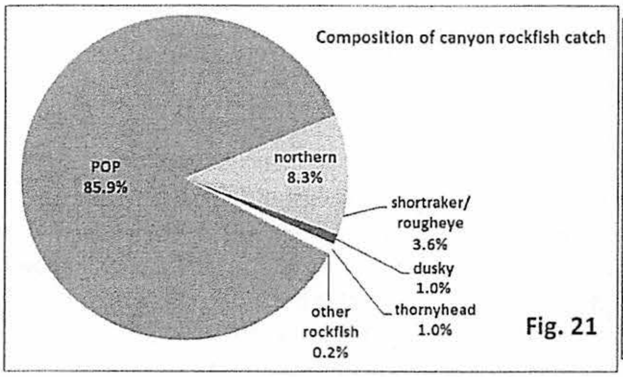


Fig. 21

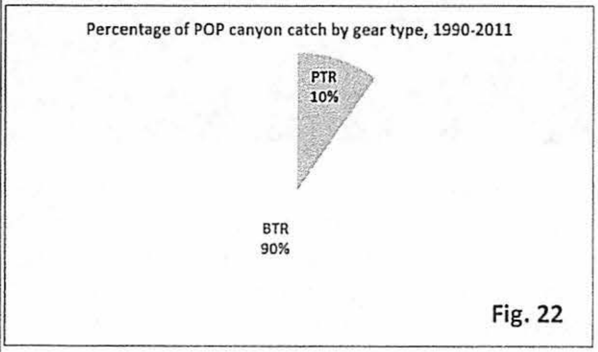


Fig. 22

As a consequence of sharply increased EBS Pacific ocean perch ABCs and TACs in 2010 and 2011, a directed fishery has developed at the end of year (after the Aleutian fishery has ended) and catches reached the highest level seen in more than 20 years in 2011 (Table 4). The observer catch database for Pribilof and Zhemchug canyons indicates that 50-70% of this recent EBS rockfish catch has occurred in the canyons, concentrated in Pribilof Canyon.

Table 4. EBS catch (mt) of Pacific ocean perch compared to observer-reported POP catch/bycatch in Pribilof and Zhemchug canyons, 1990-2011.

Year	EBS POP ABC	EBS POP TAC	EBS POP catch/a	Prib-Zhem total catch/b	Prib-Zhem % of EBS POP catch
1990/c			5,639	1,624	29%
1991	4,570	4,570	5,099	184	4%
1992	3,540	3,540	3,254	416	13%
1993	3,300	3,300	3,764	999	26%
1994	1,910	1,910	1,688	552	33%
1995	1,850	1,850	1,210	475	39%
1996	1,800	1,800	2,854	761	27%
1997	2,800	2,800	681	64	9%
1998	1,400	1,400	1,022	255	25%
1999	3,600	1,900	421	65	15%
2000	3,100	2,600	451	86	19%
2001	2,040	1,730	896	97	11%
2002	2,620	2,620	641	96	15%
2003	2,410	1,410	1,145	293	26%
2004	2,128	1,408	732	28	4%
2005	2,920	1,400	879	163	18%
2006	2,960	1,400	1,042	293	28%
2007	4,160	2,160	870	228	26%
2008	4,200	4,200	513	161	31%
2009	3,820	3,820	623	422	68%
2010/c	3,830	3,830	3,547	2,556	72%
2011/d	5,710	5,710	5,599	2,905	52%

a/ Spencer and Ianelli (2010), BS/AI Pacific ocean perch assessment, p. 1057, Table 2. In: NPFMC Bering Sea/Aleutian Islands SAFE, Dec. 2010. Includes retained and discarded catch.
b/ Combined observed catch and bycatch of POP from Pribilof and Zhemchug canyons for all gears. Source: NPGOP.
c/ Total for 1990 includes POP, northern, shortraker, rougheye, and sharpchin rockfish. NPFMC Bering Sea/Aleutian Islands SAFE 2011, Introduction, Table 2.
d/ NMFS AKRO CAS total catch through 12/17/2011: Additional fishing totaling 3,547 tons occurred between Nov. 5 and Dec. 17.

Although POP in the eastern Bering Sea and Aleutian Islands management areas have been assessed and managed as a single stock due to the paucity of data in the EBS (Spencer and Ianelli 2010), many slope rockfish populations are known to exhibit little geographic movement as adults and to represent "a mosaic of small, localized stocks" (Love *et al.* 2002). One study of trawl survey data in Alaska found that variability in rockfish abundance and species composition within a given area is related to local habitat features, and that higher habitat heterogeneity and the presence of epibenthic structures such as corals is correlated with higher diversity of species and abundance (Rooper 2008). Recently published research by Palof *et al.* (2011) using DNA analysis of POP sampled along the continental shelf break of the Gulf of Alaska and Bering Sea indicates significant geographically related stock structure at small spatial scales: adults appear to belong to "neighborhoods" at geographic scales less than 400 km and as little as 70 km. Therefore genetic interchange, movement to new areas, and boundaries of discrete stocks may depend largely on pelagic larval dispersal and juvenile life-history stages (Love *et al.* 2002, Spencer and Ianelli 2010).

Well-known life history features and the new research confirming that POP populations are highly localized and genetically differentiated has profound implications for the management of the POP and other rockfish, elevating the concern that spatially concentrated fishing could decimate discrete reproductive populations, eliminate genetic diversity within the POP population, and undermine the sustainability of the fishery. Concerns about disproportionate harvesting in the Aleutian Islands have prompted some action to subdivide BS/AI POP allowable biological catch (ABC) and total allowable catch (TAC) into four large management subareas in the EBS and AI based on the weighted averages of the biomass estimates from the three most recent groundfish surveys (Table 5).

Table 5.Apportionment of POP ABC and TAC based on proportion of stock abundance by large management subareas, 2011-2012

	Bering Sea/Aleutian Islands Subareas			
	EBS	EAI	CAI	WAI
Proportion of biomass by area:	23.1%	22.8%	20.2%	33.9%

However, the new genetics research indicates that these management units are still too large to address the relevant spatial scale of stock structure found in POP. Evaluation of more appropriate spatial management units should be a high priority for these rockfish species,[11] and the stock assessments themselves should also provide better spatial analyses of effort distribution to evaluate the risk of serial depletion of distinct, localized populations (Babcock *et al.* 2005). In the face of these considerable uncertainties and risks, marine protected areas have been proposed as an effective tool to reduce bycatch and the risk of serial overfishing of substocks of shortraker and rougheye rockfish in the Gulf of Alaska – without reducing current catch levels (Soh *et al.* 2000). Rooper (2008) suggested that MPAs could be designed for specific depth and geographic locations to protect portions of rockfish populations as part of a more explicit spatially based management approach.

In Pribilof and Zhemchug canyons, the spatial distribution of rockfish catches (all rockfish species, all gears) showed a striking shift over two decades: during 1990-2000, 83% of the observed catch occurred in Zhemchug canyon whereas, from 2001-2011, 86% of the catch came from Pribilof canyon (Fig. 23). The reason for the dramatic shift in rockfish catches between these two periods is unknown, but the patchy, localized distribution of rockfish species makes localized populations vulnerable to depletion and this possibility should be investigated in considering how to protect the canyons.

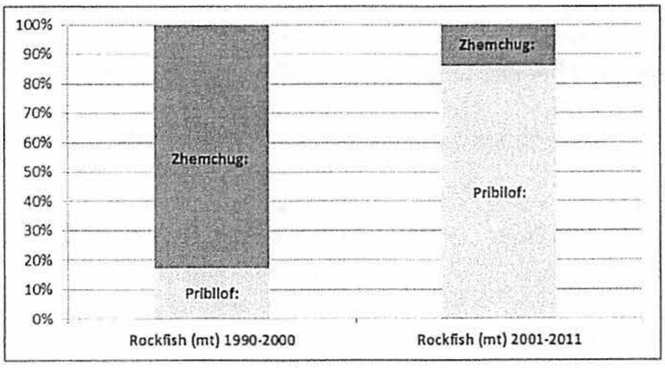


Fig. 23. Percentage of observer-reported rockfish catches in Pribilof and Zhemchug canyons for the periods 1990-2000 and 2001-2011.

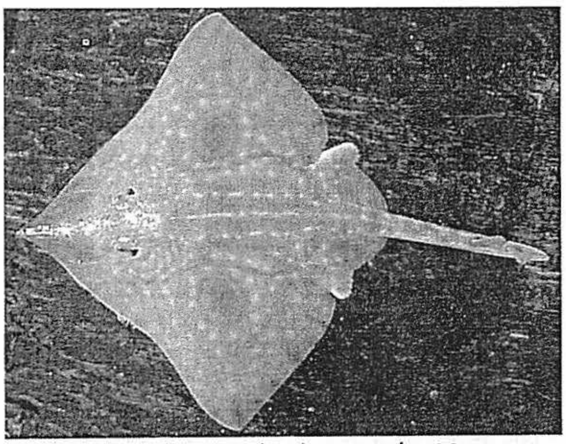
The BSAI directed rockfish fisheries are conducted almost exclusively by factory trawlers in the H&G fleet, using bottom trawl gear. The prospect of significantly increased fishing for POP and other rockfish along the EBS shelf edge and slope is especially concerning because increased bottom trawl effort in the canyons will mean increased damage to benthic invertebrates in the region. From 2003-2008, the BSAI rockfish fisheries (concentrated in the Aleutian Islands) accounted for 31% of the coral and bryozoan bycatch, 18% of the sponge bycatch, 8% of the red tree coral bycatch, and 7% of the polychaete bycatch (Spenser and Ianelli 2010).

Expanded bottom trawling for POP and other rockfish in the canyons would violate the principle of "freezing the footprint" of bottom trawling in the Bering Sea. Many rockfish species are found in high-relief benthic habitat composed of boulders, corals and other structures, hence they are not only vulnerable to bycatch and overfishing but to habitat destruction from fishing gear that diminishes their preferred habitat or renders it unusable. If these substrates are damaged or lost due to disturbance from bottom-tending gear, there is the potential that survival and growth of these species may be compromised (NPFMC 2010). Juvenile red rockfish are strongly associated with complex habitat structures such as epibenthic corals, sponges, and anemones and non-living rocky habitat features, which serve as refuges from predators (Rooper and Boldt 2005, Rooper *et al.* 2007, NPFMC 2010). Adult POP observed by ROV in Pribilof Canyon along the Bering Sea slope were closely associated with dense groves of epibenthic sea pens and sea whips (Brodeur 2001). This was confirmed by analysis of *in situ* data from the 2007 Bering Sea Canyons Expedition (Miller *et al.* 2012). Adult shortraker, rougheye, redbanded, sharpchin, and yelloweye rockfish were observed in close association with red tree coral in the eastern Gulf of Alaska, using the manned submersible *Delta* (Krieger and Wing 2002, Stone and Shotwell 2007). It is possible that corals such *Primnoa* serve multiple functions for these species (NPFMC 2010).

[11] Currently, assessment scientists are considering subdividing the northern rockfish ABC and TAC by management subareas in 2012. Paul Spencer, NMFS/AFSC, pers. comm.

Canyon HCAs along the eastern Bering Sea shelf break and slope could be an integral part of an explicitly spatial management strategy that provides rockfish refuges from directed fishing and bycatch. Canyon HCAs that prohibit the use of bottom-tending gear would provide protection for vulnerable habitats associated with rockfish as well as buffers against the considerable uncertainty associated with localized population structure and dynamics of POP and other slope rockfish species. The establishment of protected areas would also serve as controls to evaluate how unfished rockfish populations and their habitat quality compare to fished areas, thereby fostering learning within an adaptive management framework.

4.2 Skates (Rajidae)



Big Skate (*Raja binoculata*), NOAA/AFSC

At least 14 species of skates in the family Rajidae are known to occur in the Gulf of Alaska, Aleutian Islands, and Bering Sea in two genera: *Raja*, commonly known as the "stiff-snout" skates because they have a robust rostral cartilage, and *Bathyraja*, also known as the "soft-snout" skates due to their flexible rostral cartilage. Most of Alaska's skate species are included in the genus *Bathyraja*, which tend to be smaller and inhabit deeper waters than species of *Raja*.[12] The skate fauna of the eastern Bering Sea consists of at least 13 species, but populations are dominated by the Alaska skate (*Bathyraja parmifera*) on the continental shelf (0-200 m) and the Aleutian skate (*B. aleutica*) on the upper continental slope (200-1200 m). Both species possess nursery sites along the shelf-slope interface and evidence suggests that they depend on the stable environment provided by this habitat for successful reproduction (Hoff 2009).Skate life history is generally characterized by low fecundity and slow growth rates, and recent research on the deepwater whitebrow skate (*B. minispinosa*) indicates that, while smaller than species found in shallower shelf waters, this species has a longer lifespan than most Alaskan *Bathyraja* species documented in the published literature which makes it (and possibly others in the deepwater complex, Ebert 2005) especially vulnerable to overfishing (Ainsley *et al.* 2011).

While skate biomass is higher on the EBS shelf than on the slope, skate diversity is substantially greater on the EBS slope (Ormseth *et al.* 2010). Data from bottom-trawl surveys in the eastern Bering Sea indicate that species diversity is greatest in the deeper waters of the shelf-slope break at 250-500 m depth, where a total of ten skate species have been reported. Some species, including Aleutian skate (*B. aleutica*), Bering skate (*B. interrupta*), mud skate (*B. taranetzi*), and whiteblotched (*B. maculata*), are encountered from the shelf break

[12] See: http://www.afsc.noaa.gov/species/Skates.php.

down to >1000 m while another group of species, characterized by a dark ventral surface – Commander skate (*B. lindbergi*), whitebrow skate (*B. minispinosa*), and roughtail skate (*B. trachura*) – begin to appear at depths of 300-400 m and are more common in deeper waters. Stevenson et al. (2008) found that species richness was approximately 50% higher in canyons and northern gentle slope habitats than in intercanyons and southern gentle slope habitats. Table 6 (below) shows generalized species depth distributions for skates that were identified in the Pribilof and Zhemchug canyon groundfish fisheries, based on observer-reported catch data.

Table 6. Common depth ranges and min-max depth occurrence in the NMFS Eastern Bering Sea Slope Survey (2010) for skate species reported as bycatch in Pribilof and Zhemchug canyon fisheries from 2003-2011

	EBS Shelf (<50-200 m)	Shelf Break/ Upper Slope (200-1200 m)	Min-Max Depth Occurrence in 2010 EBSS Survey (m)	Occurrence in Pribilof/Zhemchug Canyon Fisheries
Big skate (*Raja binoculata*)	X			minor
Longnose skate (*R. rhina*)	X			trace
Alaska skate (*Bathyraja parmifera*)	X	X	206-416	significant
Aleutian skate (*B.aleutica*)	X	X	202-1149	significant
Bering skate (*B. interrupta*)		X	201-1065	significant
Mud skate (*B. taranetzi*)		X	202-965	trace
Commander skate (*B. lindbergi*)		X	215-1149	trace
Whiteblotched skate (*B. maculata*)		X	214-1059	minor
Whitebrow skate (*B. minispinosa*)		X	214-1149	trace
Roughtail skate (*B. trachura*)		X	597-1149	trace
Deepsea skate (*B. abyssicola*)		X	687-1014	

Numerous skate nurseries (i.e., egg-nesting sites) have been identified on the upper slopes of deepwater canyons along the Bering Sea Green Belt, particularly canyon heads (Hoff 2010). Nursery sites for the Alaska skate, the Aleutian skate and the Bering skate have been identified in the canyons at depths of 145-380 m in relatively flat sandy to muddy bottom habitat, including Pribilof and Zhemchug canyons. It appears that they are dependent on the unchanging, stable environment afforded by these nesting sites for reproductive success (Hoff 2009). Based on the observer-reported data in Pribilof and Zhemchug canyons from 1990-2011, significant quantities of skate egg cases (weighing tens to hundreds of kilograms) were commonly reported as bycatch in most years, most often in bottom trawl and longline gear, but fishing effort distribution data were not available to determine their locations within the canyons.

For all these reasons, skates are highly vulnerable to habitat disturbances and increased fishing mortality (Hoff 2009). Prior to 2011, skates were managed as part of the "Other Species" complex and skates accounted for the largest portion of the catch for the complex as a whole (NMFS 2004). The Other Species complex has now been disbanded and skates are managed separately as a stock complex with their own ABC and TAC, but life history and distribution information remain limited for most species. Persistent cumulative adverse fishing impacts to habitat could be occurring for species such as skates, but baseline conditions are unknown (NMFS 2004). Skates are caught incidentally as bycatch in nearly all of the commercial groundfish fisheries off Alaska, including fisheries targeting Pacific cod, walleye pollock, and yellowfin sole, among others (Stevenson and Lewis 2010).The walleye pollock fishery in the Bering Sea employs pelagic trawl gear, but adult pollock of the size and age targeted by the fishery are often found very close to the bottom during the daylight hours when fishing occurs and catches often include a variety of benthic species, including skates. Therefore it is likely that at least a large proportion of the skate catch in pelagic trawls is the result of the net contacting, or at least coming very close to, the seafloor (Stevenson and Lewis 2010).This is consistent with the conclusions of the Final North

Pacific groundfish EFH EIS (NMFS 2005), which estimated that pollock "pelagic" trawl gear contacts the seafloor approximately 44% of the time it is deployed (NMFS 2005).[13]

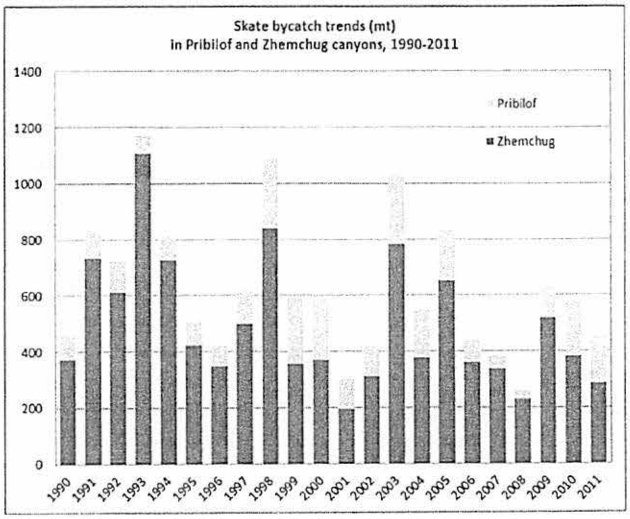


Fig. 24. Trends in Pribilof and Zhemchug canyons skate bycatch (mt), 1990-2011.

Observer-reported catch data from Pribilof and Zhemchug canyons indicate that skate bycatch averaged about 650 mt/year during 1990-2011 with considerable year-to-year variability (Fig. 24).Over this period, 79% of the reported skate bycatch came from Zhemchug Canyon (Fig. 25) and the vast majority of it (97%) occurred in longline gear (Fig. 26). From 2003-2011, the combined bycatch of canyon skates averaged about 3% of the EBS-wide skate bycatch (Table 7).

Although observer identification of skates to the species level has improved in recent years, the taxonomy of skates in the eastern Bering Sea is still not well defined (Ainsley *et al.* 2009) and the vast majority of the observed skate bycatch is still reported at the genus level (Stevenson and Lewis 2010). In Pribilof and Zhemchug canyons from 2003-2011, 80% of the reported skate bycatch was classified simply as "skate unidentified" or "soft snout skate" (*Bathyraja*), meaning that the species composition of skate bycatch and the effects of fishing mortality on individual species in the canyons is largely unknown. Of the skate bycatch identified to the species level, Alaska skate and Aleutian skate generally predominated in terms of tonnage, followed by lesser but significant quantities of Bering skate, whiteblotched skate, and Commander skate. Trace amounts (<1 metric ton) of whitebrow skate, roughtail skate, mud skate, big skate and longnose skate were reported in most years from 2003-2011 (Fig. 27).

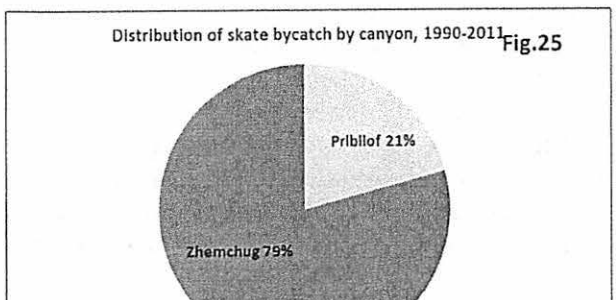


Fig. 25

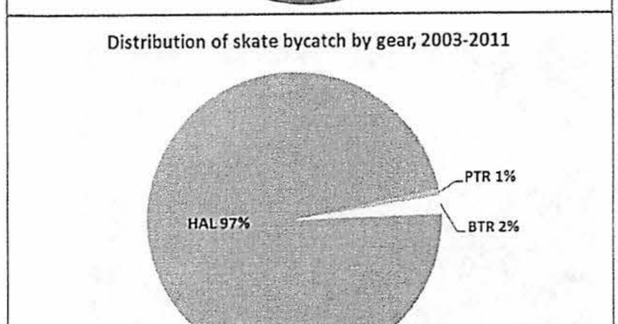


Fig. 26

[13]NMFS (2005), Final Environmental Impact Statement (EIS) for Essential Fish Habitat (EFH) Identification and Conservation in Alaska, Appendix B, Table B.2-4.

Table 7. EBS-wide skate bycatch (mt) compared to observer-reported skate bycatch in Pribilof and Zhemchug canyons during 2003-2011.

Year	EBS-wide skate bycatch/a	Prib-Zhem combined bycatch/b	Prib-Zhem % of EBS
2003	18,501	1,027	5.5%
2004	21,415	548	2.6%
2005	22,388	831	3.7%
2006	19,283	439	2.3%
2007	17,608	382	2.2%
2008	20,251	262	1.3%
2009	19,376	631	3.2%
2010	16,376	578	3.5%
2011	19,476	450	2.3%

a/ Ormseth and Matta (2011), Bering Sea and Aleutian Islands Skates, pp. 1157-1242, Table 5b, In: NPFMC BS/AI SAFE, Dec. 2011.

b/ Source: NPGOP.

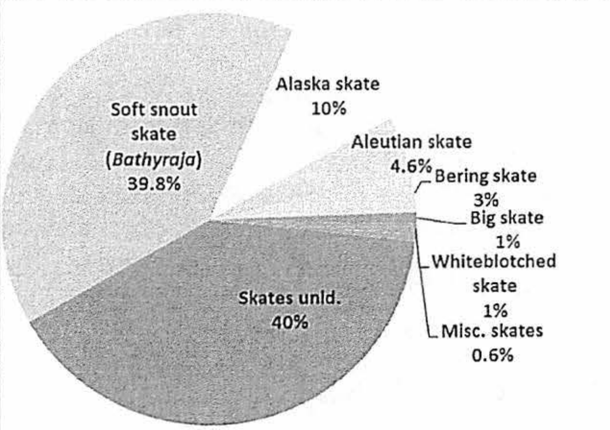
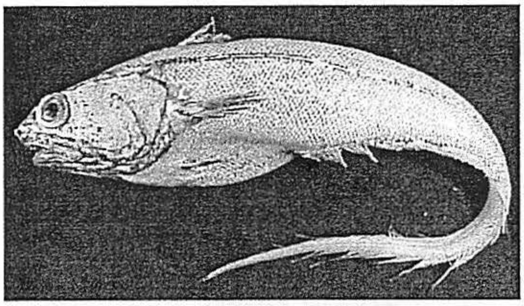


Fig. 27

Currently the Council is considering designation of six areas of known skate egg concentration situated within a number of deepwater canyons along the Green Belt as skate HAPC because the eggs and embryos are highly susceptible to disturbance, damage, or destruction from fishing gear that contacts the seafloor during their lengthy development.[14] The localized nature of these skate egg concentrations within the canyons and their vulnerability to fishing disturbance makes them logical choices for HAPC designation and protection, but the limited, site-specific approach to HAPC is not designed to address the wider impacts of fishing on the diverse and poorly understood assemblage of skate species and other vulnerable deepwater fauna that inhabit the outer continental shelf and slope of the eastern Bering Sea. Closure to all bottom-tending gear in Pribilof and Zhemchug canyons would provide this diverse assemblage of deepwater skates refuges from bycatch mortality and provide comprehensive protection to known and as-yet unidentified egg-nesting sites within the canyons.

5.3 Grenadiers (Macrouridae)



Giant grenadier (*Albatrossia pectoralis*)

[14]NPFMC Agenda C4(a), HAPC Initial Review, February 2012: 20.

Grenadiers (Family Macrouridae) are deepwater fishes related to hakes and cods that occur world-wide in all oceans. Also known as "rattails," they are especially abundant in waters of the continental slope, but some species are found at even greater depths. Like other deepwater fish species, they have life history traits such as slow growth, late maturity and long lifespan that make them particularly vulnerable to overfishing. At least seven species of grenadiers are known to occur in Alaskan waters, and three are commonly encountered in commercial fishing operations or in fishery surveys: giant grenadier (*Albatrossia pectoralis*), Pacific grenadier (*Coryphaenoides acrolepis*), and popeye grenadier (*Coryphaenoides cinereus*). Of these, giant grenadier is commonly encountered in the fisheries and groundfish surveys at depths of 200-1000 m, where it is the dominant species in terms of biomass and therefore of great ecological importance (Tribuzio *et al.* 2008). In the 2010 Eastern Bering Sea Slope survey (continental slope and canyons from 200-1200 m), the giant grenadier represented the largest biomass whereas the most abundant fish species was the popeye grenadier (Hoff and Britt 2011).

Table 8. EBS-wide grenadier bycatch (mt) compared to observer-reported grenadier bycatch in Pribilof and Zhemchug canyons,

YEAR	EBS grenadier bycatch/a	Prib-Zhem combined catch/b	Prib-Zhem % EBS bycatch
1997	2,964	481	16.2%
1998	5,011	808	16.1%
1999	4,505	459	10.2%
2000	4,067	648	15.5%
2001	2,294	136	5.9%
2002	1,891	113	6.0%
2003	2,869	185	6.4%
2004	2,223	308	13.8%
2005	2,633	449	17.0%
2006	2,070	413	19.9%
2007	1,628	363	22.3%
2008	2,670	191	7.1%
2009	2,902	695	23.9%
2010	2,052	422	20.5%
2011	na	205	

a/ David M. Clausen and Cara J. Rodgveller (2010). Alaska Grenadier Assessment, pp. 1571-1620, In: NPFMC BS/AI/GOA SAFE, Appendix 1. Includes retained and discarded catch.
b/ Source: NPGOP.

Giant grenadier is the most frequently caught member of this group as bycatch, particularly in the deepwater sablefish and Greenland turbot fisheries (Clausen 2008, Clausen and Rodgveller 2010). In the past, grenadiers were classified as "non-specified" species (requiring no management) and therefore formal stock assessments were not conducted and baseline stock status was not considered (NMFS 2004). However, observer reporting of grenadier bycatch and groundfish surveys do provide some basic information on distribution, abundance and fishing mortality that was used to develop a preliminary stock assessment for grenadiers beginning in 2006 (Clausen and Rodgveller 2010). But a Council initiative to include grenadiers in the FMP either as target species or Ecosystem Component (EC) species in plan amendment 96 (implemented in November 2010) ultimately failed, and it is uncertain if efforts to monitor fishery bycatch mortality and assess the status of these important deepwater species will continue. Early life history information is virtually non-existent, but sexual maturity is reached late in life and natural mortality is low (Rodgveller *et al.* 2010). Because the fisheries operate at depths where female giant grenadiers greatly outnumber males, the majority of the bycatch is composed of females. Although giant grenadiers are not considered to be overfished at present, the disproportionate removal of females puts them at increased risk of overfishing (Clausen 2008, Clausen and Rodgveller 2010).

Observer-reported data from Pribilof and Zhemchug canyons indicates that the grenadier bycatch in these two canyons represents a significantly large percentage of the EBS-wide grenadier bycatch in many years – as much as 20-24% in recent years (Table 8). More than 90% of this bycatch came from Zhemchug Canyon during 1990-2011 (Fig. 28 below) and demersal longline gear accounted for 94% of the total (Fig. 29 below). Although the grenadier stock complex was not considered overfished based on the preliminary assessments conducted in 2006-2010, the absence of explicit management recognition in the FMP and the continuing bycatch of these species raises serious concerns about the impacts of groundfish fisheries on a group of species of such great ecological importance in the deepwater slope ecosystem off Alaska.

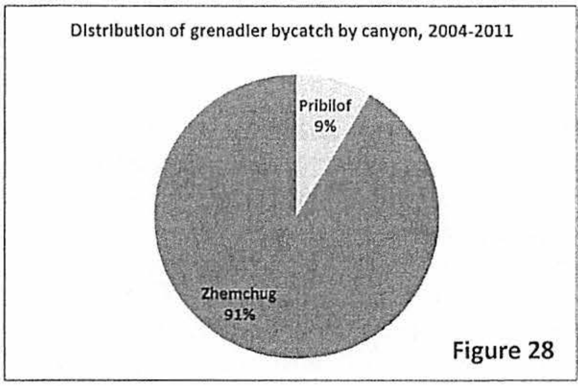


Figure 28

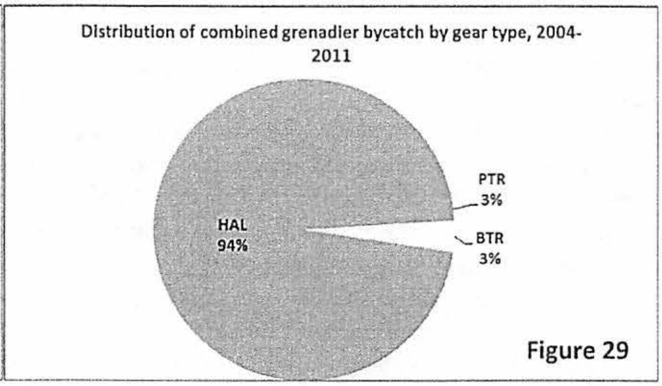
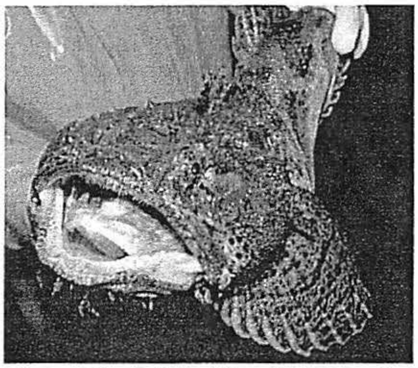


Figure 29

One way to help address these concerns would be to include grenadiers in the FMPs as Ecosystem Component (EC) species in order to monitor the impacts of the fishery and ensure that bycatch levels do not present a risk of overfishing. The basis for classifying Ecosystem Component (EC) species in an FMP under the revised National Standard 1 regulatory guidelines (74 FR 3178) is that they should be non-target species, not subject to overfishing or overfished, and not generally retained for sale or personal use.[15] EC species do not require specification of biological reference points or ACLs, but they should be monitored to the extent that any new information on catch trends, vulnerability, etc., indicate that they should be reclassified as "in the fishery." If the Council elects to classify giant grenadiers as an EC stock in the groundfish FMPs, the NS1 Guidelines require the Council to consider measures to minimize bycatch of EC species consistent with National Standard 9, and to protect their role in the ecosystem.[16]

Closure to all bottom-tending gear in Pribilof and Zhemchug canyons would provide grenadiers refuges from bycatch mortality in areas which have been shown to account for a significant percentage of the EBS-wide bycatch of grenadiers in most years, thereby providing some significant measure of insurance against the risk of overfishing. These measures would simultaneously protect representative portions of the deepwater slope habitat that they occupy.

5.4 Sculpins (Cottidae)



Bigmouth sculpin (*Hemitripterus bolini*)
NOAA/AFSC

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[15] 50 CFR § 600.310 (d)(5)(A-D).
[16] 50 CFR § 600.310(d)(5)(iii).

The highest diversity of sculpins (Family Cottidae) is found in the North Pacific. In the eastern Bering Sea, 41 species have been identified, occupying all benthic habitats and depths. Abundance estimates from the EBS shelf and slope surveys indicates that most of the sculpin biomass is found on the EBS shelf (~95%). The six most common include great sculpins (*Myoxocephalus polyacanthocephalus*), threaded sculpins (*Gymnocanthus pistillger*), plain sculpins (*M. jaok*), warty sculpins (*M. verrucosus*), bigmouth sculpins (*Hemitripterus bolini*), and yellow Irish lord (*H. jordani*). Life history information is limited but studies of reproductive biology indicate that most, if not all, sculpins lay adhesive eggs in nests and many exhibit parental care for eggs (Ormseth and TenBrink 2010). This type of reproductive strategy means that sculpins are vulnerable to the disturbance and damage to benthic habitats than other groundfish that broadcast their eggs into the water column (Ormseth and TenBrink 2010). Underwater video surveys have shown sculpins in close association with corals. Studies from elsewhere indicate that sculpins are not extremely long-lived but they mature at late ages and fecundity is rather low (Ormseth and TenBrink 2010b). Food habits data indicate that sculpins are prey for Pacific cod, halibut, walleye pollock, skates, and eelpouts, as well as pinnipeds.

Observer-reported data from Pribilof and Zhemchug canyons from 1990-2011 indicates that sculpin bycatch was much higher in the canyons at the beginning of the period and rapidly declined to a lower level (Fig. 30).Over this period, 78% of the reported sculpin bycatch came from Zhemchug Canyon, nearly equally distributed in bottom trawl and longline gear with lesser amounts in pelagic trawls (Figs. 31, 32). From 1998-2011, the combined bycatch of canyon sculpins was <1% of the EBS-wide sculpin bycatch, which is consistent with the survey data showing that sculpin abundance is much higher on the EBS shelf (Table 9).

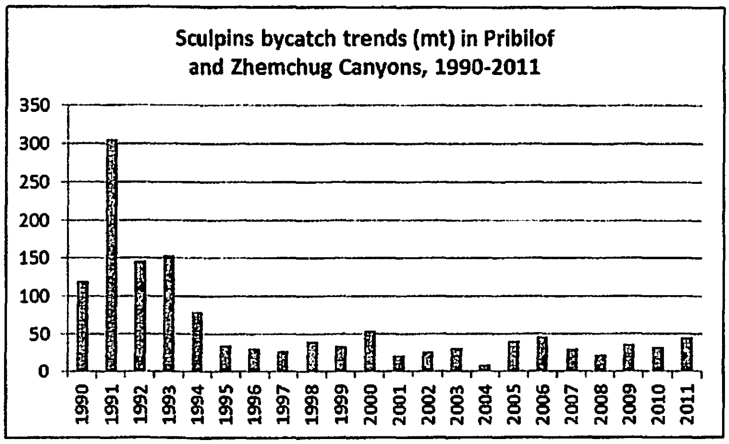


Fig. 30. Sculpin bycatch trends (mt) in Pribilof and Zhemchug canyons, 1990-2011.

Table 9. EBS-wide sculpin bycatch (mt) compared to sculpin bycatch in Pribilof and Zhemchug canyons, 1998-2011.

YEAR	EBS sculpin bycatch/a	Prib-Zhem combined bycatch/b	Prib-Zhem % of EBS bycatch
1997			
1998	5,204	40	0.7%
1999	4,503	34	0.7%
2000	5,673	54	0.9%
2001	6;067	21	0.3%
2002	6,043	26	0.4%
2003	5,184	32	0.6%
2004	5,242	9	0.1%
2005	5,114	40	0.7%
2006	4,907	47	0.9%
2007	6,505	30	0.4%
2008	6,682	23	0.3%
2009	5,915	37	0.6%
2010	5,631	33	0.6%
2011	4,592	45	1.0%

a/ Ormseth and TenBrink (2010), Bering Sea and Aleutian Islands sculpins, pp. 1537-1570, In: NPFMC BSAI SAFE, December 2010.

b/ Source: NPGOP.

Until very recently, observer reporting of sculpin bycatch has provided little species-specific information. In 2002-2003, the North Pacific Groundfish Observer Program began a project aimed at providing more detailed species information for the Other Species stock complex. Beginning in 2004, sculpin bycatch was identified to genus for the larger sculpin species, including *Hemilepidotus* spp. (Irish lords), *Myoxocephalus* spp. (great sculpins) and *Hemitripterus* spp. (bigmouth sculpins), and in 2008 observers were required to identify to species all sculpins in these three genera (Ormseth and TenBrink 2010). Observer data from Pribilof and Zhemchug canyons indicates that bigmouth sculpin (*Hemitripterus bolini*), yellow Irish lord (*Hemilepidotus jordani*), and great sculpin (*Myoxocephalus polyacanthocephalus*) were the dominant bycatch species in the canyon fisheries in all years, but small quantities of many other species were also reported, including spinyhead sculpin (*Dasycottus setiger*), crested sculpin (*Blepsias bilobus*), darkfin sculpin (*Malacoccottus zonurus*), blob sculpin (*Psychrolutes phrictus*), roughspine sculpin (*Triglops macellus*), spectacled sculpin, (*Triglops septicus*) plain sculpin (*Myoxocephalus jaok*) and warty sculpin (*Myoxocephalus verrucocus*).

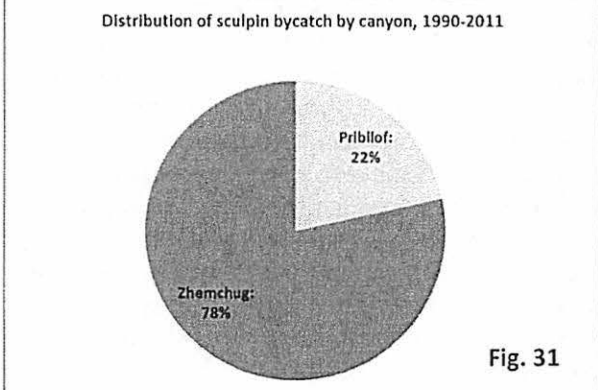


Fig. 31

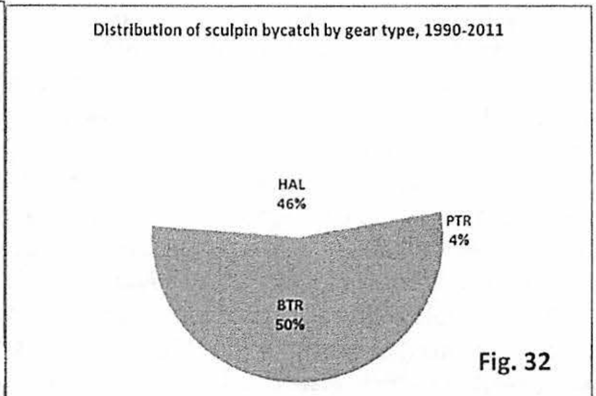
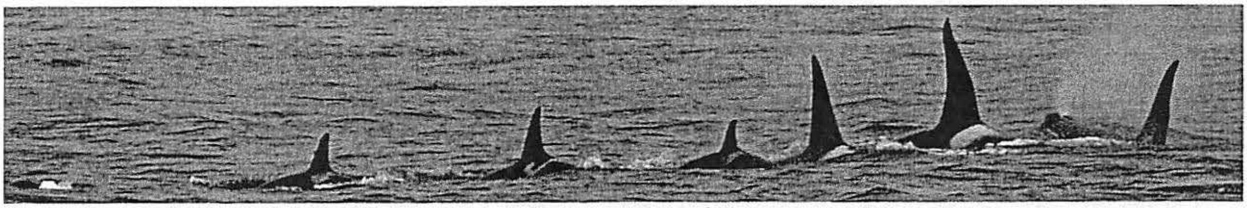


Fig. 32

Sculpin life history, species diversity and localized population structure all underscore the limitations and risks of managing this complex of species with a global aggregate catch limit (Ormseth and TenBrink 2010). As with rockfish, these life history characteristics make sculpins highly vulnerable to localized depletion and overfishing. Canyon HCAs that prohibit the use of bottom-tending gears could be an integral part of an explicitly spatial management strategy that provides refuges from directed fishing and bycatch, protection for vulnerable habitats associated with sculpins, as well as buffers against the considerable uncertainties associated with localized population structure and stock status of these species.



Killer whales (*Orcinus orca*) in Pribilof Canyon, Todd Warshaw/Greenpeace USA

6. Pelagic Habitat: Fish, Mammals and Birds of the Green Belt

Pribilof and Zhemchug canyons intersect the Bering Sea shelf break along the south-central and northern-central sections of the Green Belt. The pelagic habitat associated with them is characterized by persistent and predictable hydrographic structures such as upwelling, eddies and frontal zones that are generated by interaction with the submarine topography of the canyons. These hydrographic features concentrate plankton, zooplankton and prey fish such as squids and juvenile walleye pollock which, in turn, attract a diverse assemblage of higher trophic level predators (Springer et al. 1996, Brodeur *et al.* 1997, Stabeno *et al.* 1999, Moore *et al.* 2002, Macklin and Hunt 2004, Okkonen *et al.* 2004, Hunt *et al.* 2008, Call *et al.* 2008). The fluid, ever-changing and yet predictable features of the pelagic environment in the vicinity of the shelf break make this the most productive zone in the Bering Sea, which is why the nearby Pribilof Island Archipelago has supported some of the largest breeding colonies of marine birds and mammals in North America historically and earned a reputation as the "Galapagos of the North" (Macklin *et al.* 2008).

The largest colonies of fish-eating kittiwakes (*Rissa* spp.), murres (*Uria* spp.) and puffins (*Fratercula* spp.) in Alaska are found on the Pribilof Islands every summer, drawn to the productive shelf-edge pelagic habitat where squids, juvenile pollock and other forage fish are most often found in high concentrations. More than half of the northern fur seal population converges on the Pribilof Islands breeding and pupping grounds during the summer half of the year, feeding over a wide area of the shelf break, canyons and slope on pollock, squids, and deep-sea smelts (Lowry *et al.* 1982; Kajimura *et al.* 1984; Sinclair *et al.* 1994; Springer *et al.* 1996, NRC 1996, Robson *et al.* 2004, Call *et al.* 2008, Call and Ream 2012). Prior to whaling, much of whale biomass in the Bering Sea is thought to have been associated with the Green Belt (Springer *et al.* 1996) and many of the same species are sighted there today (Moore 2000, Moore *et al.* 2002), though not in the tens of thousands that were found before commercial whaling. The pelagic habitat of the canyons is also spawning and nursery habitat for pollock (Brodeur *et al.* 1997, Macklin and Hunt 2004, Bacheler *et al.* 2010, Quinn *et al.* 2011) as well as foraging habitat for western Alaska chinook and chum salmon.

Despite the enormous ecological importance of this ecoregion and its importance as a major fishing ground and source of the Bering Sea's fisheries bounty, the shelf break/slope habitat along the Green Belt remains unprotected – no year-round or seasonal habitat protection has been provided to date. Hyrenbach *et al.* (2000) proposed the creation of pelagic marine protected areas for these areas as a tool to ensure conservation of pelagic species and fishery resources, and specifically highlighted the persistent and predictable features of upwelling over shelf breaks, submarine canyons, seamounts, gullies, and boundaries of water masses as ideal locations for such protected areas. The distinctive features of Pribilof Canyon and Zhemchug Canyon make them ideal candidates for pelagic protected areas, encompassing areas utilized by many endangered, threatened and protected (ETP) species in addition to some of the Alaska Region's most important commercial fish species. Fully protected habitat conservation areas (HCAs) for Pribilof and Zhemchug would provide significant refuges from fishing in this pelagic convergence zone and address multiple objectives of the FMPs for conservation and management of fisheries resources.

6.1 Pelagic HCAs as Tools for Pollock Habitat Conservation

Walleye pollock (*Theragra chalcogramma*), a member of the family Gadidae (hakes and cods), is the most abundant groundfish biomass in the eastern Bering Sea and the target of one of the largest fisheries in the world. Pollock is also a major prey resource for many other fish, marine mammals, and seabirds. The scientific genus *Theragra* translates as "animal fodder" in recognition of pollock's importance to marine predators such as the northern fur seal as far back as the 19th century (Jordan *et al.* 1898). Overall, 19 of 27 marine mammal species that occur in the Bering Sea are reported to prey on pollock and other gadids (Lowry *et al.* 1982, Perez and Loughlin 1986). Large nesting colonies of fish-eating black-legged kittiwakes, common murres, thick-billed murres, tufted puffins, horned puffins, red-legged kittiwakes, pigeon guillemots and cormorants rely on the availability of dense schools of pelagic juvenile pollock (age 0-1) in the critical chick-rearing season in the eastern Bering Sea, and reproductive success has been tied to the availability of age-0 pollock to nesting birds (Springer and Byrd 1989, Springer 1993, Hunt *et al.* 1996, Byrd *et al.* 1997, Brodeur *et al.* 1997, Macklin and Hunt 2004, NPFMC 2011). Many commercially important groundfish also prey heavily on juvenile pollock (Livingston et al. 1986, Livingston *et al.* 1993). In 2003, a technical review of the Bering Sea pollock fishery for the Marine Stewardship Council concluded that pollock's importance in the Bering Sea food web is akin to the keystone role played by forage species such as krill, sand eel and capelin in other marine ecosystems around the world, and that its management requires an ecosystem approach (SCS 2003).

Since 1964, when Japanese factory trawlers first started fishing in earnest for pollock, more than 54 million metric tons (nearly 120 billion lb.) of fish biomass have been mined from the eastern Bering Sea, accounting for up to 70-80% of the Alaska groundfish catch annually – a scale of fishing that has no historical precedent in the North Pacific. Although catches in the eastern Bering Sea have remained near or above the 30-year average of 1.1 million metric tons (more than 2.4 billion pounds) under U.S. management since 1990, large spawning aggregations of pollock have plummeted in the wake of heavy fishing in the international waters of the central Bering Sea and U.S. waters of the Aleutian Basin and Aleutian Islands. Directed fishing for Central Bering Sea/Aleutian Basin pollock was halted in the early 1990s due to overfishing and plummeting stock biomass, and the prohibition remains in place today under the terms of the 1994 Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea (*aka* the "Donut Hole Treaty"). A moratorium on directed pollock fishing in the Aleutian Islands has been in place since 1999 due to low stock biomass, concerns about serial depletion, and Steller sea lion prey considerations. In both cases much of the fishing occurred on pollock spawning grounds when pollock are aggregated and most vulnerable to trawl nets.

The one remaining viable pollock population in the eastern Bering Sea continues to support the fishery but no protection has been afforded to spawning grounds. The annual allowable catch limit is subdivided into an A-season fishery and B-season fishery to prevent all of the catch from being taken during the late-winter and spring when pollock converge on spawning grounds along the continental shelf break and slope of the Bering Sea, but no spatial management measures are employed to prevent the fishery from concentrating effort in a given location. The only spatial management of any kind has resulted from Steller sea lion mitigation measures that limit the amount of the catch that may be taken in sea lion critical habitat in the eastern Aleutian Islands. These measures were adopted in the early 2000s to reduce the fishery's impact on designated sea lion foraging areas after NMFS concluded that the fishery was likely to jeopardize the survival and recovery of sea lions under the terms of the Endangered Species Act (NMFS 2000). Despite these measures, the fishery continues to be concentrated on spawning grounds off the eastern Aleutian Islands and northwestward along the outer shelf and slope to the Pribilof Islands, including Pribilof Canyon. In some years the fishery catches significant amounts of pollock in Zhemchug canyon (Fig. 33), which is also a known pollock spawning location. However, most of the pollock taken from the canyons since 2000 has come from Pribilof Canyon (Fig. 34).

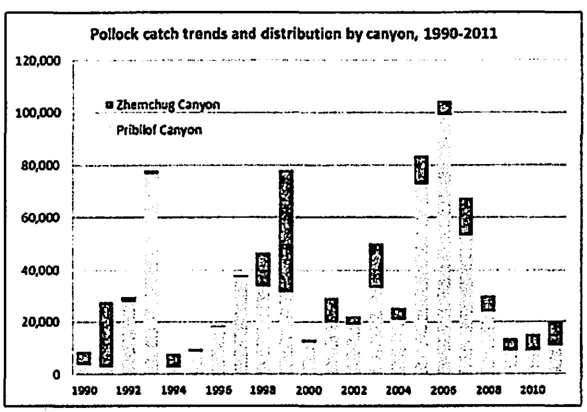


Fig. 33. Pollock catch trends and distribution by canyon, 1990-2011.

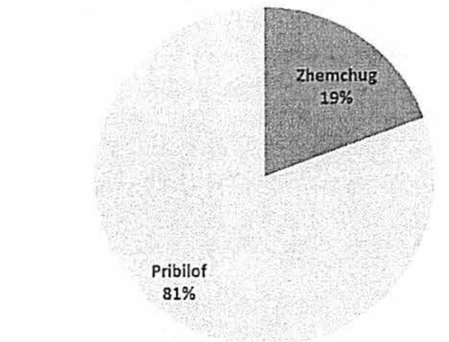


Fig. 34

Table 10. EBS-wide pollock catch (mt) and observer-reported pollock catch in Pribilof and Zhemchug canyons, 1990-2011.

Year	EBS-wide pollock catch/a	Combined Canyon Catch/b	Prib-Zhem % of EBS catch
1990	1,353,000	8,624	0.6%
1991	1,268,360	27,781	2.3%
1992	1,384,376	29,815	2.1%
1993	1,301,574	77,995	6.0%
1994	1,362,694	7,857	0.6%
1995	1,264,578	9,627	0.8%
1996	1,189,296	18,469	1.5%
1997	1,115,268	37,987	3.4%
1998	1,101,428	46,506	4.2%
1999	889,589	77,963	8.7%
2000	1,132,736	13,343	1.2%
2001	1,387,452	29,379	2.1%
2002	1,481,815	22,177	1.5%
2003	1,489,997	50,160	3.7%
2004	1,480,398	25,481	1.7%
2005	1,483,271	83,494	5.6%
2006	1,486,284	104,447	7.0%
2007	1,354,097	67,617	5.0%
2008	990,566	30,092	3.0%
2009	815,522	13,738	1.7%
2010	811,680	15,511	1.9%
2011	1,198,880	20,285	1.7%

a/ EBS pollock fishery data are from Ianelli et al. (2011), pp. 51-168, Table 1.37, In: NPFMC Bering Sea/Aleutian Islands SAFE, December 2011.
b/ Canyons catch data from NPGOP.

Overall, the amount of pollock coming from Pribilof and Zhemchug canyons is a small percentage of the EBS-wide pollock catch, averaging about 3% over the entire time period from 1990 through 2011 (Table 10). But this level of fishing is still a large amount by ordinary fishery standards and it may represent a large portion of the pollock biomass in a local area, such as Pribilof Canyon. In the absence of effective spatial management of the pollock allowable catch, there is a real risk that uniquely adapted local spawning subpopulations will be depleted or eliminated in a serial fashion over time, as may have occurred in the Aleutian Islands and Aleutian Basin. Given the enormous ecological and economic importance of pollock and the uncertainties associated with pollock stock structure (see 6.1.1 below), the Council should strive to conserve population substructure and diversity by protecting reproductive habitat and providing refuges during the period when pollock are most vulnerable to fishing.

6.1.1 Pelagic spawning HCAs as buffers against uncertainties in pollock stock structure

Although pollock in the eastern Bering Sea do not form one homogeneous population, the actual stock structure is not well known. Three stocks are recognized for management purposes in the Bering Sea and Aleutian Islands (eastern Bering Sea, Aleutian Basin and Aleutian Islands) but the relationship and interchange between these stocks is uncertain and the degree of fine-scale population structure within the eastern Bering Sea itself is largely unknown. Pollock are known to spawn at predictable times and locations and there are several well-known spawning areas that may be discrete stocks, including areas in and around Pribilof Canyon and Zhemchug canyon (Hinckley 1987, Bailey 1998, Napp *et al.* 1998, Bailey *et al.* 2000, Quinn *et al.* 2011). The uncertainty associated with stock structure has large implications for the sustainability of the fishery.

Pollock are known to spawn in predictable locations such as sea valleys and canyons along the outer margin of the continental shelf (Bailey 1998, Bailey *et al.* 2000), including areas in Pribilof Canyon and Zhemchug Canyon as shown in Fig. 35 (Bacheler *et al.* 2010, Quinn *et al.* 2011). There is also evidence to suggest that the large eastern Bering Sea "stock" may be comprised of multiple, discrete breeding subpopulations. Hinckley (1987) postulated the existence of separate pollock stocks in three major spawning areas: the Aleutian Basin near Bogoslof Island, north of Unimak Island along southeast slope and shelf (Bering Canyon/Horseshoe + Pribilofs), and the shelf/slope region northwest of the Pribilof Islands (encompassing Zhemchug Canyon). Differences in population characteristics (e.g., length at age, fecundity), timing of spawning and geographic separation supported the hypothesis of multiple stocks. More recent studies confirm that there are consistent seasonal patterns of pollock spawning locations in the eastern Bering Sea that may be a manifestation of spawning activities from multiple subpopulations, consistent with the hypothesis of previous research (Bailey et al. 2000, Bacheler *et al.* 2010).

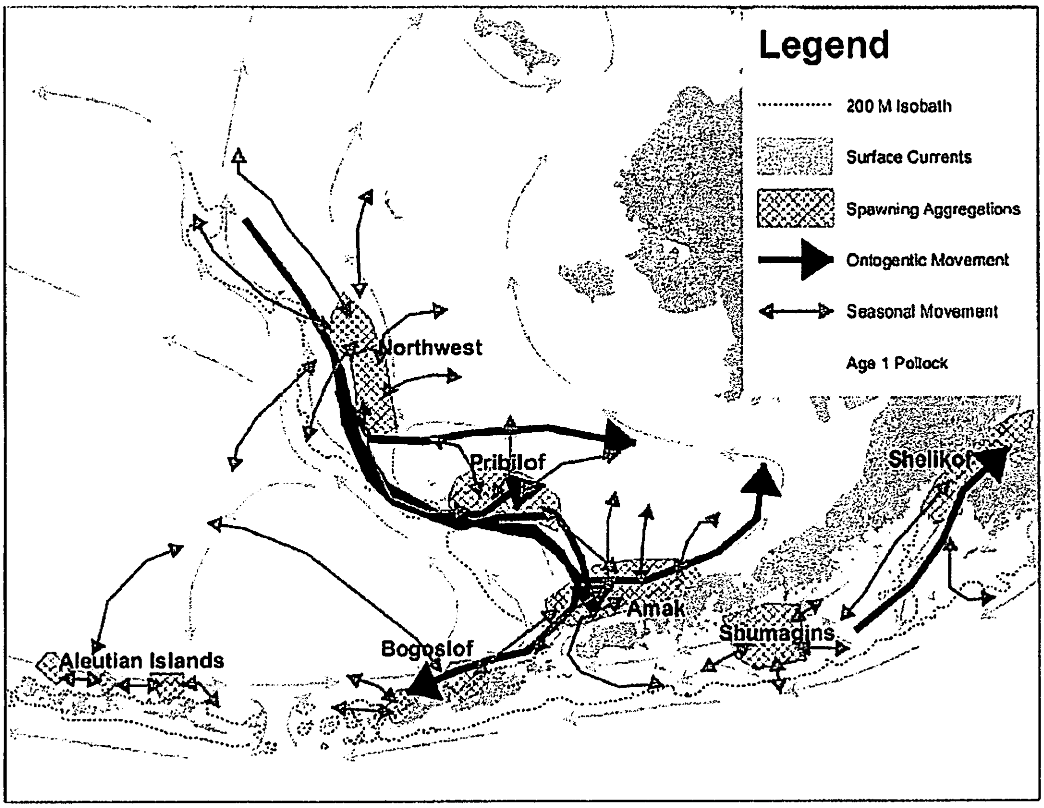


Fig. 35. Conceptual model of walleye pollock seasonal and ontogenetic movements with shaded areas representing recent spawning locations. Source: Quinn *et al.* (2011).

Thus it appears likely that there may be considerable stock separation among pollock in the eastern Bering Sea and that these stocks return to the same spawning grounds each year along the Green Belt, including areas in and around Pribilof Canyon and Zhemchug Canyon (Bacheler *et al.* 2010, Quinn *et al.* 2011). A prohibition on pelagic trawling in Pribilof and Zhemchug canyons would afford significant protection to known spawning grounds along the Green Belt and provide a buffer against the uncertainties associated with pollock stock structure and population dynamics within separate stocks in order to reduce the risk of depleting unidentified local subpopulations, losing genetic diversity and undermining population resilience (Bailey 1998, Bailey *et al.* 2000).

6.2 Pelagic HCAs as Tools for Reducing Pelagic Trawl Bycatch: Salmon, Squids and Juvenile Pollock

Chinook salmon (*Oncorhynchus tshawytscha*) and chum salmon (*O. keta*) are the primary salmon species reported as incidental bycatch in Pribilof and Zhemchug canyons groundfish fisheries. Pelagic pollock trawls accounted for most of salmon taken in the canyon fisheries, although bottom trawls accounted for a significant portion of the salmon bycatch in some years. Although the salmon bycatch coming from Pribilof and Zhemchug canyons represents a small percentage of the total catch of all species in the canyons during 1990-2011, quantities can be quite high when salmon are encountered and could pose a significant threat to vulnerable stocks (NMFS 2004). Observer-reported numbers of chinook bycatch in the canyons accounted for as much as 20-34% of the EBS-wide bycatch of chinook in the pollock fishery in some years (Table 11).

Declining returns of Western Alaska stocks of chinook salmon have been a major source of concern for many Native communities in Western Alaska who rely on the return of salmon to their natal rivers for subsistence, and a large percentage of the chinook bycatch in the Bering Sea pollock fishery comes from Western Alaska watersheds. Based on genetic analysis of chinook bycatch in the 2010 Bering Sea trawl fishery, Coastal Western Alaska Stocks accounted for nearly half of the salmon sampled with smaller contributions from Upper Yukon River, North Alaska Peninsula and Middle Yukon River (Fig 36).

Table 11. EBS-wide bycatch of chinook and chum salmon (numbers of fish) in the Bering Sea pollock fishery and chum bycatch (numbers of fish) from Pribilof and Zhemchug Canyons/a

YEAR	EBS Chinook (n)	Canyons Chinook (n)	EBS Chum (n)	Canyons Chum (n)
1997	43,336	789	61,504	296
1998	49,373	663	62,276	26
1999	10,187	1,912	44,585	568
2000	3,966	1,357	56,707	124
2001	30,107	669	52,835	223
2002	32,222	527	76,998	728
2003	43,021	4,994	180,872	4,698
2004	51,700	2,643	440,477	9,021
2005	67,364	5,732	704,586	5,101
2006	84,436	6,314	310,858	7,075
2007	127,409	7,610	100,261	1,384
2008	22,123	2,146	15,845	131
2009	13,010	668	47,602	148
2010	10,129	677	14,194	8,852
2011	25,451	286	191,441	6,807

a/ Ianelli et al. (2011), pp. 51-168, Table 1.37, In: NPFMC Bering Sea/Aleutian Islands SAFE, December 2011. Canyons data from North Pacific Groundfish Observer Program.

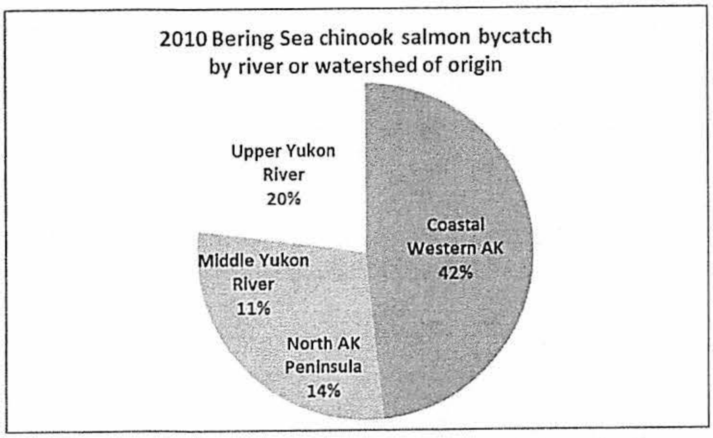


Fig. 36. Genetic stock composition analysis of chinook salmon bycatch samples from the 2010 Bering Sea trawl fisheries. Source: Guthrie *et al.* (2012).

Historically, one of the largest sources of unwanted bycatch in the pollock fishery was undersized juvenile pollock. Prior to the adoption of the Improved Retention/Improved Utilization program (IR/IU, FMP Amendment 49) in 1998, requiring groundfish fisheries to retain all pollock and cod, the magnitude of pollock bycatch and discards in the groundfish fishery was considered significant enough to be taken into account when estimating population size and forecasts of future pollock yield. Fritz (1996) estimated that discards of juvenile pollock (20-29 cm, ages 2-3 years) in the Bering Sea fishery reached levels as high as 114,975 mt in 1990, 160,260 mt in 1991, and136,702 mt in 1992 – larger than most directed fisheries in the United States. The directed fisheries for pollock and cod have accounted for the lion's share of these pollock discards. During 1991-2004, nearly 1 million tons of pollock were reported as unwanted bycatch and/or discards in the Bering Sea and Aleutian Islands pollock fishery (Table 12).

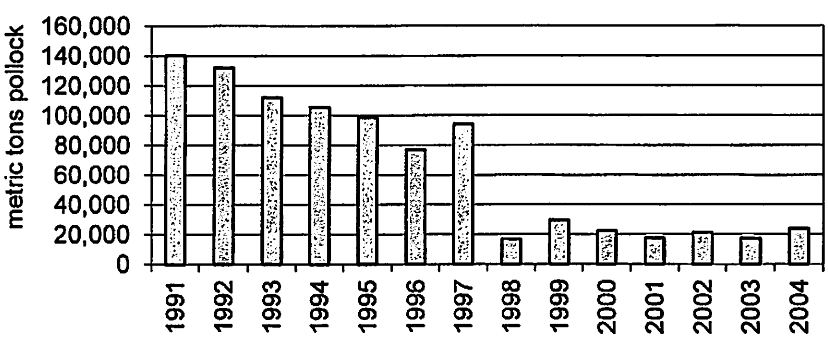
Table 12. Estimates of discarded pollock (metric tons) by area and as a percent of total BS/AI pollock catch, 1991-2004./a

	Aleutian Islands	Bogoslof region	Northwest Bering Sea	Southeast Bering Sea	Total pollock discards	% Total Catch
1991	5,231	20,327	48,205	66,789	140,552	9%
1992	2,982	240	57,609	71,195	132,026	9%
1993	1,733	308	26,100	83,989	112,130	8%
1994	1,373	11	16,083	88,098	105,565	8%
1995	1,380	267	9,715	87,491	98,853	7%
1996	994	7	4,838	71,367	77,206	6%
1997	617	13	22,557	71,031	94,218	8%
1998	164	3	1,581	15,135	16,883	2%
1999	480	11	1,912	27,089	29,492	3%
2000	790	20	1,941	19,678	22,429	2%
2001	380	28	2,450	14,873	17,731	1%
2002	758	12	1,439	19,226	21,435	1%
2003	468	n/a	2,980	14,063	17,512	1%
2004	758	0	2,723	20,302	23,783	2%

a/ Ianelli et al. (2005), pp. 31-124, Table 1.3, In: NPFMC BS/AI SAFE, Dec. 2005.

The adoption of IR/IU regulations in 1998was a means of reducing *economic discards* of pollock dramatically. After IR/IU went into effect, reported discards of pollock dropped from >94,000 t of pollock (8 percent of the pollock catch) in 1997 to only ~16,900 t of pollock in 1998 (2 percent of the catch) (Fig. 37).

Fig. 37. Trends in BS/AI pollock bycatch/discards in the EBS pollock fishery, 1991-2004. Source: Ianelli *et al.* 2005.



Although IR/IU reduces economic discards and waste, there is no evidence that the program reduces unwanted juvenile pollock bycatch, except to the extent that the provision requiring retention of all pollock and cod causes fishing vessels to modify fishing practices to avoid bycatch of pollock and other non-target species. There is no information indicating that such modifications of fishing practices have occurred. Major sources of the pollock bycatch in the surimi factory trawl fleet, for instance, have on-board fishmeal plants and may simply grind the bycatch of unwanted fish juvenile pollock into meal or minced product forms.

In addition, the pelagic trawl gear employed in the pollock fishery catches a variety of other important forage fish, including squids (Gonatidae), smelts (Osmeridae), and herring (Clupeidae).Observer data indicates all these species were caught in pelagic trawl gear in Pribilof and Zhemchug canyons during 1990-2011, although bycatch of squids in bottom trawl gear was sometimes significant. Squids were the dominant biomass of forage fish other than pollock reported in pelagic trawls and bycatch of squids was highest in years when pollock catches in the canyons were highest (Fig. 38). Most squid bycatch came from Pribilof Canyon, which is to be expected since most pollock were caught in Pribilof Canyon. Eulachon was the most commonly reported smelt species in most years but was reported in far lower quantities than squids, while herring rarely occurred at more than trace levels.

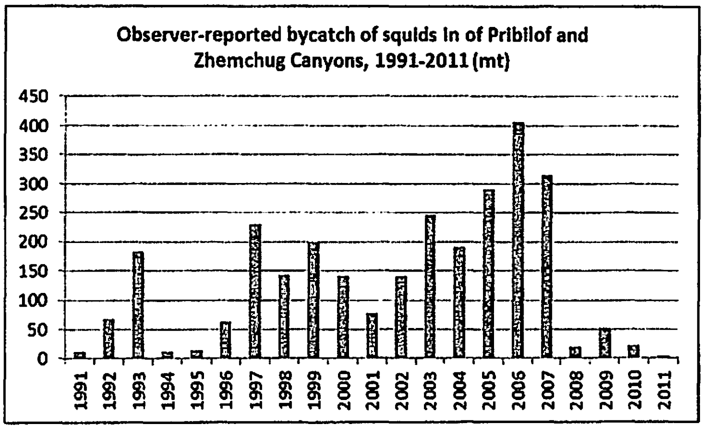


Fig. 38. Trends in squid bycatch from Pribilof and Zhemchug canyons, 1991-2011. Source: NPGOP.

All of these species are important prey for millions of sea birds and tens of thousands of northern fur seals on the Pribilof Islands during the summer half of the year. While a prohibition on pelagic trawling in Pribilof and Zhemchug canyons will not encompass all the important foraging areas of seabirds and marine mammals in the region, it would provide significant protection to prey availability in areas of the shelf break that are utilized by all these species.

6.3 Pelagic HCAs as Tools to Protect Marine Mammal Foraging Habitat and Prey Availability

Prior to whaling, much of whale biomass in the Bering Sea is thought to have been associated with the Green Belt (Springer *et al.* 1996). Sperm whales (*Physeter macrocephalus*), which were prime targets of whalers, are squid specialists and they reportedly concentrated on the shelf edge of the Bering Sea and Aleutian Islands during the whaling period (Omura 1955, Okutani and Nemoto 1964). The abundance of fin whales (*Balaenoptera physalus*) on the whaling grounds was reportedly highest at upwelling and frontal zones along the shelf edge from the southeastern Bering Sea to Cape Navarin, and more recent sightings confirm that they commonly feed in these areas today (Nasu 1966, Springer *et al.* 1996, Moore 2000, Moore *et al.* 2002). Historically, right whales (*Eubalaena japonica*) also had an extensive offshore distribution and were commonly seen in deep waters of the outer continental slope and basin in areas where few or no whales are sighted today (Clapham *et al.* 2004, Shelden *et al.* 2005). Minke whales (*Balaenoptera acutorostrata*), which were never hunted commercially in the eastern Bering Sea (Mizroch and Rice 2006), have been sighted throughout the southeastern and central-eastern Bering Sea along the upper slope in waters 100-200 m deep and along the 100 m contour near the Pribilof Islands (Moore 2000, Moore *et al.* 2002). Blue whale (*Balaenoptera musculus*), Stejneger's beaked whale (*Mesoplodon stejnegeri*) and Dall's porpoise (*Phocoenoides dalli*) are also associated with the shelf edge (Lowry *et al.* 1982; Springer *et al.* 1996; NRC 1996, Allen and Angliss 2011). Most of the northern fur seal population gathers on the Pribilof Islands breeding and pupping grounds during the summer half of the year, foraging extensively along the shelf break and around the submarine canyons on the pollock and squid (Lowry *et al.*

1982; Kajimura *et al.* 1984, Sinclair *et al.* 1994, Springer *et al.* 1996, Robson *et al.* 2004, Call *et al.* 2008). Steller sea lions and ribbon seals also utilize these foraging grounds during parts of the year. Platforms of Opportunity (POP) sightings from 1958-2000 show that Steller sea lion encounter rates were high along the continental shelf break throughout the Bering Sea and Gulf of Alaska (NMFS 2000, 2010).

The availability of abundant fish, squid and zooplankton resources in these offshore foraging areas is critical to all these species, and the lack of adequate prey resources is an especially acute concern for two of the region's most iconic pollock predators, the Steller sea lion (*Eumetopias jubatus*) and northern fur seal (*Callorhinus ursinus*).The protracted, decades-long decline of sea lion and fur seals in western Alaska (Fig. 39) stands in stark contrast to increasing trends for seals and sea lions from Southeast Alaska to California since the end of bounty programs and is not expected in species that have evolved life history strategies which should be expected to buffer them from drastic population responses to normal and recurrent environmental fluctuations (Merrick 1997).

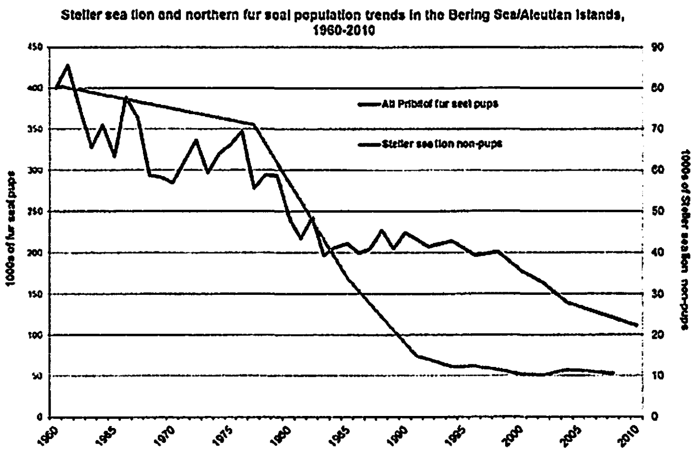


Fig. 39. Steller sea lion and northern fur seal population trends in the Bering Sea and Aleutian Islands, 1960-2010.

These trends and the accompanying declines of some of the largest nesting colonies of fish-eating seabirds in the world on the Pribilof Islands appear to indicate that a major change in the structure of the ecosystem has occurred in recent decades such that food supplies are limited or reduced and the ecosystem is no longer capable of supporting as many top predators as in the past (Merrick 1997). However, at the time of the northern fur seal listing as depleted under the Marine Mammal Protection Act in 1998, NMFS noted that there is no compelling evidence that environmental carrying capacity has declined substantially since the late 1950s to some new equilibrium level and that remains true today (NMFS 2007). Indeed, some of the largest fisheries in the world were pioneered and rapidly expanded to unprecedented levels during this same period, targeting many of the key prey species of the declining top predators. If the declining populations of top predators such as the Steller sea lion and northern fur seal are food-limited, something other than a severe decline in the environmental carrying capacity of the eastern Bering Sea is responsible, and the large-scale groundfish fisheries for pollock and important prey have long been suspected as a major factor.

The potential for conflict between large-scale commercial fisheries for pollock and large populations of pollock predators in the North Pacific was recognized thirty years ago in the final Environmental Impact Statement for the Bering Sea/Aleutian Islands Fishery Management Plan (1981), which considered the threat especially high for competing pollock predators with the greatest potential for direct competition such as the Steller sea lion and the northern fur seal (Table 13). In a 1982 report to the North Pacific Fisheries Management Council, Lowry *et al.* (1982) noted the phenomenal expansion of fishing for pollock and other groundfish from the 1950s to the early 1970s and cautioned that large-scale groundfish fishery removals may reduce the carrying capacity for competing predators. In a 2002 report to the North Pacific Council reviewing the fishery harvest policy currently employed in groundfish management, scientists concluded that a fishing strategy designed to reduce the biomass of the target stock by a large fraction could be expected to reduce the total consumption by competing predator populations by a similar large fraction, resulting in a decline in their populations over time (Goodman *et al.* 2002). More recently, in an ESA Section 7 consultation biological opinion on the fisheries and Steller sea lions, NMFS reached a similar conclusion that the fisheries are likely to lower sea lion carrying capacity (NMFS 2010).

Table 13. Relative importance of walleye pollock in the diet of pinnipeds and cetaceans in the eastern Bering Sea./a

Predators	Walleye Pollock	Fish and/or Squid	Sizes Consumed
Steller sea lion	major	major	Capable of consuming all sizes
Northern fur seal	major	major	Capable of consuming all sizes
Largha seal	minor	major	Principally <20 cm length
Harbor seal	major	major	Capable of consuming all sizes
Ribbon seal	major	major	Principally <20 cm length
Ringed seal	minor	major	Principally <20 cm length
Bearded seal	minor	major	Principally <20 cm length
Minke whale	minor	major	probably <30 cm length
Sei whale	minor	major	Probably <30 cm length
Fin whale	major	major	<30 cm length
Humpback whale	minor	major	30-40 cm length
Dall's porpoise	minor	major	Probably <40 cm length

a/ Kajimura and Fowler (1984), Apex predators in the walleye pollock ecosystem in the eastern Bering Sea and the Aleutian Islands regions, In: D.H. Ito (ed.), Proceedings of the Workshop on Walleye Pollock on its Ecosystem in the EBS. NOAA Tech. Memo. NMFS F/NWC-62.

The northern fur seal population on the Pribilof Islands rookeries, which numbered more than 2 million in the 1950s, has now declined by ~70% since 1960. The early phase of the decline can be attributed to a female culling program from 1956-1968, when approximately 300,000 females were removed from the population following complaints by Japan that fur seals were too numerous and interfering with its developing factory fisheries (York and Hartley 1981). After stabilizing for a short period from the mid-1970s to early 1980s, fur seal numbers declined to less than half of the 1950s, resulting in the eventual designation of the population as depleted under the Marine Mammal Protection Act in 1988. These trends, which have continued into the present, stand in sharp contrast to the fortunes of the pollock fishery, which has removed a cumulative total of over 54 million metric tons (nearly 120 billion lb.) from the eastern Bering Sea since 1964 (Fig. 40).

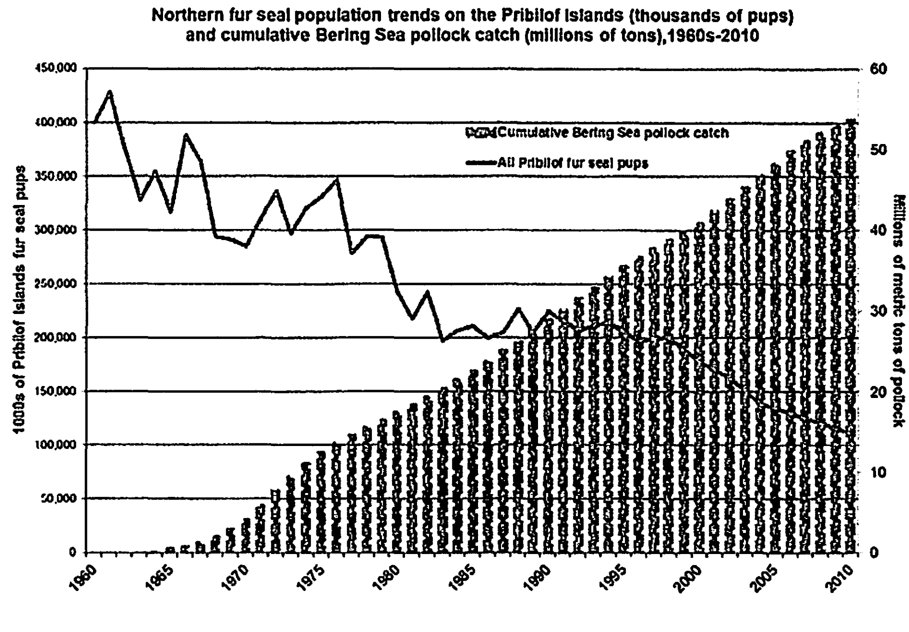


Fig. 40. Northern fur pup trend counts and cumulative Bering Sea pollock catch (millions of tons), 1960s-2010.

All past studies dating back to the 19th century and numerous recent studies have consistently found that juvenile walleye pollock and gonatid squid are the dominant prey of adult females while at the Pribilofs (Jordan et al. 1898, Fiscus *et al.* 1962, Kajimura 1984, Sinclair *et al.* 1994, Robson *et al.* 2004, Call and Ream 2012).With fur seal pup production continuing to plunge, protecting the availability of pollock, squids and other prey on fur seal foraging grounds should be a top priority. As with the Steller sea lion, fur seal reproduction is energetically expensive for the mother. Perez and Mooney (1986) calculated that the average daily feeding rate for lactating northern fur seals was 60% greater than for non-lactating females. Studies of northern and southern hemisphere fur seal species show strong links between food availability and reproductive success, and food shortages in one season may affect the pregnancy status of females in subsequent seasons, blocking estrus, terminating pregnancy, and preventing lactation (Costa *et al.* 1989, Costa 1993, Lunn and Boyd 1993).

Foraging fur seals on the Pribilofs range over large areas of the eastern Bering Sea continental shelf, shelf edge, slope and basin waters, but areas within 200-300 km from the Pribilofs are considered especially important to foraging females with pups (Robson *et al.* 2004, NMFS 2007, Call *et al.* 2008). Past analyses of pollock fishing effort in important fur seal foraging habitat indicated that the proportion of the total June-October pollock catch in fur seal foraging habitat increased sharply from an average of 40 percent in 1995-1998 to 69 percent in 1999-2000, and NMFS has acknowledged the concern that this increased fishing pressure could negatively impact lactating females from St. George Island where catch rates were consistently higher than in areas used by females from St. Paul (NMFS 2004). This area encompasses Pribilof Canyon, situated directly south of St. George.

The fishery observer data indicate that pollock catches accounted for 80% of all observed groundfish catch in Pribilof Canyon during 2000-2011. In some years pollock catches from the canyon ranged as high as 70,000-100,000 mt, although canyon catches have been variable and much lower in some years (Fig. 33, Table, Section 6.1 above). The pelagic trawl gear used in the pollock fishery is also responsible for the vast majority of squid bycatch from the canyons, which has been highest in years when pollock catches in the canyons were highest (Fig. 38, Section 6.2 above). While a prohibition on pelagic trawling in Pribilof and Zhemchug canyons will not encompass all the important fur seal foraging areas within 200-300 km of the Pribilof rookeries, it would provide substantial protection to foraging areas of the shelf break and slope utilized by fur seals and reduce the impact of the fishery on two of the top-ranked fur seal prey.

6.3 Pelagic HCAs as Tools to Reduce Seabird Incidental Takes: Short-Tailed Albatross

All three species of North Pacific albatross are closely associated with shelf-edge and canyon habitats throughout the Gulf of Alaska and Bering Sea, including the highly endangered short-tailed albatross (*Phoebastria albatrus*). Long-term sightings data indicate that the largest concentrations of short-tailed albatross are regularly found along the Bering Sea shelf edge and canyons, particularly near the heads of canyons (Piatt et al. 2006, USFWS 2008). Incidental takes of short-tailed albatross that pursue baited hooks deployed by longline fisheries pose the biggest fishing threat to recovery of the species. In 2010, two juvenile short-tailed albatross were reported as incidental takes by observers in the factory longline fishery for cod along the margins of the eastern Bering Sea shelf break northwest of the Pribilof Islands. Based on the observed takes, the total number of birds killed that year is estimated to be 15. In October 2011, another incidental take was reported in the longline fishery in reporting area 523 along the shelf break northwest of the Pribilof Islands. Prior to 2010, a total of five short-tailed albatross takes had been recorded in the Alaska longline fisheries since 1993, including at least one observed take in Zhemchug Canyon (in 1998). Telemetry tracking locations of short-tailed albatross in the Bering Sea during 2001-2011 are depicted below (Fig. 41) in brown dots, and the locations of incidental takes from 1983-2010 are shown by stars with the green star representing the most recent take. Two observed incidental takes have been reported in Zhemchug Canyon since 1983, including one in 1998.

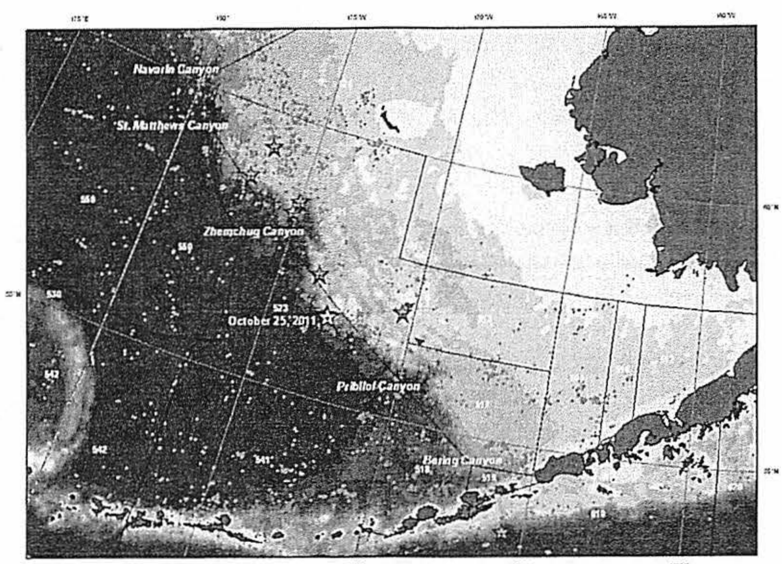


Fig. 41. Locations of short-tailed albatross in the Bering Sea during 2001-2011. Brown dots depict telemetry locations. Observed incidental takes from 1983-2010 are indicated by stars, with the green star representing the most recent take (in 2011). Sources of data: Suryan *et al.* 2006, Suryan *et al.* 2007, Suryan and Fischer 2010, http://www.fakr.noaa.gov/index/infobulletins/bulletin.asp?BulletinID=7771

The USFWS (2003) allows for an *observed* incidental take of 4 birds over any given two-year period of time in the demersal groundfish longline fishery as well as two in the halibut fishery and two in the groundfish trawl fishery. The short-tailed albatross killed in October 2011 is the first observed take in the two-year period that began on September 16, 2011. Laudable efforts by the Council and industry to adopt seabird deterrent devices have significantly reduced the takes of seabirds in longline gear from the peak mortalities of the late-1990s, but the longline groundfish fleet in Alaska continues to pose a threat to short-tailed albatross recovery. Trawl fisheries also pose a significant potential hazard and source of mortalities resulting from collisions with net wings, trawl warps and third wires, and mortalities from these sources would not be accounted for in the catch on observed vessels. Short-tailed albatross mortalities have been reported in net fisheries elsewhere, but no takes have been observed in the Alaskan trawl fisheries to date (Zador 2008). Groundfish trawl and pot fisheries are responsible for a portion of the incidental takes of other seabird species, but longline gear accounts for the great majority of all *observed* seabird takes in the Alaska groundfish fishery. During 2007-2011, Alaskan longliners accounted for about 85% of all reported seabird takes in all groundfish fishing gears over all areas, including 100% of all albatross takes (Fitzgerald 2011). Bering Sea longliners are the single biggest source of seabird mortalities in the Alaska groundfish fishery overall, accounting for 66% of seabird takes by all gears in all areas during the same period (Table 14).

Observer-reported seabird takes in longline gear in Pribilof and Zhemchug canyons averaged 3% of the total EBS-wide longline seabird take over the same period (2007-2010), but in 2009 observer-reported canyon takes of Laysan albatross (n = 6) accounted for 46% of all Laysan taken in longline gear in the EBS longline fishery that year and reported takes of black-footed albatross (n = 3) accounted for 60% of all black-footed albatross in the EBS longline fishery that year (Table 15). All three species of albatross (Laysan, black-footed and short-tailed) were identified as incidental takes in Zhemchug Canyon over the entire period from 1990-2011, including at least one observed short-tailed albatross take (3 birds total) in Zhemchug in 1998, whereas Laysan was the only albatross species identified in Pribilof Canyon. All positively identified albatross incidental takes occurred in longline gear, but trawl gear was responsible for some of the mortalities of northern fulmar, sooty and short-tailed shearwaters, black-legged kittiwakes, glaucus gulls, guillemots, auklets and murrelets that were reported in canyon fisheries.

Table 14. EBS-wide estimated seabird takes in bottom longline groundfish fisheries, 2007-2010./a

Species/Species Group	2007	2008	2009	2010
Unidentified albatross	16	0	0	0
Short-tailed albatross	0	0	0	15
Laysan albatross	4	130	13	40
Black-footed albatross	18	7	5	9
Northern fulmar	2,526	1,791	6,582	1,647
Shearwater	2,795	1,162	566	480
Storm petrel	0	0	0	0
Gull	421	1,279	808	640
Kittiwake	10	0	10	0
Murre	5	5	13	0
Puffin	0	0	0	5
Auklet	0	0	0	0
Other alcid	0	0	0	0
Other bird	0	0	0	0
Unidentified bird	445	31	122	15
Total	6,224	4,405	8,119	2,851
Percent of all seabird	60.8%	63.7%	77.8%	62.0%

a/ Shannon Fitzgerald (2011). Preliminary Seabird Bycatch Estimates for Alaskan Groundfish Fisheries, 2007-2010.

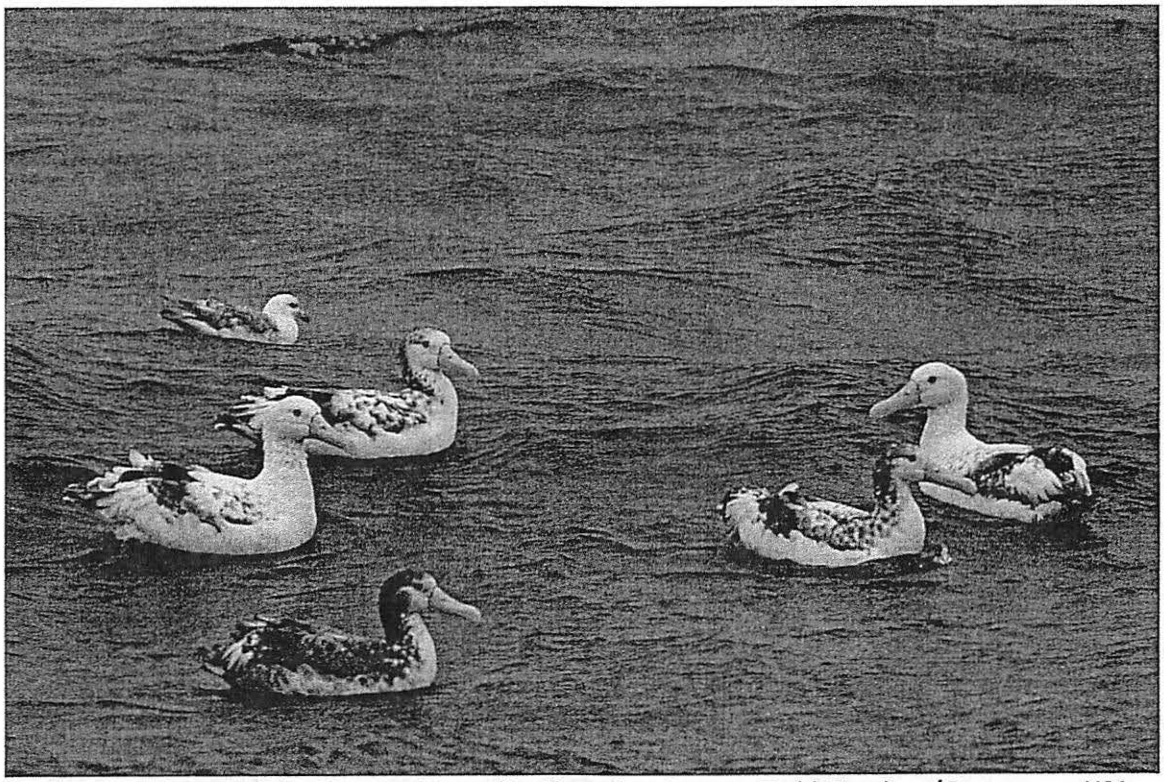
Table 15. Observer-reported seabird takes (n) in bottom longline fisheries of Pribilof and Zhemchug canyons, 2007-2010./a

Species/Species Group	2007	2008	2009	2010
Unidentified albatross				
Short-tailed albatross				
Laysan albatross			6	
Black-footed albatross			3	
Northern fulmar	122	44	187	39
Shearwater	116	40	31	49
Storm petrel				
Gull	15	12	28	3
Kittiwake				
Murre				
Puffin				
Auklet				
Other alcid				
Other bird				
Unidentified bird	3		10	
Total	256	96	255	91
Percent of EBS-wide longline seabird takes	4.1%	2.2%	3.1%	3.2%

a/ Data from NPGOP.

Highly endangered species such as the short-tailed albatross are few in number and encounter rates are low, but birds are known to concentrate in hot spots along the margins of Zhemchug, St. Matthews and Pervenets canyons, as well as Navarin Canyon on the Russian side of the Bering Sea, thus the potential for fatal encounters can be very high in localized areas (Piatt *et al.* 2006, Hunt *et al.* 2010).In one instance an estimated 200 short-tailed albatross (~10% of the total adult population) were observed near one fishing vessel in the Bering Sea (Piatt *et al.* 2006).

The true number of short-tailed albatross incidental takes in the groundfish fishery may be significantly higher than the reported numbers suggest, either because there is no observer on board a vessel to report them or because birds may drop off the hook underwater before it is hauled into view of the observer, and this unknown mortality is not factored into estimates of seabird takes in the fishery. Prohibiting the use of longline gear in addition to trawl gears in Pribilof and Zhemchug canyons would provide significant pelagic habitat protection to important seabird foraging areas where albatross and other seabirds often congregate in large numbers and where they are regularly taken in fishing gear, reducing the potential for fatal encounters on the Bering Sea shelf break and slope significantly.



Short-tailed albatross (*Phoebastria albatrus*) in Zhemchug Canyon, Todd Warshaw/Greenpeace USA

7. Summary Conclusion

Technological changes have allowed fishermen to locate fish and exploit areas which, in the past, would have been de facto refugia (Wilson *et al.* 1996, Watling and Norse 1998). The groundfish fisheries operating on the outer shelf and slope of the Bering Sea Green Belt today offer a case in point of how fishing in the past half century has expanded offshore and into depths that were out of reach to past generations of fishermen. Much of this area has been intensively fished since the arrival of the foreign factory ships in the late 1950s and early 1960s, when many whale species and many fish species such as slope rockfish, sablefish, and Greenland turbot were serially depleted in a short period of time. Benthic habitats and deep-sea corals were undoubtedly severely affected as well, although no one was monitoring those impacts. From a cumulative impacts perspective, the baseline condition of the Bering Sea Green Belt has already been adversely impacted in a variety of ways due to historical and continuing fishing impacts in these areas (NMFS 2004).

The establishment of Bering Sea Canyon HCAs would provide comprehensive protection for rare, unique and representative habitat types on the outer shelf and slope of the Bering Sea Green Belt, an area of great ecological importance that has received no protection up to now. The establishment of fully protected HCAs for Pribilof and Zhemchug canyons would address multiple FMP objectives for conservation and management of fish, mammal and bird fauna that utilize these offshore waters extensively. With respect to poorly documented deep-sea corals and other epibenthic invertebrate fauna in the region, new evidence from *in situ* observations documents the presence of previously unknown deep-sea coral and sponge species in the Bering Sea Canyons. Prohibiting the use of all bottom-tending gears in the proposed Bering Sea Canyon HCAs would provide significant protections to those living habitats while research continues to discover the full extent of those little-studied habitats.

Given how little is known about the true extent of the biodiversity in the Bering Sea Canyons or the cumulative, long-terms impacts of fishing on their representative benthic and pelagic fauna, the Council's policy should be to manage explicitly for habitat diversity and complexity *now*, while research on "essential" habitats continues (Auster *et al.* 1997). Although our scientific understanding of these unprotected marine habitats is still rudimentary in many respects, the available research clearly demonstrates the importance of the canyons as major features of the Green Belt affecting ocean circulation and nutrient transport to the shelf and harboring rare, unique and endangered fauna. A system of fully protected Canyon HCAs that *build in* refuges from fishing would provide buffers against the considerable scientific and management uncertainties associated with managing these resources sustainably for present and future generations.

For all these reasons, the Council should initiate a staff review of new and existing information in preparation for the development of a plan amendment that would include the option of establishing Habitat Conservation Areas (HCAs) encompassing the entirety of Pribilof and Zhemchug canyons, as described in this paper, with the aim of conserving the EFH of managed species, minimizing the bycatch of vulnerable non-target species, providing refuges from bottom fishing in sensitive deepwater coral and sponge habitats, and protecting the associated pelagic habitat utilized by mobile fish, seabird and marine mammal predators. The staff's analysis of HCAs should also consider the cultural importance and traditional Alaska Native subsistence uses of fish and other marine wildlife within these protected areas, as well as the benefits of establishing control areas where scientists can evaluate the responses of a fished and unfished environment over time.

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