AGENDA D-3(c)
MARCH 2007

MEMORANDUM

TO: Council, SSC and AP Members

FROM: Chris Oliver
Executive Director

DATE: March 19, 2007

SUBJECT: Habitat Conservation

ESTIMATED TIME
6 HOURS
(all D-3 items)

ACTION REQUIRED:

c) Final action on EFH AI open area adjustment

BACKGROUND:

Aleutian Island Habitat Conservation

The Council took action in February 2005 to conserve essential fish habitat (EFH) from potential adverse effects of fishing. EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. The EIS prepared for the action concluded that while fisheries do have long term effects on benthic habitat, these impacts were minimal and had no detrimental effects on fish populations. The Council adopted several new measures to minimize the effects of fishing on EFH in the Aleutian Islands and Gulf of Alaska.

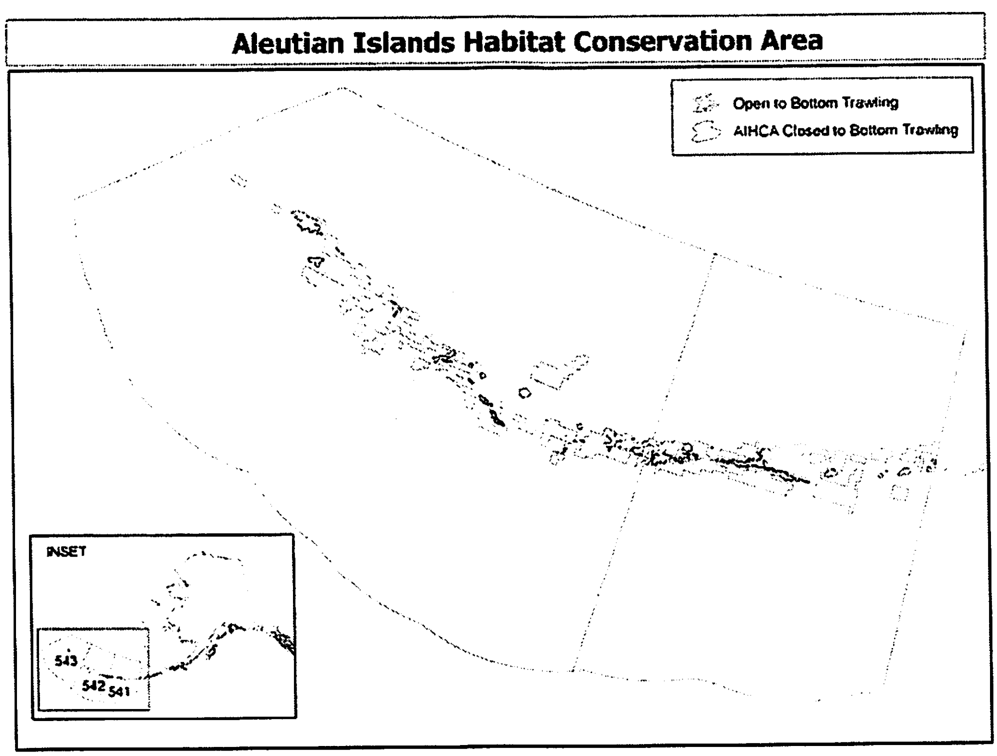
The Aleutian Island Habitat Conservation Area (AIHCA) was adopted as part of a suite of conservation measures to minimize the adverse effects of fishing in the Aleutian Islands subarea. The AIHCA prohibits the use of non-pelagic trawl fishing gear in designated areas of the AI to reduce the effects of fishing on corals, sponges, and hard bottom habitats, while allowing most fishing areas that have been trawled repeatedly in the past remain open.

During the June 2006 meeting, fishery participants requested that the open area boundaries be slightly modified to allow fishing in areas historically fished and to prevent bottom trawling in areas that have not been repeatedly fished. One location near Agattu Strait had been historically fished and was included into the closure area. A second location near Buldir Island was included in the portions of the AIHCA open to bottom trawling but has some documented presence of sponges. The proposed amendment would open the Agattu area and close the Buldir area. The Council made an initial review of the analysis in February. The analysis for final review was mailed to you two weeks ago; the executive summary is attached as Item D-3(c)(i). The Council is scheduled to take final action at this meeting.

Executive Summary

The Aleutian Island Habitat Conservation Area (AIHCA) was adopted as part of a suite of conservation measures for essential fish habitat (EFH) to minimize the adverse effects of fishing in the Aleutian Islands subarea (AI). The EFH rule became effective July 28, 2006 (71 FR 36694, June 28, 2006). The EFH action amended the Alaska fishery management plans (FMPs) to prohibit the use of certain bottom contact fishing gear in designated areas of the AI to reduce the effects of fishing on corals, sponges, and hard bottom habitats, protecting habitats from potential future disturbance without incurring significant short-term costs. The AIHCA closed most of the Aleutian Islands subarea to bottom trawling (279,114 square nautical miles). Most fishing areas that have been trawled repeatedly in the past remain open.

The designated open areas for bottom trawling were based on the analysis in the EFH EIS which summarized areas of high fishing effort from 1990 through 2003, with specific modifications based on data analysis of input from AI trawl fishermen and specific modifications to reduce those open areas to avoid coral habitat. These modifications were necessary because the observer data base has limitations on methods to document the actual path the fishers use and only records trawling start and end positions. Open and closed areas adopted under this action are shown in Figure ES-1. The closed areas are irregular in shape, and each latitude and longitude of the closure was designated in the FMP and regulations. After the proposed rule was published, careful review of the specific latitudes and longitudes of the AIHCA was conducted by participants of the fishery. Fishery participants determined that two changes to the areas described for the AIHCA were necessary to ensure the AIHCA met the intent to allow fishing in areas historically fished and to prevent bottom trawling in areas that have not been repeatedly fished. The Council recommended NMFS analyze the recommended changes and present the analysis at the February 2007 Council meeting for consideration.



ES- 1. The Aleutian Island Habitat Conservation Area (AIHCA), yellow areas, are closed to bottom trawling beginning July, 2006, implemented as part of Essential Fish Habitat mitigation action.

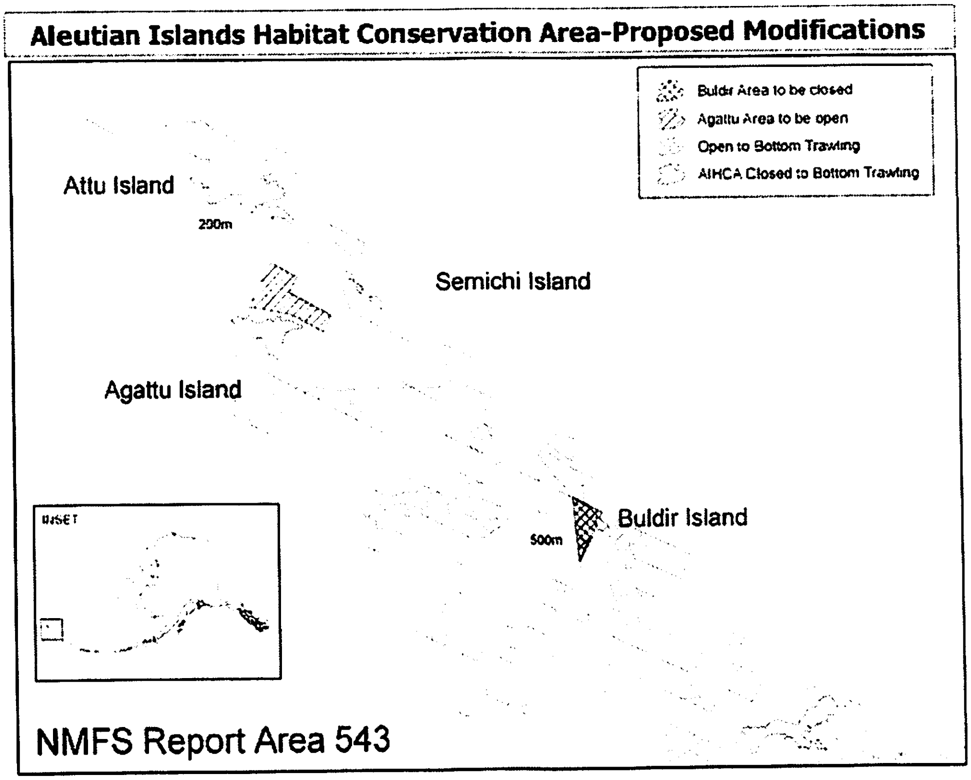
Two separate alternatives are analyzed in this EA as follows:

Alternative 1: No Action

Alternative 2: Modify the latitude and longitude definitions for open areas for the AIHCA which would effectively change the boundaries in two areas, one north of Agattu Island and one north of Buldir Island.

Proposed AIHCA Area	Latitude	Longitude	Management	NOAA Chart number	Area
North of Agattu Island	52°40.0 N 52°30.0 N 52°32.0 N 52°32.0 N 52°36.0 N 52°36.0 N 52°40.0 N	173° 25.0 E 173° 25.0 E 173° 40.0 E 173° 54.0 E 173° 54.0 E 173° 36.0 E 173° 36.0 E	Remove from AIHCA closure (area will now be open)	530_1	128 nm^2 or 383 km^2
North of Buldir Island	52°24 N 52°24 N 52°12 N	175°42 E 175°54 E 175°54 E	Add to AIHCA (area will now be closed)	530_1	50 nm^2 or 149 km^2

Table ES-1.1-1 Name, location and area pf proposed AIHCA changes (Alternative 2)



ES- 2. Proposed modifications of the AIHCA under Alternative 2. Yellow areas are closed to bottom trawling and the green areas are opened.

The analysis of direct, indirect and cumulative effects for the proposed action indicated no significant impacts on the human environment from the alternatives. The status quo provides EFH protection measures that provide habitat protection for vulnerable benthic habitat by bottom trawl closures. Thus Alternative 1 is not likely to result in any significant effects regarding habitat, target species, non-target resources, protected species or the ecosystem. The impacts of Alternative 2 likely are similar in magnitude to Alternative 1 due to the slight size change of the boundary areas and the trade off between the open and closed areas from an environmental perspective in terms of protecting fragile coral and sponge habitat. Additionally, Alternative 2 would provide some economic benefit to the fishery.

The proposed open area north of Agattu Island will likely cause an insignificant impact to habitat since the area has been historically fished for years according to industry sources, and fishing is of limited duration in the spring, Although some coral has been documented near Agattu Island these coral locations do not intersect with the proposed modified open area.

The proposed closure of the Buldir Island location is currently outside the AIHCA. This area contains both corals and sponges documented both by NOAA Fisheries as well as anecdotal information from local fishers.. This vulnerable habitat is an example type of habitat of that may be affected by fishing gear. A closure of this area would result in a slight positive effect on habitat since no potential bottom trawling would occur in the area.

Because Alternative 2 may protect areas of known coral and sponge occurrence, Alternative 2 may be more protective of habitat than Alternative 1. The remaining resource categories have similar effects as Alternative 1. By prohibiting bottom trawling in locations where coral and sponge occur, Alternative 2 may result in less mortality or damage to living substrate than Alternative 1. Based on available data of coral and sponges occurrence, protecting the Buldir Area under Alternative 2 may be more protective of benthic diversity and habitat suitability than Alternative 1.

AGENDA D-3
Supplemental
APRIL 2007

Bering Sea Habitat Conservation Gear Modification Implementation

Prepared by Melanie Brown, NMFS Alaska Region (AKR) Sustainable Fisheries Division (SF)
March 21, 2007

Background

This document describes a potential implementation program for gear modification under the Bering Sea Habitat Conservation action being considered by the North Pacific Fishery Management Council (Council). Alternative 3 of the Council's December 2006 motion for this proposed action states that gear modifications would be required for all flatfish fishing in the Bering Sea. Discs or other elevating device (e.g. bobbins) would be required to be installed on the sweeps to reduce seafloor contact and/or increase clearance between the gear and the substrate (Fig. 2). A performance standard of at least 2.5 inches elevation of the sweep from a flat surface adjacent to the elevating device as the sweep is stretched out on the surface would be required. Spacing of the elevating devices installed on the sweeps would be within an interval of 25 to 35 feet based on the most recent research, but this spacing may increase based on new research results available in May 2007.

While not part of the trawl net, sweeps are part of the trawl system used to herd fish into the trawl. In a typical flatfish trawl, sweeps extend from the aft end of the door bridles back to the forward end of the wing extensions (Figure 1). On most trawl vessels, when the trawl is onboard the vessel, the trawl net is wound onto the net reel on top of the sweeps. On vessels using 200 fathoms of sweeps, which is likely the maximum amount of sweep used for flatfish fishing, more than 35 elevating devices on each side of the trawl would need to be installed to meet the spacing requirement. This totals to 70 elevating devices and spaces that may need to be checked to determine if the requirements are being met. Practically, the sweeps are much too long to be completely stretched across a vessel deck. A detailed, onboard inspection would require examining the sweep by sections while stacking the remainder, putting it onto another net reel (if available), or while the net is being set or hauled. Sweeps are constructed by the fishers using sections provided by the manufacturer. Spare sections and parts are usually carried on the vessel.

A few flatfish catcher processor vessels in Alaska do not have net reels and wind the sweeps onto the main deck winches over the top of the trawl main wire (Jeff June, personal communication, January 9, 2007). The Fishing Company of Alaska boats and the F/V Seafisher currently are the only flatfish trawl vessels without net reels, and those boats are among the largest in the trawl non-AFA catcher-processor fleet (H&G fleet). All other vessels in this fleet have net reels including the smallest ones. For these vessels, the net has to be deployed or stacked onto the deck to access the sweeps.

To establish a requirement for modified trawl sweeps for the directed flatfish fishery in the Bering Sea, requirements for using the gear and performance standards for the gear must be stated in the regulations. NMFS would need to establish a method of ensuring that vessel owners and operators comply with the gear requirements. The program should ensure the gear is properly constructed, used, and maintained. Manufacturers, fishers, and personnel from the Alaska Fisheries Science Center (AFSC), NOAA Office of Law Enforcement (NOAA OLE), North Pacific Groundfish Observer Program (NPGOP), Sustainable Fisheries (SF) and USCG would need to develop and implement the program. This requirement may apply to approximately 207 vessels based on the number of license limitation program permits with BS trawl endorsements issued in 2007. Not all of those 207 vessels currently fish for flatfish, and the expected number of vessels that would be affected by this proposed regulation is approximately 30.

Potential Regulation Changes:

Several regulations in 50 CFR part 679 would need to be revised to implement a modified trawl sweep requirement.

1. New definitions under § 679.2 should be added for a non-pelagic trawl sweeps and other trawl components and for directed fishing for flatfish for purposes of the gear modification requirement.

§ 679.2 Definitions

* * * *

Bridles means the lines connecting the trawl sweeps to the net or the doors on a non-pelagic trawl.

* * * *

Directed Fishing for Flatfish means for purposes of non-pelagic trawl restrictions under § 679.22 (X) and gear modification requirements under §§ 679.7(c)(3) and 679.24(f), fishing with non-pelagic trawl gear during any weekly reporting period that results in a retained aggregate amount of yellowfin sole, rock sole, Greenland turbot, arrowtooth flounder, flathead sole, Alaska plaice, and other flatfish that is greater than the retained amount of any other fishery category defined under § 679.21(e)(3)(iv).

* * *

Sweeps means the lines connecting the door bridles to the net bridles and wing extensions on a non-pelagic trawl.

* * * * *

2. A new subparagraph (3) also would be added to § 679.7(c) to prohibit directed fishing for BS flatfish without sweeps that meets the standards specified at § 679.24(f).

§ 679.7(c)(3) Conduct directed fishing for flatfish as defined in § 679.2 in any reporting area of the Bering Sea as described in Figure 1 to this part without meeting the requirements for the non-pelagic trawl sweeps specified in § 679.24(f).

3. To establish standards and requirements for the use of modified non-pelagic trawl sweeps, add paragraph (f) to § 679.24 Gear Limitations.

§ 679.24 Gear Limitations

* * * * *

§ 679.24(f) Non-pelagic trawl sweeps for directed flatfish fishing in reporting areas of the BS, as described in Figure 1 to this part.

(1) Vessel owner or operators using non-pelagic trawl gear for directed fishing for flatfish must have elevating discs, bobbins or similar devices installed on the sweeps that raise the sweeps at least 2.5 inches (6.35 cm), as measured adjacent to the device when resting on a hard, flat surface, regardless of device orientation. Elevating devices must be secured along the entire length of the sweeps at the spacing specified under subparagraph (2). The largest cross-section of the sweeps between elevating devices shall not be greater than at the nearest measurement location. Wider

cross-sections resulting from doubling the line back for section terminations and devices required to connect sections are exempt from this requirement.

(2) The distance between elevating devices on the sweep must be between 25 feet (7.62 m) and 35 feet (10.67 m), unless the Regional Administrator specifies an alternative spacing that is at least as effective at elevating the sweep and minimizing contact with the sea floor.

Paragraph 2 may not work and may need t o use 25-35 feet only in combination with paragraph 1. Dr. Craig Rose is doing additional research on the effective distance and may have results by May 2007 that could be used for the final action in June. The goal is to increase the distance as long as the increased spacing results in sufficient clearance in order to achieve the benefits attained in Dr. Rose's sweep modification studies. If the increased spacing is effective in terms of providing sufficient clearance, the expectation is that benthic protection would be increased due to further reduction in seafloor contact

Implementation Program:

Responses to questions regarding gear standard programs were received from three of the five other NMFS regions. Each region responding has some form of gear standard that had to be met. Program implementation essentially is through performance standards in the regulations and ensuring compliance through inspections. No pre-approval or certification programs were used. Fishers improved compliance with the standards in a year or two after implementation, especially after one or more citations were issued for failure to comply. It appears that this model (like the seabird avoidance gear model in Alaska) is likely the most effective and less resource intensive for the agency than a pre-approval or certification program.

The implementation of a trawl sweep program will involve manufacturers, fishers and NMFS, NPGOP, USCG, and OLE personnel. The fishers will be responsible to ensure their sweep meets the standards, and this will be randomly checked by several methods. An at-sea observer may observe the deployment or retrieval of the net to determine the presence or absence of the modified sweep. The OLE would be notified if it appears that the sweep may not meet the standard and may follow up with a more intensive dockside inspection. The USCG may conduct at sea inspections to determine if a modified sweep is present and if it meets the standards. The procedures to be used by each organization will need to be developed and personnel trained before implementation of the gear modification requirement.

It is likely that many fishers will purchase the sweep components and do the assembly, including installation of elevating devices. The gear also is likely to receive wear during use, requiring at sea repairs to elevating devices and potential replacement of sweep sections. It is possible that the sweep bought at the beginning of the year may not be exactly the same as the sweep present during an inspection. For these reasons, approval at the beginning of the fishing season may not be sufficient to determine compliance with the standards. The manufacturer could provide written assurance with the sweeps that they manufactured meets the standards. This manufacturer's warranty may be helpful to inspection personnel early in the fishing year or for new gear.

The following are steps and considerations that need to be addressed to design the implementation program.

1. Work with manufacturers to construct sweeps that meet the standards.
    a. Contact all known manufacturers of flatfish trawl sweeps. (Completed by John Gauvin 3/07)

b. Meeting with industry, NMFS NPGOP, AFSC RACE, NOAA OLE, USCG and SF to review standards and determine if any difficulties or issues need to be resolved. Discuss methods to ensure sweep components are manufactured in a way to visually determine compliance. Need to determine if elevating devices are properly spaced on the sweeps and if the elevating device can give the required 2.5 inches clearance of the sweep from the bottom. (Meeting held at Dantrawl on 3/14/07, notes from the meeting below.)

2. Provide training to fishers to ensure they are obtaining and maintaining sweeps to meet the standard. Could AFSC do this or could a contract be used?

3. Work with NPGOP, OLE, NMFS SF, and USCG on implementation of program
   a. Where can each organization participate in checking compliance?

      i. Observers may watch sweep during retrieval or deployment to see if elevating devices are present and appear to be in the right location. Use spot checks. May be accomplished by either markings on the sweeps or markings on the deck of the vessel.

      ii. OLE staff check presence of modified sweeps on board during dock side inspection. Compare presence of modified gear with catch and fishing location. If notified of potential problems, inspection may be more intensive to determine if standards are met.

      iii.
      NMFS SF staff work with manufacturers to build sweeps to standards. NMFS SF staff may also check for presence of modified sweep during scale inspections on vessels.
      USCG performs onboard inspections to check for presence of modified sweeps.

   b. Need to address enforcement concerns and develop inspection protocol:

      i. What happens if the vessel is fishing, and it is discovered that the sweep doesn't meet the standard for a variety of reasons? Is one missing elevating device as bad as several? If elevating device spacing is not consistently 25-35 feet, is that a problem? When would a vessel be required to stop fishing?

      ii. OLE, NPGOP, USCG, and NMFS SF will need to work with the fishing industry to develop workable standards to effectively and reasonably enforce the gear modification requirements, taking into account wear and tear of the sweeps. Field criteria could be developed to establish when a violation may occur.

Results of the 3/14/07 Meeting with NMFS, USCG and Industry Regarding Modified Trawl Sweeps

A meeting was held at Dantrawl, Inc. in Seattle on March 14, 2007 to discuss the potential sweep modification requirement for the flatfish fishery. The meeting was attended by personnel from two flatfish trawl sweep manufacturers (all 4 sweep manufacturers that currently make flatfish nets for the Bering Sea fleet were invited by John Gauvin), fishing industry representatives, AFSC research and observer program staff, USCG, NOAA OLE, and NMFS SF. John Gauvin of Gauvin and Associates organized the meeting.

Attendees	Affiliation
Craig Rose	AFSC
Carwyn Hammond	AFSC
Jennifer Ferdinand	AFSC NPGOP
JR Osuga	Cascade Fishing
Tim Meintz	Cascade Fishing
Todd Loomis (by phone)	Cascade Fishing
Phil Dang	Cascade Fishing
Paul Pedersen	Dantrawl Inc
Elias Olafsso	Dantrawl Inc
Lori Swanson	Groundfish Forum
John Gauvin	Head and Gut Workgroup
Melanie Brown	NMFS SF AKR
Koji Tamura	Nets
Steve Patterson	Nets
John Adams	Nets
Michael Killary	NOAA OLE
Mitch Hull	Ocean Peace
Jody Nummer	USCG

Below are the issues identified regarding the construction of a sweep that would meet the proposed standards for spacing and elevation.

1. Can the sweep be marked so that one could easily see if the elevating devices are spaced as required?

The participants determined that it would be possible to mark the sweep with paint or tape at the appropriate intervals. There are concerns that tape or paint may wear. It also may be possible to insert a chain between sweep components where an elevating device should be installed so that the absence of the device could be easily detected. This could reasonably be done every 90 feet, since sweeps are often manufactured in 90 foot sections. Mandating chain every 30 or 45 feet is not reasonable as it would double or triple the amount of hardware (thimbles, hammerlocks, swedging sleeves, etc) and increase the amount of wire needed due to increased splices or swedges.

Another potential method for checking the spacing of the elevating devices is to mark the vessel deck, trawl alley or trawl way fence where the sweep is brought back onto the vessel. This method may work better for larger vessels without an aft reel and would reduce concerns for the markings possibly wearing off the sweeps after use.

2. Can the elevating devices be manufactured so one could easily see if they have worn to the point of not providing the elevation necessary to meet the standards?

The participants determined that the bobbins used on the combination sweep line could be notched such that it would indicate if wear has made the device not meet the standard. On cookie sweeps, the discs could have 3 evenly spaced holes drilled into them so that reaching the holes through wear would show that the discs no longer provide the necessary elevation to meet the standard.

The goal is to provide the crew, observers, OLE, and USCG a quick visual method to determine if an elevating device is not meeting the standard and may need replacing.

3. **Should any distance from the footrope be exempt from the need for elevating devices?**

The original proposal for the gear modification would have provided an exemption from having elevating devices for the section of the lines within 25 fathoms of the footrope.

The participants reviewed the construction of the trawl, including the attachment of the doors and net to the sweeps by the use of bridles. The bridles are likely to be plain steel cable, except for the bottom bridles on the net, which may have a protective covering. Bridles connecting the net to the sweeps may be from 15 to 30 fathoms long. It was determined that because the bridles are a small portion of the entire trawl which has contact with the bottom, and the fishers may need to use different size bridles, it would be more practical and still effective to limit the requirements for the elevating devices to only the sweep components of the trawl. Therefore, bridles should be exempt from the portion of the gear where elevating devices are required. The elevating devices would be required on the sweep spanning from the point where the bridles come together between the trawl doors and the net.

4. **Can the modified sweep fit on the reels and can it be wound level?**

The participants were concerned that some vessels may not have the reel capacity to handle modified sweeps because their current trawl system takes up nearly all the room on their net reel. Also, for vessels without net reels, problems may occur with the elevating devices getting hung up on the level wind device on their main winches as the sweep is wound on the main winches. The flatfish fleet is working with gear manufacturers and Dr. Craig Rose to evaluate the amount of additional space the modified discs take on net reels that are already close to capacity. For vessels with net reels that may not have sufficient space, one remedy would be to cut back on the amount of sweep used by the vessel. This would be expected to reduce the vessel's area swept per tow relative to prior to the sweep modification and could reduce catch rates proportional to the reduction in sweep used. Alternatively, vessels could install larger net reels or work with gear manufacturers to find bobbins or discs that achieve the standards of the regulation while taking up relatively less space on the net reel.

For vessels without net reels, vessel owners are working with Dr. Rose and trawl system engineers to come up with elevating devices that slip through the level wind devices on trawl winches without damaging the discs or level winds. Preliminary work in this area indicates that elevating devices can be used on vessels without net reels. If further evaluation indicates otherwise, vessels without net reels would have to install sweep winches to handle the modified sweeps.

Vessel owners also are concerned that the elevating devices could cause the sweeps to wind unevenly on the net reel, resulting in an uneven circumference on the reel. This causes one side of the net (the side wrapping around the larger circumference) to come in faster than the other side. This can result in damage to the gear if the net or its components experience uneven stress during haulback or while on the net reel.

These issues are being tested now on a several vessels to determine the nature of any problems and potential solutions.

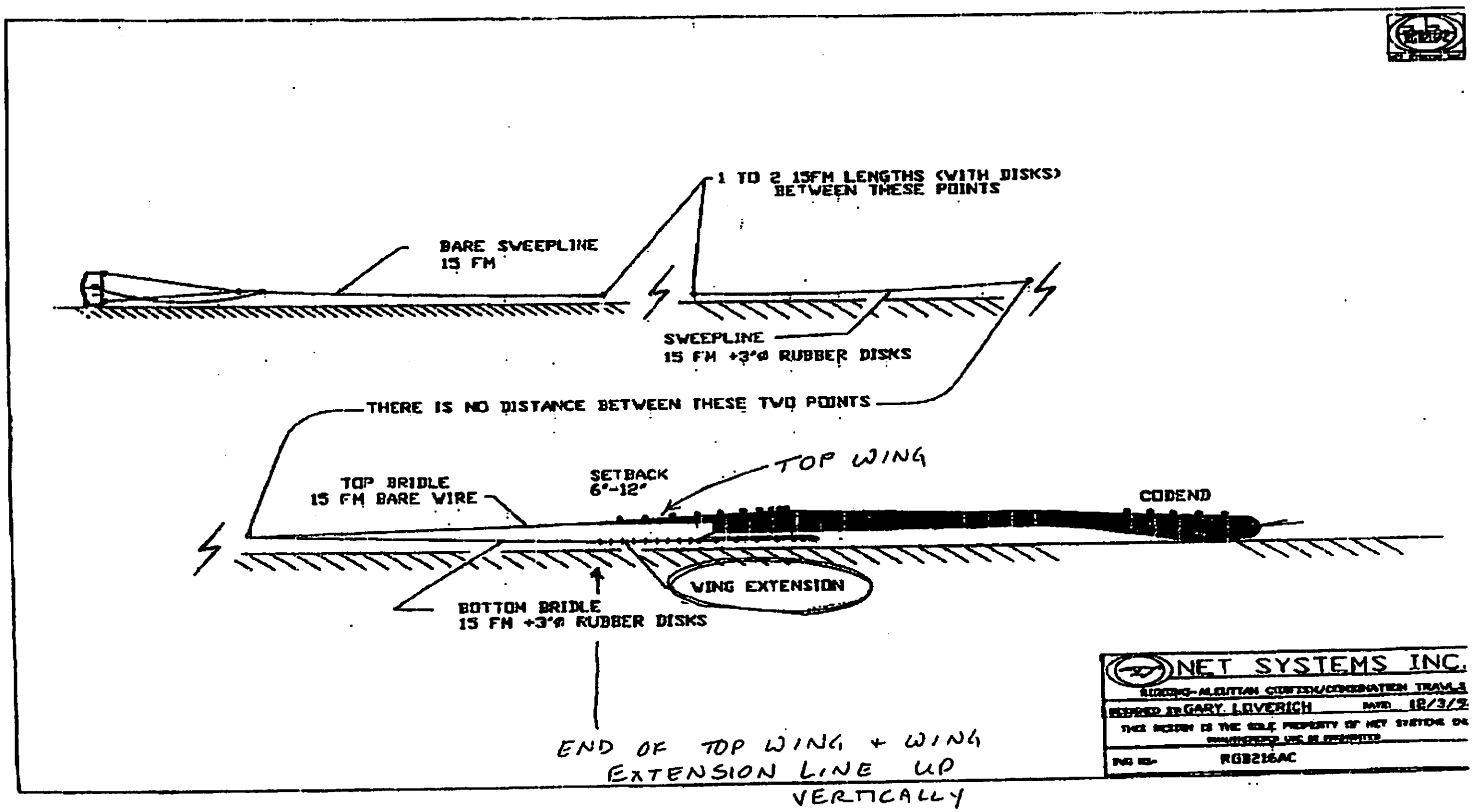


Fig. 1 Non-pelagic Trawl (Source: Use by permission from Steve Patterson, NET Systems, Inc. March 21, 2007)

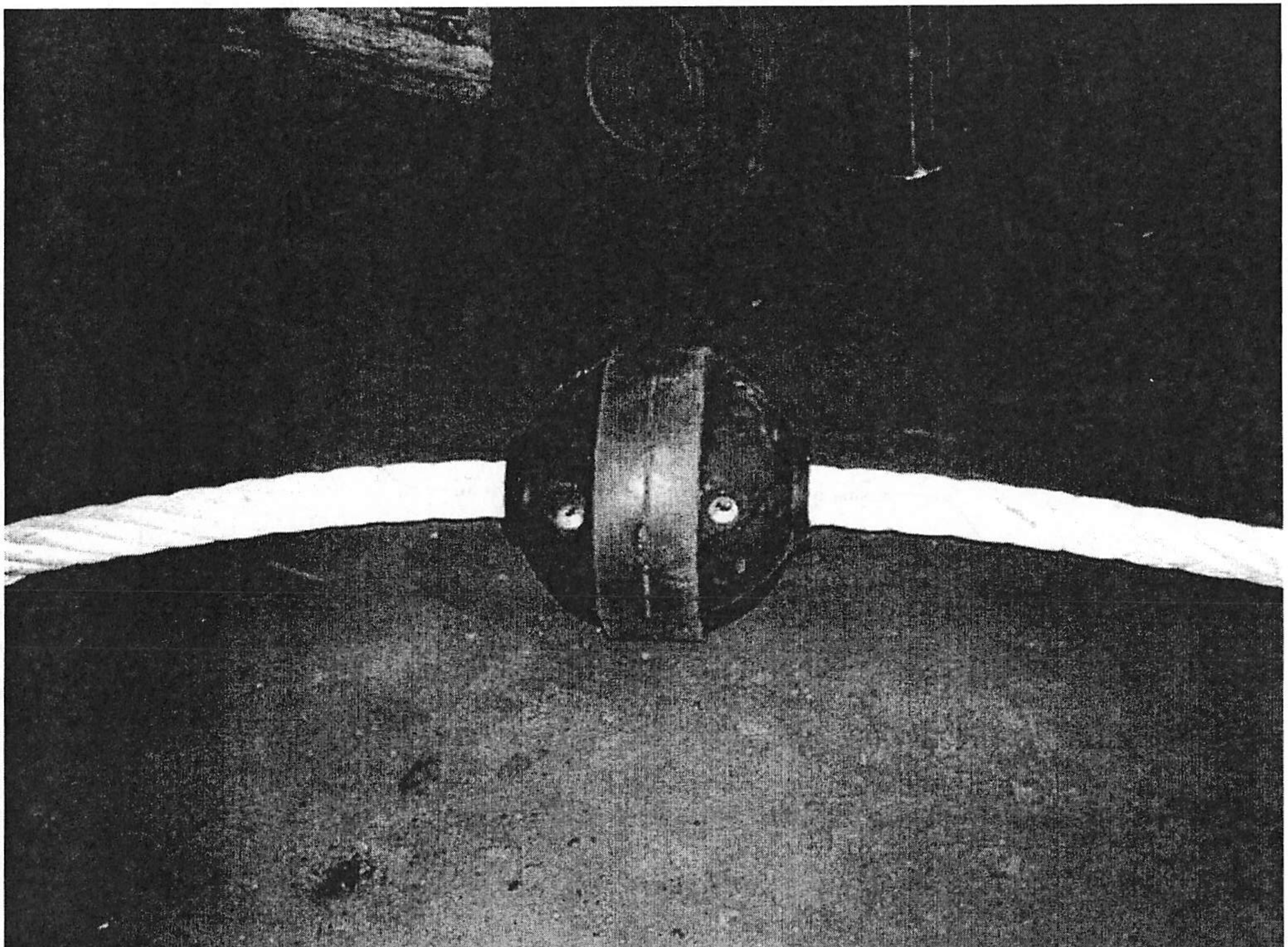


Figure 2. Example of an elevating device. Bobbin on combination line sweep. (Source: Dantrawl, Inc. March 2007)

AGENDA D-3
Supplemental

APRIL 2007

A Review of Scientific Information Related to Bering Sea Canyons and Skate Nursery Areas

Prepared for the North Pacific Fishery Management Council
by the Alaska Fisheries Science Center

18 November 2006

Table of Contents

Background

The North Pacific Fishery Management Council ("Council") is one of eight regional councils overseeing management of the Nation's fishery resources. One of their specific responsibilities is compliance with provisions of the Magnuson-Stevens Fishery Management Act related to essential fish habitat (EFH). EFH is broadly defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". The mandate includes a requirement to "encourage the conservation and enhancement of such habitat". The Council is currently developing a list of alternatives to be analyzed in an Environmental Assessment for Bering Sea habitat conservation measures.

The Alaska Fisheries Science Center (AFSC) was contacted 25 October and asked to produce a white paper summarizing current scientific information on Pribilof, Middle (actually Pervenets)[1] and Zhemchug Canyons in the eastern Bering Sea (EBS), as well as skate nursery areas in the EBS. This document addresses the specific requests considered most relevant for the Council action:

1. Summarize AFSC research conducted in these areas and the principal findings;
2. Identify specific locations of AFSC sampling or dive surveys in these areas;
3. Document AFSC videos of these habitat features;
4. Summarize other available information regarding the ecology of these areas and their use by commercially important species;
5. Provide a qualitative assessment of the habitat value of these areas for managed species and their susceptibility to disturbance; and
6. Provide a list of pertinent scientific and technical references.

Because of time constraints, the document has been structured as an inventory of available data and information that are applicable to a thorough review and evaluation of the Proposal. Various database queries and GIS projects generated to produce these results have been archived.

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[1] Close examination of Figure 6 in the OCEANA public testimony indicates the Middle Canyon closure boundary actually encompasses Pervenets Canyon, which is located due west of St Matthew Island and to the north of Middle Canyon (canyon head located at 58° 37' N, 176° 45' W). For clarity, Pervenets Canyon is used in this document to refer to this area.

AFSC Research on Skate Nursery Areas

The goal of this research is to understand skate nursery dynamics and the physical and biological parameters that support successful skate reproduction. These nurseries are recent discoveries and it is presently unknown how many of these areas exist. To date six skate nursery sites have been identified in the eastern Bering Sea. All sites occur along the shelf-slope interface between 150 and 400 meters in depth and are associated with slope canyon areas and areas of significant upwelling. Three sites for the Alaska skate *Bathyraja parmifera*, two for the Bering skate *B. interrupta* and one for the Aleutian skate *B. aleutica* have been located and investigated in years 2004 and 2006.

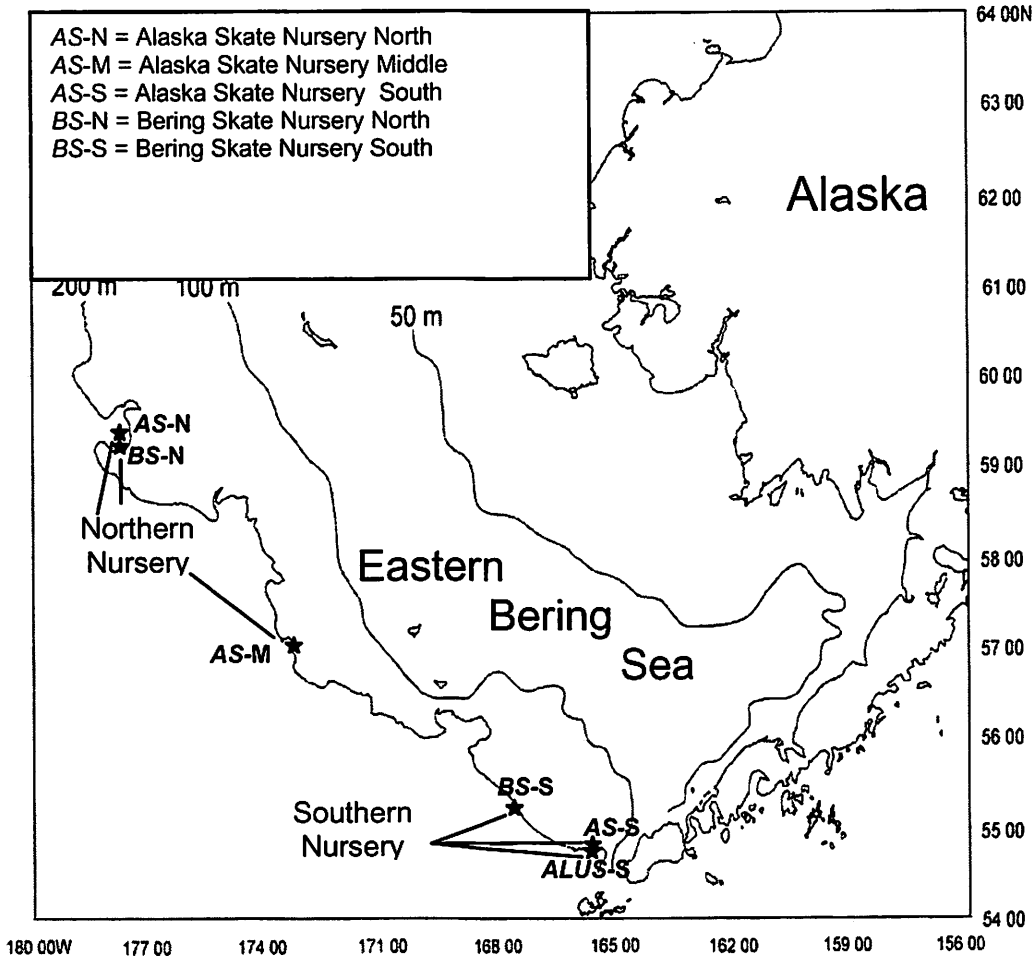
Each site has been explored using bottom trawls to determine the density of egg cases, the extent of the nursery sites, mortality sources to young skates and distinguishing abiotic features of the site that may define essential fish habitat. Two sites, that of the Alaska and Aleutian skates in the south EBS near Unimak Pass have been studied on a seasonal basis to determine timing of egg deposition and hatching as well as seasonal use of the nursery site by predator species.

Details of the Alaska Skate nursery site in the southern EBS have been synthesized in a final report to the North Pacific Research Board (Appendix 1) and are the focus of Gerald Hoff's PhD dissertation, which is currently in draft form. The final dissertation will be available for distribution in late January of 2007. A synthesis of the six nursery sites will be presented in a manuscript that will be available in February of 2007.

All nursery sites show similar characteristics and at this point Hoff feels that many biological and physical processes can be generalized for the six known EBS skate nursery sites:

1. Nursery sites are single species and used over multiple years.
2. Nursery sites are small in area (<2 km^2) with high densities of eggs.
3. Nurseries occur along the shelf-slope environment which may provide many physical and biological features that maximize skate production.
4. Nurseries are used exclusively by mature and developing embryos with other life stages rarely found in nurseries.
5. Embryo development time is long (>3 years) with multiple cohorts developing within the nursery at the same time.

6. Embryos and newly hatched juveniles are susceptible to mortality due to snail and fish predators.
7. Nursery sites may be vulnerable to disturbances from trawling due to the protracted embryo development time, limited habitat area, and low annual productivity of the species.



Map of the six skate nursery sites in the eastern Bering Sea.

AFSC Research in Bering Sea Canyons

Scientific research in the Bering Sea canyon areas by the Alaska Fisheries Science Center is limited to three opportunistic studies in and around the Pribilof Island Area. Two of the studies use data from a pair of cruises aboard NOAA ship *Miller Freeman* which was engaged in a multidisciplinary study of the frontal region near the Pribilof Islands. Summary statements for each of these studies follow.

Rockfish – sea whip associations

Brodeur (2001; Appendix 2) reported on one aspect of a larger multidisciplinary study of fish - zooplankton interactions in and around Pribilof Canyon, a large canyon with depths ranging from 130 – 3200 m. Sampling with a variety of devices was concentrated at the head of the canyon.

Sampler	Deployments	Maximum Depths (m)
CTD[2]	3	246, 256
Light levels[3]	unspecified	unspecified
ROV with color video[4]	7	184-243
Bottom trawl[5]	5	200-248
Acoustic transect[6]	4	230-264
Methot midwater trawl[7]	2	214, 234

Bottom water temperatures in the study area were generally 4-5° C. Illumination levels at 200 m were 4.3 x 10^{-6} μEs^{-1} m^{-2} (day) and 6.2 x 10^{-7} μEs^{-1} m^{-2} (night) and were considered very low however suitable for feeding by planktivorous fish.

The ROV revealed a seabed of compacted mud and silt with little geological relief, except for occasional rocks and small boulders. Five of seven ROV dives encountered dense, evenly spaced

[2] Sea-Bird model SEE-9
[3] In situ light levels recorded at several stations using an International Light IL-1700 Research Radiometer.
[4] Super Phantom II ROV on a 300 m umbilical, with a color CCD video camera recorded on Hi-8 tapes.
[5] Nylon Nor-eastern bottom trawl with roller gear and 1.5 m x 2.1 m steel doors.
[6] Simrad EK-500 calibrated echosounder at 38kHz and 120 kHz (7° beam width)
[7] 5 m^2 opening with 13cm – 8.9 cm mesh sizes, and a 3.2 cm liner in the codend.

1-2 m high stands of sea whips (*Halipteris willemoesi*) along the central and western flank of the canyon. Hundreds of mature adult rockfish were observed in these "forests" at night, or just above them during the day. Other species of groundfish were also observed but with no apparent affinity for the sea whips. Lower densities of rockfish were observed in large sea whip beds with some non-upright specimens. Neither rockfish nor sea whips were observed during the two easternmost and shallowest (181-224 m) ROV dives.

The bottom trawl captured 16 species of groundfish, with Pacific ocean perch, arrowtooth flounder and Pacific cod most abundant. Invertebrate catches were probably small due to the roller gear and, although taxa such as sea whips were collected, invertebrates were not quantitatively assessed due to anticipated losses through the trawl meshes. King crabs (*Paralithodes* spp.), large anemones (*Metridium giganteum*, *Urticinal* spp.), and large basket stars (*Gorgonocephaluseucremis*) were observed during ROV dives.

Acoustic transects along the shelf break and across the axis of the upper canyon detected substantial aggregations of large scatterers within 10 m of the seabed with smaller scatterers above and occasionally overlapping them. Based on theoretical scattering models, the large scatters were thought to be rockfish (or cod), while the smaller scatters could have been either euphausiids or gelatinous zooplankton.

Macrozooplankton and micronekton in the Methot trawls were dominated by euphausiids (primarily *Thyanoessa inermis*), which accounted for 87% (1995) and 98% (1996) of the total catch.

Taken together, the findings are interpreted that rockfish rest in sea whips at night and reside above them during daylight hours possibly feeding on euphausiids. The paper concludes the following:

1. "This study is the first to show the importance of the Pribilof Canyon in general and the sea whip 'forest' in particular as a distinctive habitat for adult Pacific ocean perch in the Bering Sea".
2. The sea whips in this region may provide important structural habitat for Pacific ocean perch in an otherwise featureless environment."

3. Because sea whips may be slow-growing and long-lived, "...fishing operations that disturb the bottom and uproot the sea whips may have a lasting effect on the rockfish population inhabiting this region."

Age and growth of sea whips

Wilson *et al.* (2002; Appendix 3) examined age and growth of the sea whip, *Halipteris willemoesi*, using measurements obtained from the axial rod endoskeleton of 12 colonies. The colonies were selected from two trawl samples in the EBS. The colonies were divided for analysis into three size classes (four colonies each), based on length of the axial rod. The largest colonies came from the northwestern head of Pribilof Canyon (56°16.8' N, 169°25.8' W; 248 m depth; 3.5° bottom temperature), while the "small" and "intermediate" classes were collected on the shelf to the northwest (56°16.8' N, 169°25.8' W; 248 m; 2.0° C.). Age and growth rates were estimated based on an assumption that growth ring couplets visible in thin cross-sections of the axial rod represented annuli. Annuli were counted, and axial rod lengths and diameters were measured to estimate colony ages and annual growth rates.

Group	Size (cm)	Mean ± Standard Error	
		Age (yr)	Growth Rate (cm yr^{-1})
Small	25–29	7.1 ± 0.7	3.9 ± 0.2
Medium	98-130	19.3 ± 0.5	6.1 ± 0.3
Large	153-167	44.3 ± 2.0	3.6 ± 0.1

A predictive age model was developed using the average annual increase in maximum diameter of the axial rod ($R^2 = 0.99$). However, growth rates and corresponding ages could not be validated using two different radiometric methods and alternative methods were suggested for future studies. The authors conclude that:

1. "Growth in total rod length is slow at first, fastest at medium size, and slows toward maximum size, with an estimated longevity approaching 50 years."
2. "...the longevity of these organisms and the biogenic habitat they may provide to other species makes it essential that fishing-related impacts be studied in detail."

Habitat associations of fish and crab

Busby *et al.* (2005; Appendix 4) analyzed 45 ROV dives conducted in the Pribilof Island area of the eastern Bering. Seven of the dives were in Pribilof Canyon and were the basis for the Pacific ocean perch – sea pen analysis by Brodeur (2001).

ROV Dive	Date	Time (GMT)	N. Latitude	W. Longitude	Depth (m)	
					ROV	Bottom
12	9/17/1995	4:06	56.30	-169.44	203	203
13	9/17/1995	11:44	56.29	-169.46	211	211
25	9/24/1995	3:47	56.31	-169.68	209	209
26	9/24/1995	10:41	56.28	-169.60	184	184
27	9/24/1995	22:16	56.29	-169.30	197	197
3	9/10/1997	23:22	56.28	-169.43	243	243
4	9/11/1997	5:41	56.28	-169.43	234	234

These two studies are based on sampling from NOAA ship *Miller Freeman* during 9-26 September 1995 and 8-18 September 1997. The primary objective of the Busby *et al.* analysis was to describe small-scale habitat associations of demersal fish and crabs using underwater video collected with an ROV. Secondarily, the study evaluated video as a survey tool by comparing observed species compositions with those obtained in coordinated bottom trawl samples. Similar to Brodeur (2001), sampling sites were chosen to represent different hydrographic regimes that supported the primary mission focus on frontal regions in the area. Contrary to Brodeur's emphasis on rockfish and canyon locations with sea whips, pleuronectid flatfish (primarily the northern rock sole *Lepidopsetta polyxystra*) were the most frequently observed taxa, and the majority of Busby's observations occurred on silt bottoms with no cover.

Overall, 42 taxa representing 16 families of fish and 8 taxa from 3 families of crabs were observed. Statistical analyses with six habitat classes revealed some species showed clear substrate preferences (e.g. yellowfin sole *Limanda aspera*; snow crab *Chionoecetes opilio*), while other taxa associated with multiple habitat types (e.g. walleye pollock *Theragra chalcogramma*; Korean horsehair crab *Erimacrus isenbeckii*). Most rockfish were associated with rocky outcrops or biogenic structure, and rock sole were frequently observed swimming along troughs in seabed waves. Eight color plates included in the paper show species in their common habitats.

Statistical analyses also indicated significant differences in species composition among habitats and depth intervals. Finally, there was significant correlation between species composition and ranked abundances of taxa from the ROV observations and bottom trawl pairs. Several dives at the head of Pribilof Canyon showed "silt throughout the center with large fields of gravel-cobble and rocks-near the edges of the canyon."

Research summary and significant uncertainties

Relatively few biological studies have been conducted in the three submarine canyons. The three AFSC studies conducted to date were confined to the uppermost head of the Pribilof canyon and adjoining continental shelf. No AFSC research has occurred in Zhemchug or Pervenets Canyons. In all cases, video and trawl sampling was limited to less than 10% of the maximum canyon depth. Sampling for the two habitat studies was further constrained by the primary scientific mission of the research vessel (Brodeur 2001; Busby *et al.* 2005). Although mature POP are reported to associate with sea whips in canyon head areas, the relative importance of this habitat compared to deeper habitats in the canyon is unknown. In fact, Brodeur (p. 219) reports that Krieger[8] "found that adult Pacific ocean perch were more likely to inhabit flat, pebble substrate based on submersible observations off Southeast Alaska." Apparent preference for upright sea pen beds based on high abundance in sea whips, substantially lower numbers in "perturbed" beds, and absence in other shallower areas without whips (Brodeur 2001) could perhaps be related to other environmental factors not being considered. It also is difficult to compare the POP densities observed inside and outside the sea whip beds relative to other areas not being considered for closure. This is due to the inherent difficulty of determining the physical area being observed with video (i.e., the width of the video camera's field of view and the distances traveled by the ROV are frequently unknown and variable; Busby *et al.* 2005). Similarly, significant habitat function in the canyon areas is not demonstrated by Busby *et al.*'s research. The substrates described in this study are rather typical of those found elsewhere in the Bering Sea[9] and inordinately large concentrations of fish or invertebrates were not reported. It would perhaps be

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[8] Krieger, K.J. 1992. Distribution and abundance of rockfish determined from a submersible and by bottom trawling. Fishery Bulletin 91: 87-96.

[9] The authors cite Smith, K.R. and R.A. McConnaughey. 1999. Surficial sediments of the eastern Bering Sea continental shelf: EBSSED database documentation. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-104. 41 p.

useful to compare the relationships between bottom type and fish distribution reported from their study with those for the full EBS shelf [10].

The studies each express concern about possible consequences of destructive fishing practices and losses of important habitat. For example, Brodeur reported that perturbed sea whip beds contained substantially fewer rockfish and "fishing operations that disturb the bottom and uproot the sea whips may have a lasting effect on the rockfish populations inhabiting this region". However, it is unknown whether uprooted sea whips are truly lost as a result, given a propensity in certain whip species to detach, drift and re-attach (Wilson *et al.* 2005). First and foremost in the context of EFH, it is unknown whether there exists an essential functional dependency between rockfish and sea whips that is affected by the disturbance. Concerns about disturbance by fishing are particularly warranted for slow-growing and long-lived species, as reported for the sea whip, *Halipteris willemoesi*. There are however acknowledged uncertainties about the age and growth determinations for this species, including the existence of true annuli and the inability to validate the reported ages (Wilson *et al.* 2005).

AFSC Data Sources

The AFSC is responsible for research on living marine resources in the coastal oceans off Alaska (http://www.afsc.noaa.gov). Its mission is to plan, develop, and manage scientific research programs, which generate the best scientific data available. These data are used to understand, manage and conserve the region's living marine resources, as well as the environmental quality essential for their existence. This section provides information on data holdings from various AFSC monitoring and assessment activities in the conservation areas of interest. These data collectively provide the most comprehensive set of biological and ecological information that is currently available.

Bottom trawl surveys – EBS shelf and EBS slope

The RACE Division of the Alaska Fisheries Science Center conducts annual bottom trawl surveys of the EBS continental shelf. These surveys provide data for stock assessments and management of the fishery resources. Each June–August, the EBS shelf (approximately 463,400

[10] McConnaughey, R.A. and K.R. Smith. 2000. Associations between flatfish abundance and surficial sediments in the eastern Bering Sea. Can. J. Fish. Aquat. Sci. 57: 2410-2419.

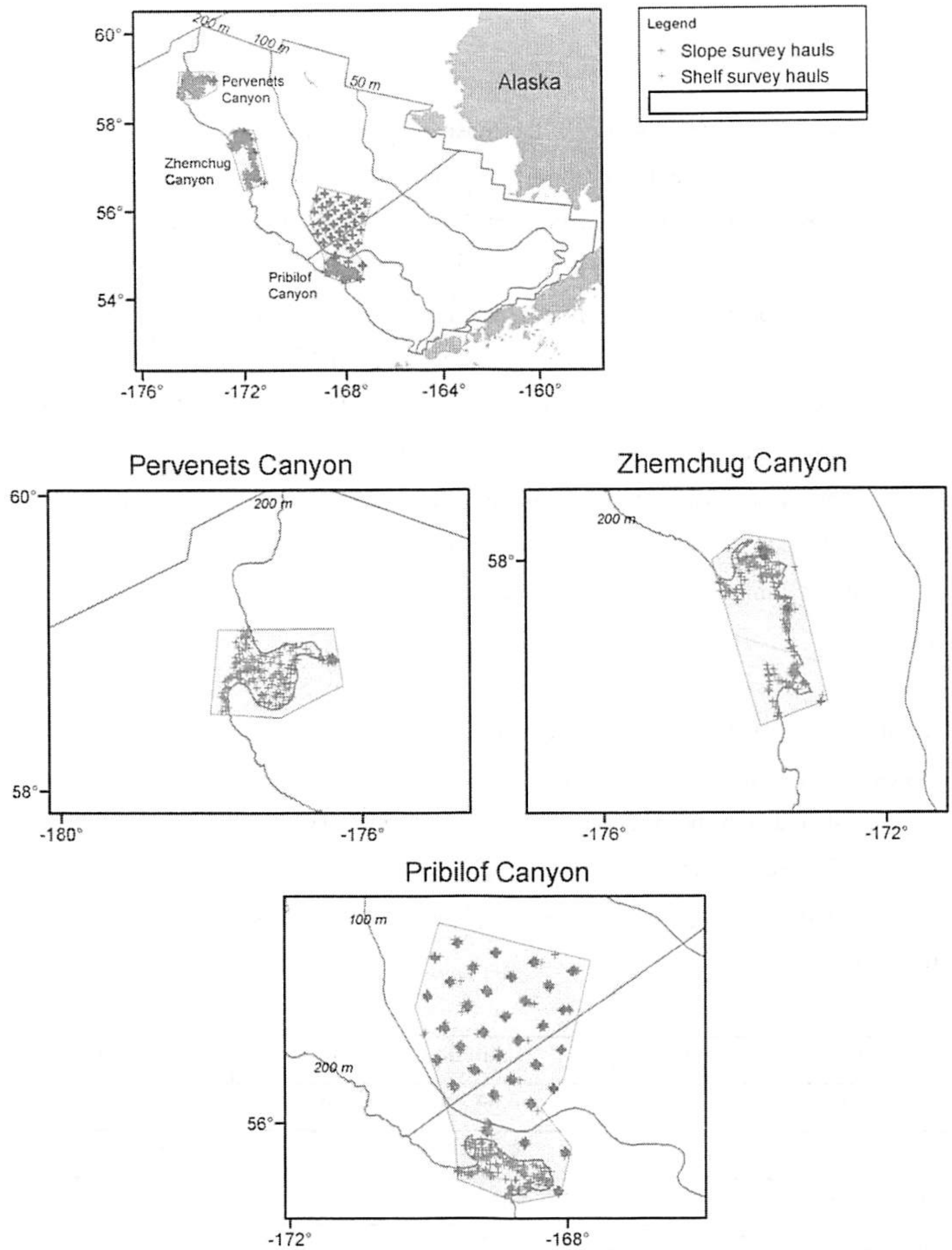
km^2) is systematically surveyed at depths ranging from 20 to 200 m. An 83-112 eastern otter trawl is deployed from chartered vessels at 356 standard stations in a sampling grid with 20 × 20 nautical mile cells. Each sample consists of a 30-min tow at 3 kn. The catch is processed to determine total weight and numbers by species and sex, and a variety of biological measurements and samples are collected from individual specimens. Acoustic net mensuration data and a global positioning system are used to standardize catches (CPUEs) according to area swept.

The RACE Division also conducts bottom trawl surveys along the upper slope of the EBS in order to produce standardized estimates of groundfish and invertebrate abundance. Compared to the shelf survey, the time series is less complete and standard protocols have been implemented only recently. The slope survey was conducted during the period 1975-1991 using a variety of nets, vessels, methods, and sampling locations. A pilot study in year 2000 compared performance of two versions of a Poly Nor'eastern bottom trawl and concluded that the net with mud-sweep roller gear was more efficient and should thereafter be used exclusively. The first standardized biennial survey using this gear occurred in 2002. It should be noted that comparability of data before and after the year 2000 has not been examined and caution is therefore required when examining time series of catches. The standardized survey extends from Unalaska and Akutan Island to the U.S. Russian border near the International Date Line, at depths from 200 to 1,200 m. The survey area encompasses several geologically distinct bathymetric types described as broad low slope areas, canyon areas (including Pribilof and Zhemchug), and steep-slope inter-canyon faces. Trawl sampling occurs at pre-selected locations where depth changes less than 50 m over a distance of 2 nm and the bottom is judged to be free of obstructions that would impede completion of the tow or negatively affect performance of the gear. A standard sample at all depths on the slope consists of a 30-minute tow at 2.5 knots. Available shelf and slope survey data from the three Bering Sea Canyons:

Year	Number of Hauls (Shelf Survey)			
	Pribilof	Zhemchug	Pervenets	Total
1982	32	2	1	35
1983	34	3	1	38
1984	34	3	1	38
1985	34	2	1	37
1986	34	2	1	37

Year	Number of Hauls (Shelf Survey)			
	Pribilof	Zhemchug	Pervenets	Total
1987	34	2	1	37
1988	36	2	1	39
1989	35	2	1	38
1990	34	3	1	38
1991	34	3	1	38
1992	33	2	1	36
1993	33	2	1	36
1994	34	2	1	37
1995	34	2	1	37
1996	34	3	1	38
1997	34	2	1	37
1998	33	3	1	37
1999	34	3	1	38
2000	33	2	1	36
2001	34	2	1	37
2002	34	2	1	37
2003	34	2	1	37
2004	33	2	1	36
2005	33	2	1	36
2006	34	2	1	37
Total	845	57	25	927
Year	**Number of Hauls (Slope Survey)**			
	Pribilof	**Zhemchug**	**Pervenets**	**Total**
1975	0	2	2	4
1976	2	4	0	6
1979	10	19	13	42
1981	27	24	15	66
1982	19	29	32	80
1985	28	32	32	92
1988	10	4	8	22

Year	Number of Hauls (Shelf Survey)			
	Pribilof	Zhemchug	Pervenets	Total
1991	6	5	9	20
2000	14	18	14	46
2002	10	14	12	36
2004	19	19	14	52
Total	145	170	151	466



Distribution of standard eastern Bering Sea bottom trawl survey hauls conducted by the Alaska Fisheries Science Center within the three canyon areas.

Longline survey - EBS slope

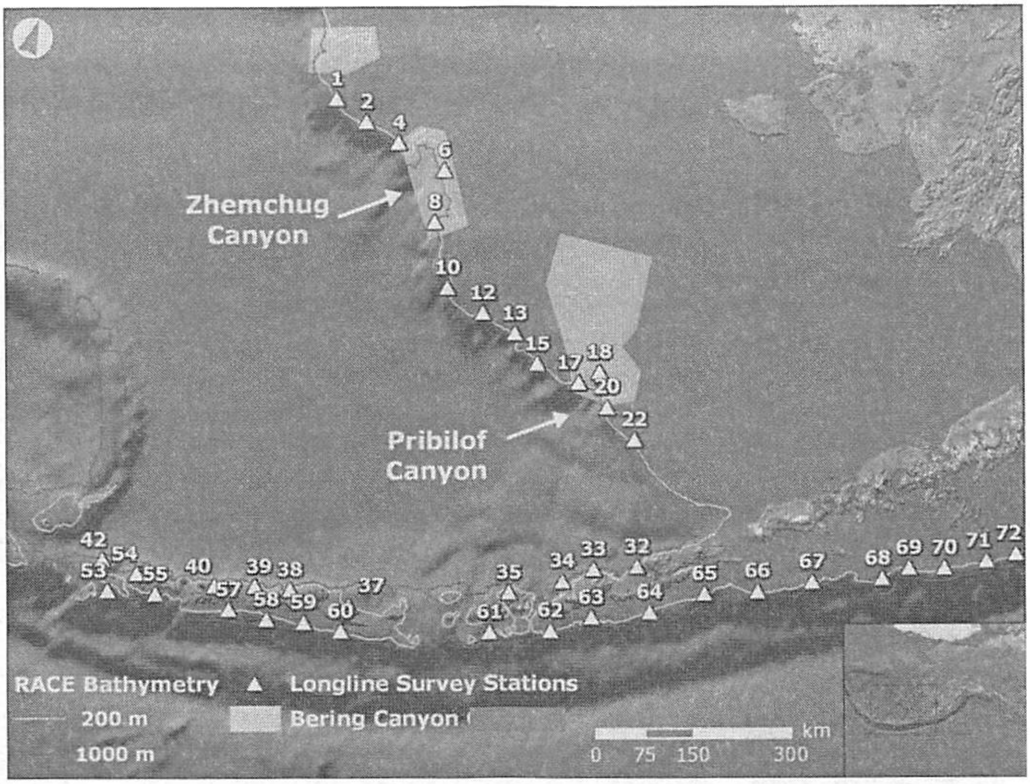
Since 1995, the Auke Bay Laboratory of the Alaska Fisheries Science Center has conducted annual longline surveys of sablefish (*Anoplopoma fimbria*) resources in Alaskan waters. These surveys were designed to continue the time series (1979-94) of the Japan-U.S. cooperative longline survey that was discontinued after 1994. The EBS was sampled annually as part of the cooperative survey between 1982 and 1993 and then biennially since 1997 (Table below).

Sixteen stations along the upper continental slope of the EBS are surveyed (Figure below). Surveyed depths range from approximately 200 to 1000 m, although slightly shallower or deeper depths are fished at some stations. Units of gear (skates) are 100 m long and contain 45 size-13/0 Mustad circle hooks. Hooks are attached to 38 cm gangions that are secured to beckets tied into the groundline at 2 m intervals. Total groundline at each station consists of 180 skates with 8100 hooks.

Catch data are recorded on hand-held electronic data loggers. A scientist records the species of each hooked fish during gear retrieval and the depth strata (100 m intervals) of each gear set. In addition to fish and crab species, coral and sponge catch was generically recorded beginning in 1997. In 2005, coral catch was recorded to higher taxonomic categories (i.e. gorgonians, *Primnoa* sp., *Paragorgia* sp., bamboo corals, scleractinians, black corals, pennatulaceans, and hydrocorals).

Region	Station #	Latitude/Longitude	Survey Years
Pribilof Canyon	17	56.04° N, 169.62° W	82-93,97,99,01,03,05
Pribilof Canyon	18	56.24° N, 169.17° W	82-93,97,99,01,03,05
Pribilof Canyon	20	55.81° N, 168.93° W	82-93,97,99,01,03,05
Zhemchug Canyon	4	58.50° N, 175.68° W	82-93,97,99,01,03,05
Zhemchug Canyon	6	58.33° N, 174.32° W	82-93,97,99,01,03,05
Zhemchug Canyon	8	57.63° N, 174.16° W	82-93,97,99,01,03,05

Stations from AFSC longline survey in submarine canyons of the eastern Bering Sea (see Figures below). Note that the survey does not extend as far north as Pervenets Canyon and consequently no survey data are available for that region.


Zhemchug Canyon
Pribilof Canyon
1
2
4
6
8
10
12
13
15
17
18
20
22
42
54
53
55
40
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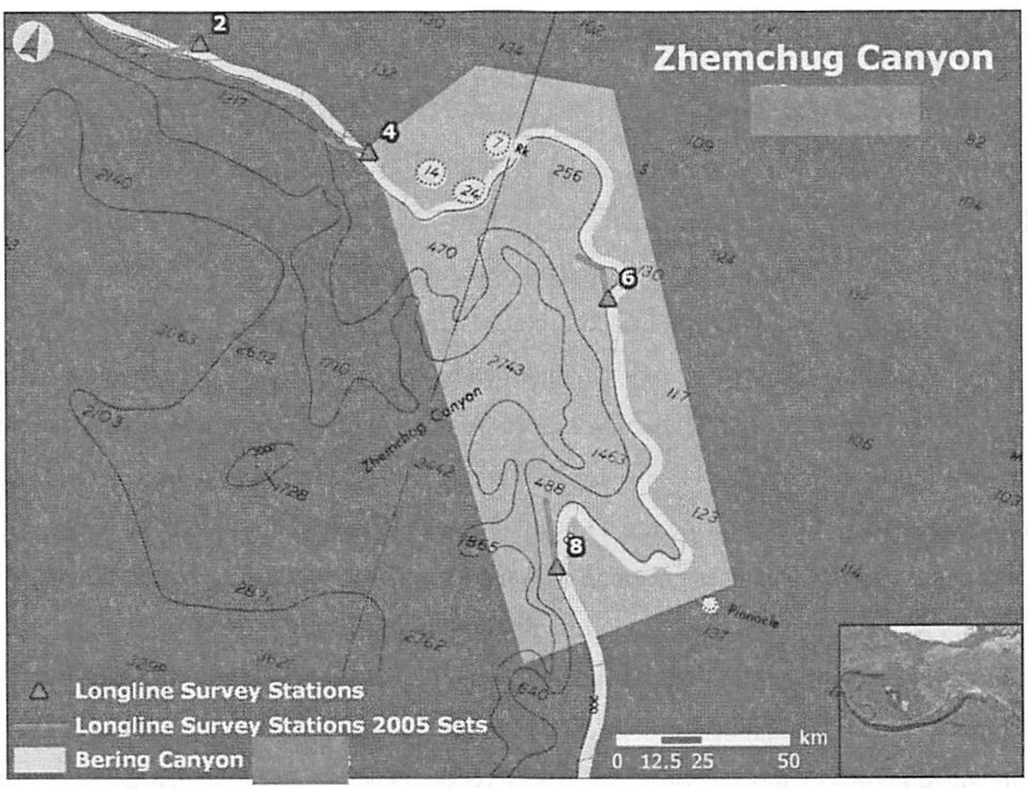
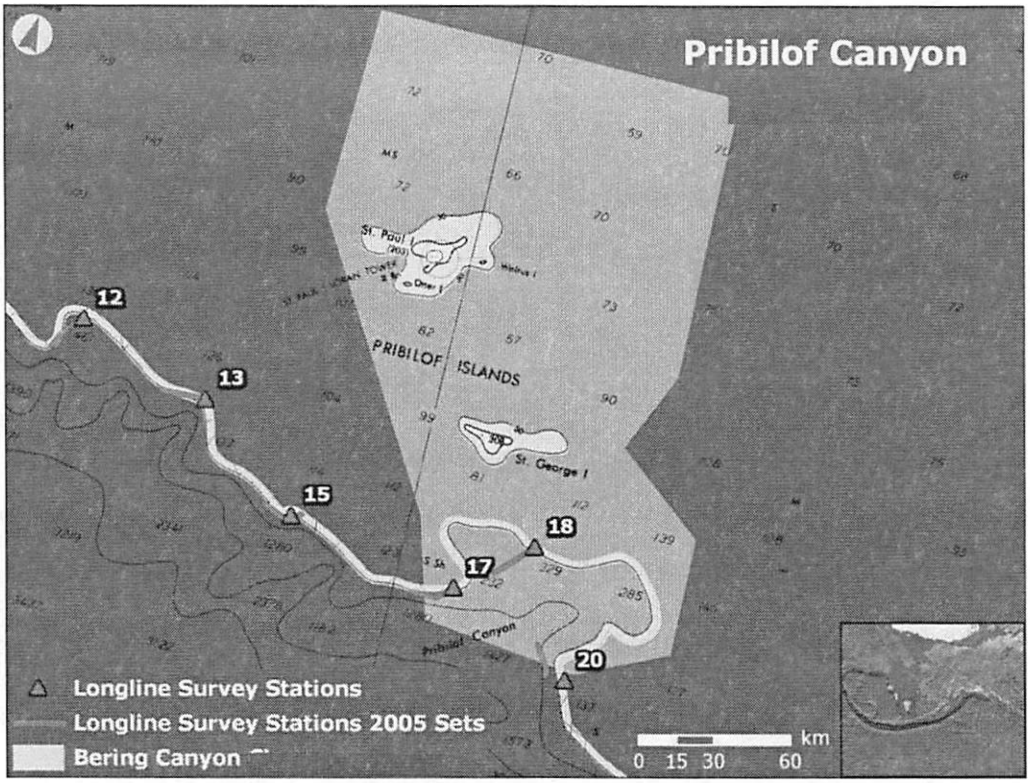
71
72
RACE Bathymetry
200 m
1000 m
Longline Survey Stations
Bering Canyon
km
0 75 150 300


Zhemchug Canyon
2
4
6
8
Zhemchug Canyon
Pinnacle
Longline Survey Stations
Longline Survey Stations 2005 Sets
Bering Canyon
km
0 12.5 25 50



NORPAC fishery observer database

As part of a comprehensive data-gathering program for North Pacific fisheries, certified fishery observers are placed on larger vessels during commercial fishing operations. These observers collect a variety of data, including total catch, effort, catch composition and occurrence of prohibited species. These data are transmitted at regular intervals and are used for in-season fishery management and other scientific purposes. Historical observer data reside in the NORPAC relational database, which is maintained by the Fisheries Monitoring and Analysis (FMA) Division at the Alaska Fisheries Science Center. These data cover three distinct periods in the development of North Pacific fisheries (foreign, joint-venture or j/v, domestic). Commercial bottom trawls during the domestic period are easily identified from gear information recorded in the field. This gear information is not available for hauls during the foreign and j/v period and it was therefore necessary to use a judicious combination of vessel type, processor type and presence of benthic invertebrates in the catch to identify bottom trawl activity. Because observers did not process all catches prior to 1988, roughly half of all hauls during the period are not included by this method (J. Berger, FMA Division, pers. comm.). Furthermore, the estimates of fishing effort do not account for variable and incomplete coverage of vessels over all years so, in general, the counts should be considered conservative. In general, in all three canyon areas commercial trawl hauls were made near or above the 1000m contour.

The following table summarizes the number of commercial bottom trawls observed in the three canyon areas.

Year	Number of Commercial Bottom Trawls		
	Pribilof	Zhemchug	Pervenets
1977	104	13	11
1978	82	159	86
1979	128	251	88
1980	122	96	29
1981	164	119	137
1982	432	407	569
1983	436	966	1,380
1984	616	941	971
1985	564	413	788
1986	627	149	335
1987	446	126	314
1988	445	12	0
1989	591	30	0
1990	2,298	1,388	23
1991	1,989	1,204	449
1992	2,830	467	242
1993	2,205	489	289
1994	1,763	335	455
1995	83	104	169
1996	96	122	9
1997	212	72	102
1998	82	91	95
1999	93	48	30
2000	433	84	135
2001	256	11	222

Year	Number of Commercial Bottom Trawls		
	Pribilof	Zhemchug	Pervenets
2002	367	13	202
2003	316	18	16
2004	229	7	92
2005	107	67	21
2006	257	276	7
Totals	18,373	8,478	7,266

Food habits database

The Resource Ecology Fisheries Management (REFM) Division of the Alaska Fisheries Science Center conducts food habits studies during bottom trawl surveys in the EBS. These data are used to estimate the total biomass and numbers of commercially important crab and groundfish consumed by major groundfish species, as well as describe the diet composition of groundfish species in the region. In most years, stomachs are removed at sea and preserved for laboratory analysis. Beginning in 2005 and 2006, food habits data are based primarily on at-sea scans of stomachs. The capture location, as well as fork length, sex and spawning condition of the source animal are recorded. In the laboratory, prey organisms are identified to the lowest practical taxon, enumerated and wet weights determined. Measurements of standard length (fish prey) and carapace length/width (crab prey) may also be determined. The following tables summarizes the number of predator stomachs collected in the canyon areas, and the corresponding list of predators sampled:

Year	Number of Stomachs Collected			
	Pribilof	Zhemchug	Pervenets	Total
1982	72	58	7	137
1983	200	67	268	535
1984	425	95	177	697
1985	635	99	266	1,000
1986	637	90	201	928
1987	953	347	360	1,660
1988	821	76	59	956
1989	811	86	20	917

Year	Number of Stomachs Collected			
	Pribilof	Zhemchug	Pervenets	Total
1990	689	188	55	932
1991	824	172	142	1,138
1992	991	53	112	1,156
1993	1,213	43	83	1,339
1994	1,183	109	126	1,418
1995	1,740	52	30	1,822
1996	1,396	11	19	1,426
1997	860	59	39	958
1998	832	41	4	877
1999	929	174	23	1,126
2000	769	230	157	1,156
2001	111	0	492	603
2002	733	270	195	1,198
2003	483	1	24	508
2004	393	163	82	638
2005	146	0	10	156
2006	134	0	5	139
Total	17,980	2,484	2,956	23,420

Predator Name	Number of Stomachs Collected			
	Pribilof	Zhemchug	Pervenets	Total
Albatrosia pectoralis (giant grenadier)	43	82	87	212
Anoplopoma fimbria (sablefish)	66	58	78	202
Aptocyclus ventricosus (smooth lumpsucker)	0	0	3	3
Aspidophoroides bartoni (Aleutian alligatorfish)	0	0	10	10
Atheresthes evermanni (Kamchatka flounder)	165	44	156	365
Atheresthes sp.	41	9	188	238
Atheresthes stomias (arrowtooth flounder)	1,168	215	1,374	2,757
Bathyagonus nigripinnis	0	0	12	12
Bathyraja aleutica (Aleutian skate)	36	37	45	118

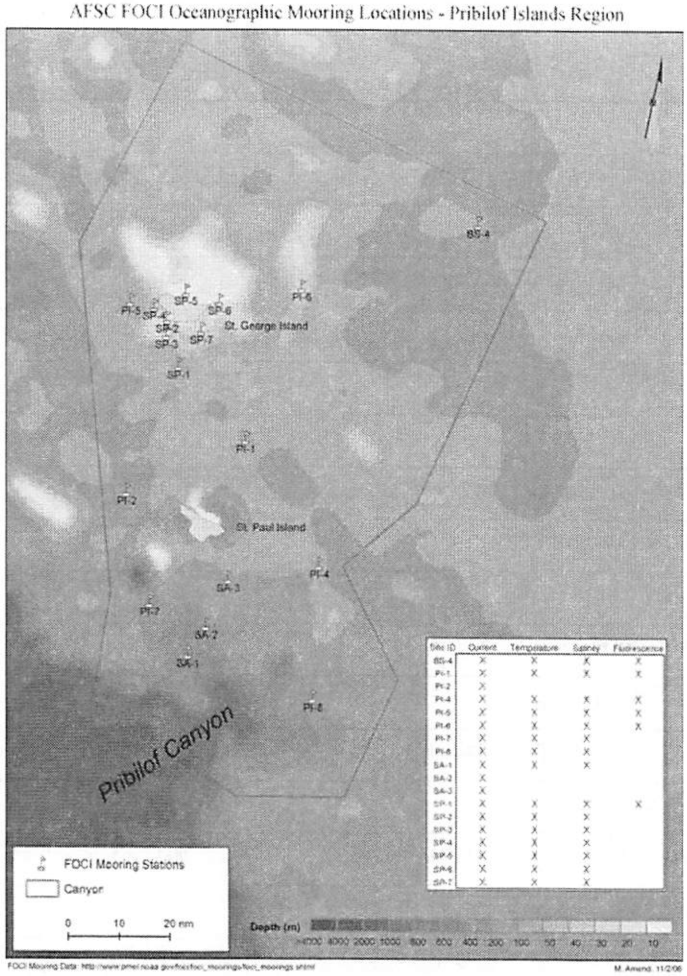
Predator Name	Number of Stomachs Collected			
	Pribilof	Zhemchug	Pervenets	Total
Bathyraja binoculata (big skate)	0	0	2	2
Bathyraja interrupta (Bering skate)	3	0	38	41
Bathyraja lindbergi (commander skate)	21	10	32	63
Bathyraja maculata (white blotched skate)	10	0	23	33
Bathyraja parmifera (Alaska skate)	68	1	408	477
Bathyraja sp. (skate)	2	0	63	65
Bathyraja tarantetzi (mud skate)	12	3	17	32
Bathyraja trachura (black skate)	3	0	3	6
Bothrocara spp. (two-line eelpouts (fat and skinny))	0	0	15	15
Clupea pallasi (Pacific herring)	0	0	27	27
Coryphaenoides acrolepis (Pacific rattail)	0	0	64	64
Coryphaenoides cinereus (popeye grenadier)	92	25	20	137
Embassichthys bathybius (deepsea sole)	0	0	48	48
Errex zachirus (rex sole)	0	11	36	47
Gadus macrocephalus (Pacific cod)	2,785	271	1,574	4,630
Hemilepidotus hemilepidotus (red Irish lord)	0	0	50	50
Hemilepidotus jordani (yellow Irish lord)	15	0	211	226
Hemitripterus bolini (bigmouth sculpin)	10	0	1	11
Hippoglossoides elassodon (flathead sole)	320	86	856	1,262
Hippoglossoides robustus (Bering flounder)	0	0	13	13
Hippoglossus stenolepis (Pacific halibut)	255	20	484	759
Icelus canaliculatus (sculpin)	0	0	1	1
Icelus spiniger (thorny sculpin)	0	0	3	3
Lepidopsetta polyxystra (northern rock sole)	172	4	349	525
Leuroglossus schmidti (northern smoothtongue)	0	0	3	3
Leuroglossus stilbius (California smoothtongue)	0	0	4	4
Limanda aspera (yellowfin sole)	0	0	1,019	1,019
Lycodes brevipes (shortfin eelpout)	0	0	11	11
Lycodes concolor (ebony eelpout)	0	0	5	5
Lycodes diapterus (black eelpout)	0	0	19	19
Lycodes palearis (wattled eelpout)	0	0	12	12

Predator Name	Number of Stomachs Collected			
	Pribilof	Zhemchug	Pervenets	Total
Myoxocephalus jaok (plain sculpin)	0	0	5	5
Myoxocephalus polyacanthocephalus (great sculpin)	0	0	20	20
Oncorhynchus tshawytscha (chinook salmon)	0	0	4	4
Pleurogrammus monopterygius (Atka mackerel)	0	0	8	8
Pleuronectes quadrituberculatus (Alaska plaice)	0	0	168	168
Pleuronectidae (flatfish)	0	0	4	4
Rajidae (skate)	62	0	83	145
Reinhardtius hippoglossoides (Greenland turbot)	117	69	163	349
Sarritor frenatus (sawback poacher)	0	0	44	44
Sebastes alutus (Pacific ocean perch)	95	45	53	193
Sebastes polyspinis (northern rockfish)	0	0	20	20
Sebastolobus alascanus (shortspine thornyhead)	29	0	15	44
Somniosus pacificus (Pacific sleeper shark)	0	0	11	11
Thaleichthys pacificus (eulachon)	0	0	8	8
Theragra chalcogramma (walleye pollock)	5,510	780	2,621	8,911
Zaprora silenus (prowfish)	0	0	6	6
Total	11,100	1,770	10,597	23,467

FOCI ocean moorings

The Alaska Fisheries Science Center's and Pacific Marine Environmental Laboratory's FOCI Program has maintained a number of ocean moorings in the eastern Bering Sea over the period 1994 to the present. 18 of these moorings are located within the Pribilof Island and Pribilof canyon area. The moorings support a number of meteorological and oceanographic instruments, with most data available online at http://www.pmel.noaa.gov/foci/foci_moorings/foci_moorings.shtml. The following figure indicates the location of the moorings relative to the Pribilof Island and Pribilof canyon area, as well as the data types available from the onboard instrument pack.

AFSC FOCI Oceanographic Mooring Locations - Pribilof Islands Region



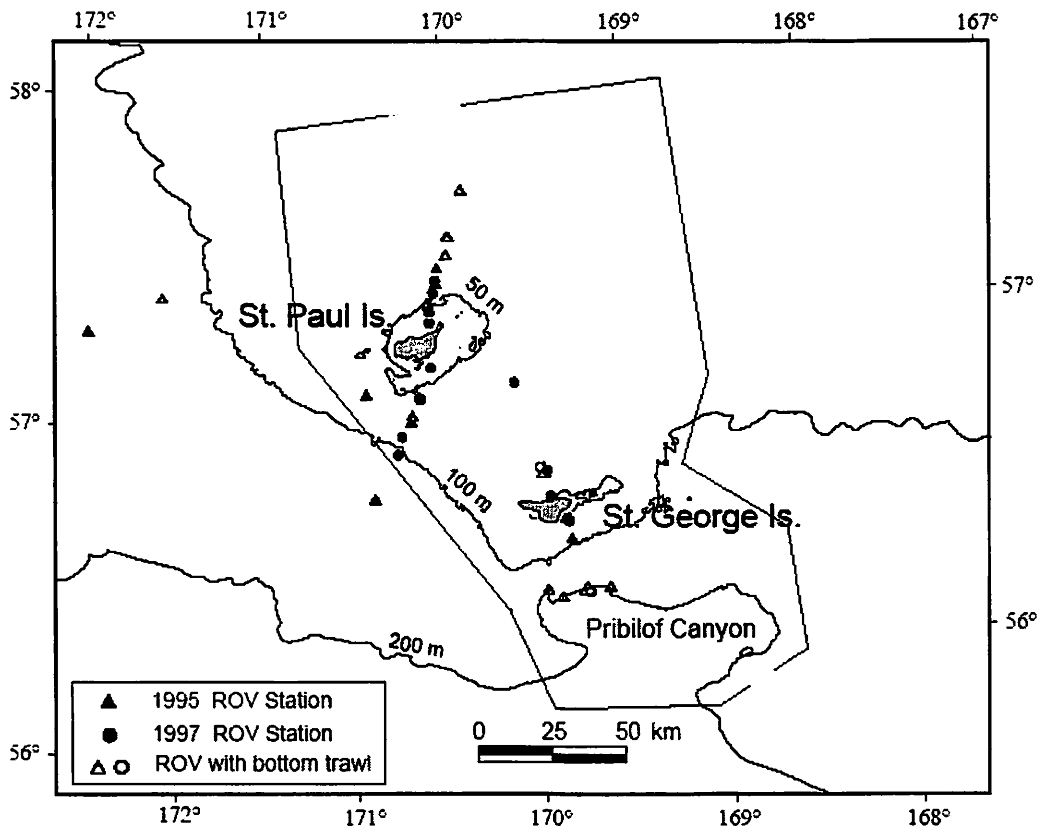
Site ID	Current	Temperature	Salinity	Fluorescence
BS-4	X	X	X	X
PI-1	X	X	X	X
PI-2	X			
PI-4	X	X	X	X
PI-5	X	X	X	X
PI-6	X	X	X	X
PI-7	X	X	X	
PI-8	X	X	X	
SA-1	X	X	X	
SA-2	X			
SA-3	X			
SP-1	X	X	X	X
SP-2	X	X	X	
SP-3	X	X	X	
SP-4	X	X	X	
SP-5	X	X	X	
SP-6	X	X	X	
SP-7	X	X	X	

AFSC Underwater Video from Canyon Areas

Pribilof Island / Canyon areas

Seven of the 45 ROV video camera dives conducted in the EBS during the 1995 and 1997 *Miller Freeman* cruises were in Pribilof Canyon (Brodeur 2001; Busby *et al.* 2005). All of this footage and notes of observations are available for additional study if needed. The following table lists the amount and type of video footage recorded at the dive locations indicated in the figure. (Also see additional information included in the Busby *et al.* research summary above.)

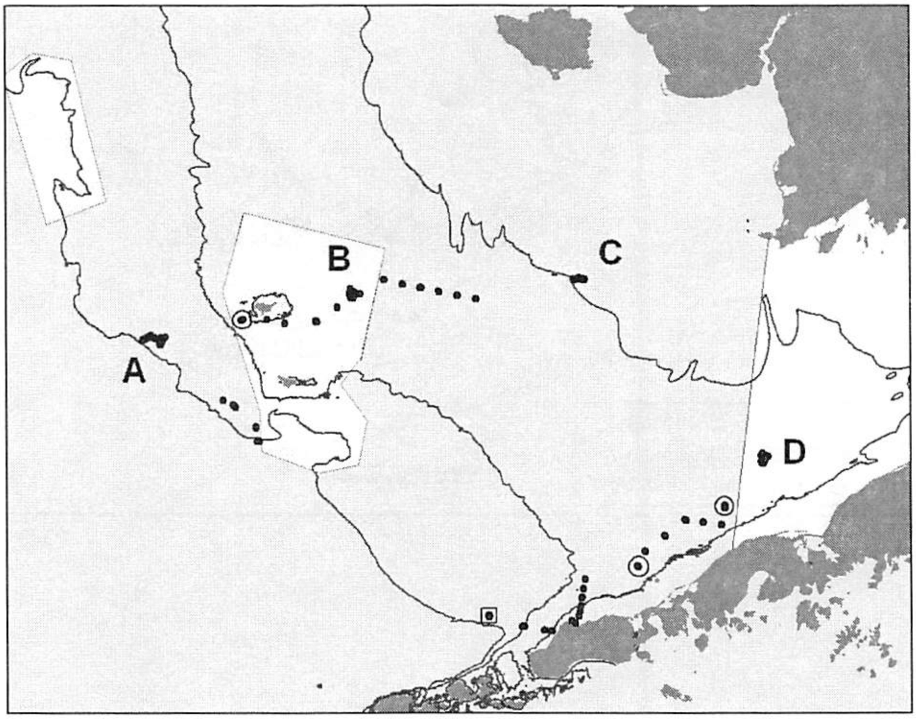
ROV Dive	Elapsed Recording Time (min.)	
	Midwater	On-Bottom
12	30	60
13	35	15
25	60	15
26	20	15
27	25	50
3	30	65
4	25	60



Pribilof Island closure and skate nursery area

From 23 May to 7 June 2006, RACE scientists conducted research to compare the effects of conventional and modified trawl sweeps on sessile invertebrates at four study sites on the EBS shelf. Included were sites 45 nm east of St. Paul Island (area B in the figure), which were primarily characterized by colonial ascidians (*Halocynthia*, *Boltenia* and *Styela*). At each site, experimental trawling created parallel tracks with the four types of gear being investigated. A seafloor sled outfitted with both a Didson imaging sonar and video sensors was then towed across the tracks at several points to compare the condition of seafloor animals in areas affected by these different gears. The imagery from these sensors has not been analyzed, but will be used to estimate the relative effects of the different sweep designs on the structure-forming invertebrates.

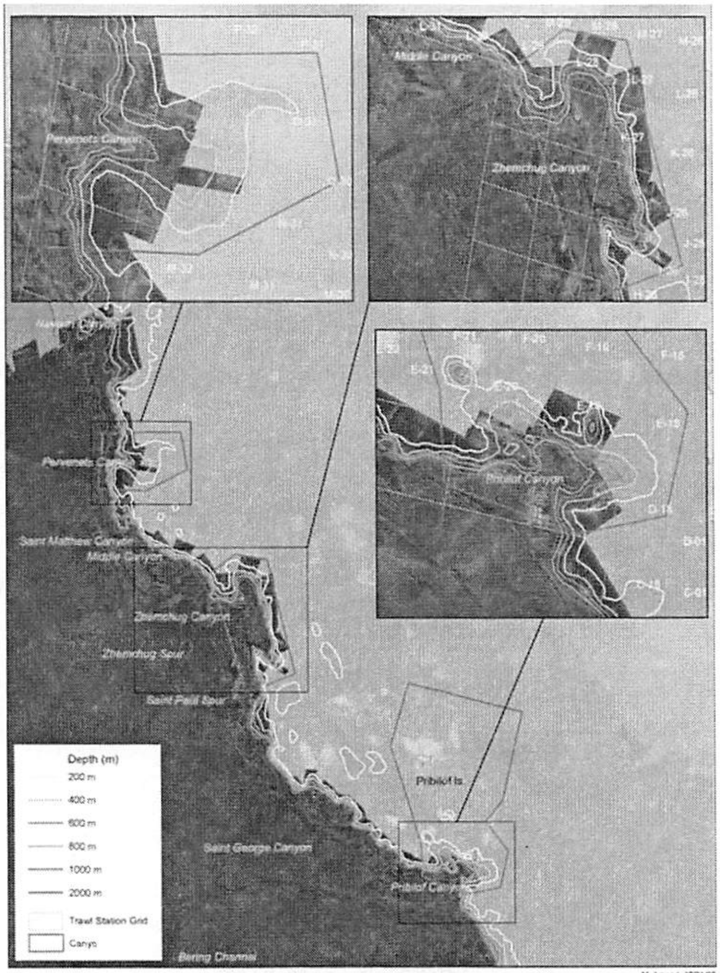
One of the EBS skate nursery areas was also examined with the sled, and very high densities of skate egg cases were observed, confirming prior trawl observations and also providing finer-scale distribution information.



External Data Sources

U.S. Geological Survey – GLORIA mapping

The U.S. Geological Survey conducted a 1986-1987 survey of the Bering Sea, as part of a national program to map the U.S. EEZ. The survey encompassed all of the Aleutian Basin and Bowers Basin deeper than 200 m that is east of the U.S. – U.S.S.R. Convention Line of 1867. This coverage includes many of the canyons located along the shelf margin. The primary mapping tool was GLORIA, a 6.5 kHz long-range sidescan sonar producing digital backscatter data with each pixel representing ~125 m by 45 m of seabed. Additionally, bathymetry data and both acoustic and air-gun seismic reflection data were collected over 40,000 line km of geophysical transects. An atlas summarizing data from this effort is included in the section "Pertinent Scientific and Technical References".



USGS Gloria Sonar Imagery: Bering Sea AFSC Trawl Stations near canyons

OCSEAP Data

NOAA initiated the Outer Continental Shelf Environmental Assessment (OCSEAP) program in 1975, at the request of the Bureau of Land Management. Its purpose was to assess the environmental impact of outer continental shelf oil and gas development in designated large environmental regions or lease areas in Alaska. These areas include the three Bering Sea canyons. Hundreds of biological, chemical, physical and geological/geophysical studies were conducted, many of them in the EBS. A large number of documents including bibliographies[11] and data inventories[12] exist to facilitate identification of studies and data applicable to review of

[11] Anonymous. 1981. Environmental assessment of the Alaskan continental shelf – comprehensive bibliography. Office of Marine Pollution Assessment, National Oceanic and Atmospheric Administration, Washington, D.C. Distributed by the U.S. Government Printing Office, Washington, D.C. 177 pp.
[12] Anonymous. 1979. NODC catalog of OCSEAP data. Part 2. Inventory of digital data by lease area for the Alaska Outer Continental Shelf Environmental Assessment Program. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Information Service.iv + 84 pp.

the Proposal. Hood and Calder (1981)[13], for example, produced a two-volume publication based on a 1979 OCSEAP-sponsored symposium held to review and evaluate the available data for the EBS. Formatted digital data, referenced to the original OCSEAP research study by the Research Unit (RU) number, are archived by NOAA at the National Oceanographic Data Center (NODC) and the National Geophysical Data Center (NGDC).

Summary and Recommendations

The EFH mandate, in very simple terms, is intended to identify, conserve and enhance "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity".

Skate populations are characterized by low fecundity and slow growth rates, suggesting a bottleneck during early life history stages. As such, areas supporting large numbers of egg cases are extremely important and warrant special consideration. This is especially true in this case given evidence of extended embryonic development (> 3 years) and expected vulnerability of egg cases to removal or disturbance by bottom fishing activity. It is admittedly unknown how many of these nursery areas exist in the EBS. Nevertheless, it seems prudent to consider protecting these nursery areas until such time as the extent of their contribution to the skate populations in the EBS (and perhaps elsewhere) is better understood. Such protective action would fall squarely within the scope of the EFH mandate. Furthermore, the aggregate size of the six closures is quite small suggesting impacts on other fisheries would be minor.

Submarine canyons are significant geological features that cut the continental slope and function as conduits for organic and inorganic matter moving between deep basins and the continental shelf.[14,15] The resulting fluxes can support diverse communities with high biomass, as compared to non-canyon regions at similar depths. Canyons are rare habitats, occupying <4% of the world sea floor and commonly contain unique species assemblages.

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[13] Hood, D.W. and J.A. Calder (eds.). 1981. The eastern Bering Sea shelf: oceanography and resources. Volumes I and II. Office of Marine Pollution Assessment, National Oceanic and Atmospheric Administration, Washington, D.C. Distributed by University of Washington Press, Seattle, WA. xviii + 1339 p.

[14] Glover, A.G. and C.R. Smith. 2003. The deep-sea floor ecosystem: current status and prospects of anthropogenic change by the year 2025. Environmental Conservation 30(3): 219-241.

[15] Vetter, E.W. and P.K. Dayton. 1998. Macrofaunal communities within and adjacent to a detritus rich submarine canyon system. Deep-Sea Research II 45: 25-54.

There are at least 15 distinct canyon systems along the EBS continental shelf, including the three largest submarine canyons in the world.[16] Zhemchug is the largest of these; each of its two main branches is larger than typical continental shelf canyons (e.g. Monterey). Pervenets and Pribilof Canyon are substantially smaller. Two of these canyons (Middle, St. Matthew) were discovered as recently as 1982.[17]

Despite rather extensive geological studies of submarine canyons in the EBS, very little biological information is available to assess the value of canyon habitat. Although these canyons, including the three evaluated in this paper, are likely to be important at the ecosystem level, the EFH guideline is much more restrictive and a direct link to commercial fish production has not been established. Unfortunately, fisheries research is limited to two AFSC studies in the upper head of a single canyon. These studies indicate the presence of commercially important groundfish and crabs, characterize different benthic habitats, and describe some common fish-habitat associations (Brodeur 2001; Busby *et al.* 2005). One of these associations is between mature rockfish and sea whips, which provide vertical structure in an otherwise featureless area. A third study suggests that sea whips grow slowly with 50 yr longevity (Wilson *et al.* (2002), and it has been argued that rockfish populations could be negatively affected if sea whips are disturbed by fishing (Brodeur 2001). Although insightful for the areas and times sampled, these studies provide no information about the biology and habitat characteristics found in the majority of this canyon system. Taken together, the information from these three studies do not support any proposals for closures based on the existence of unique and/or essential habitat, nor do they make the case for inordinately sensitive habitat in need of immediate protection. Clearly, additional research is required to evaluate the significance of habitat in the proposed canyon areas. A detailed analysis using other data sources identified in this document would likely address the deficiencies at depth and in other canyons and thereby improve an analysis based on existing data.

Ultimately, a thorough assessment of EBS canyon habitats will require a dedicated study. Although it is relatively straightforward to designate EFH in areas with obvious and significant ecological value, such as the skate nursery sites, it is much more difficult to judge habitat quality and discern true habitat dependencies based solely on patterns of biological abundance. This

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[16] Normark, W.R and P.R. Carlson. 2003. Giant submarine canyons: is size any clue to their importance in the rock record? Geological Society of America Special Paper 370. 15 p.
[17] Carlson, P.R. J.M. Fischer, and H.A. Karl. 1983. Two newly discovered submarine canyons on Alaskan continental margin of Bering Sea. U.S. Geological Survey Open-File Report 83-24. 37 pp + 1 plate.

requires a systematic survey of habitats and coordinated biological sampling over *the full range* of a species' abundance. Having done this, the relative importance of different habitat characteristics can be compared and the essential elements identified. Management decisions can then be made based on the expected vulnerability of these habitats to anthropogenic disturbance.

Pertinent Scientific and Technical References

Baldauf, J.G. 1984. Diatom analysis of surface samples recovered from Pervenets Canyon. *In* Carlson, P.R. and H.A. Karl, eds., Surface and near-surface geology, Navarin Basin province; results of the 1980-81 field seasons: U.S. Geological Survey Open-File Report 84-0089, p. 100-112.

Belykh, I.N., S.L. Klemperer, D.W. Scholl, J.R. Childs and H. Gnibidenko. 1995. New deep seismic profiles across the Bering Sea shelf margin, EOS, Transactions, American Geophysical Union, 76(46 suppl.): 590.

Abstract. As part of the NSF-CD Bering Shelf-Chukchi Sea continental transect, in 1994 we recorded two crustal (17 s) marine seismic- reflection profiles across the Beringian margin. One profile runs from the Navarin Basin across the shelf edge at St. Matthew Canyon; the other crosses the shelf edge near Zhemchug Canyon and the epicenter of a 1991 Ms=6.8 earthquake. Although a tilted sedimentary basin sequence is seen in this area, no clear fault-plane reflections are visible. On both profiles the top of oceanic crust can be seen at 8 s travel-time beneath about 4 s of Tertiary sediments of the Aleutian Basin. Oceanic crust and Moho can only reliably be traced beneath the smooth sedimentary pile of the basin to the foot of the rough slope on our (currently) unmigrated profiles. On the Zhemchug Canyon profile, NE-dipping reflections can be traced from the top of oceanic crust near the base of the slope to > 12 s, probably equivalent to reflections identified by Marlow & Cooper (1985) as possibly representing the too of oceanic crust subducted into an early Tertiary trench. Complex layered reflections at 12 s at or beneath the base of oceanic crust are also present in this area. Reflection Moho is intermittently visible beneath the outer Bering Shelf at 10 to 12 s (30 to 38 km?) beneath 1 to 2 s carapace sedimentary deposits, but shallows to <10 s, thinning significantly to c. 10 km basement thickness beneath the >6 s (c. 10 km) Navarin Basin.

Bering Sea EEZ-SCAN Scientific Staff. 1991. Atlas of the U.S. Exclusive Economic Zone, Bering Sea. U.S. Geological Survey, Miscellaneous Investigations Series I-2053. 145 pp.

Summary. This atlas compiles results from a 1986-1987 survey of the Bering Sea by the U.S. Geological Survey as part of a national program to map the U.S. EEZ. The survey encompassed all of the Aleutian Basin and Bowers Basin deeper than 200 m that is east of the U.S. – U.S.S.R. Convention Line of 1867. This coverage includes canyons located along the shelf margin. The primary mapping tool was GLORIA, a 6.5 kHz long-range sidescan sonar producing digital backscatter data with each pixel representing ~125 m by 45 m of seabed. Additionally, bathymetry data and both acoustic and air-gun seismic reflection data were collected over 40,000 line km of geophysical transects. Data summaries in the atlas consist of (1) sonar imagery mosaics with geologic interpretations and bathymetry, and (2) seismic reflection, magnetic, and gravity profiles.

Blueford, J. R. 1983. Distribution of Quaternary Radiolaria in the Navarin Basin geologic province, Bering Sea. Deep-Sea Research. 30(7A): 763-781.

Abstract. Radiolarians from the surface sediments of the Navarin Basin geologic province in the western part of the Bering Sea are more diverse and abundant than previous reports indicate. The shelf is dominated by two spongy radiolarian species groups (Stylochlamydium venustum and Spongotrochus glacialis groups), while the slope has more diversity. The distributions can in part, be explained by present oceanographic conditions. Studies of five cores along the slope show that there is a faunal change within the top 5 m of sediment. The spongy radiolarians are more abundant in recent sediments but gradually decrease downcore as Cycladophora davisiana becomes the dominant species, which probably reflects an environmental change. The disappearance of Lychnocanoma grande in the area occurred around 17,000 to 34,000 y BP, but more research is needed to confirm whether the extinction is a useful biostratigraphic marker.

Blunt, D.J., and K.A. Kvenvolden. 1984. Aspartic acid geochronology of mollusks. *In* Carlson, P.R. and H.A. Karl, eds., Surface and near-surface geology, Navarin Basin province; results of the 1980-81 field seasons: U.S. Geological Survey Open-File Report 84-0089, p. 113-118.

Brodeur, R.D. 2001. Habitat-specific distribution of Pacific ocean perch (*Sebastes alutus*) in Pribilof Canyon, Bering Sea. Continental Shelf Research 21(3): 207-224.

Abstract. Shelf edge canyons are well-known sites of enhanced biomass due to on-shore transport and concentration of zooplankton along their axes, both of which contribute to the high densities of nekton frequently found in these canyons. Using a combination of acoustics, trawling, and in situ observations with a remotely operated vehicle (ROV), the distribution of pelagic and demersal biota within Pribilof Canyon in the Bering Sea was examined in September of 1995 and 1997. Near-bottom acoustic scattering patterns in the 38 kHz data showed high concentrations of biomass beginning around the 180m bottom depth contour and continuing to about 220m, which were presumed to be adult fish based on their target strength distributions. The 120 kHz data also showed very strong scattering in the water column between 150 and 175 m, which was absent from the 38 kHz data, and therefore attributed mainly to zooplankton. The dominant taxa collected in bottom trawls and mid-water plankton tows were adult rockfishes (Pacific ocean perch, *Sebastes alutus*) and euphausiids (*Thysanoessa* spp.), respectively. In situ videos revealed dense aggregations of these rockfishes inhabiting a ``forest" of attached sea whips, *Halipteris willemoesi*, during night deployments of the ROV, while areas with damaged sea whips had far fewer rockfish, and areas without this biotic habitat structure had no rockfish. During the day, the rockfishes were seen above the ``forest", where they were apparently feeding on dense swarms of euphausiids. It appears that these rockfish utilize this predictable and abundant food resource in the canyon during the day and are associated with the sea whip habitat at night during periods of inactivity. More research is needed on these slow-growing biotic habitats and how fishing activities in the Bering Sea and elsewhere may impact these habitats.

Busby, M.S., K.L. Mier and R.D. Brodeur. 2005. Habitat associations of demersal fishes and crabs in the
Pribilof Islands region of the Bering Sea. Fisheries Research 75: 15–28.

Abstract. Habitat associations of demersal fishes and crabs were determined from observations of videotapes recorded by a camera equipped remotely operated vehicle (ROV) in the Bering Sea near the Pribilof Islands in September 1995 and 1997.We identified 42 taxa

representing 16 families of fishes and 8 taxa from 3 families of crabs. Families Pleuronectidae (righteye flounders) and Cottidae (sculpins) were represented by the greatest number of taxa. *Lepidopsetta polyxystra* and *Chionoecetes opilio* were the most frequently observed fish and crab species. Other fish species in the families Pleuronectidae, Gadidae, Scorpaenidae, Agonidae, and Bathymasteridae were also encountered frequently. Six classifications based on substrate and cover were used to describe the habitat where each fish and crab was observed. Agonids and pleuronectids were typically observed on silt, mud, or sand substrate with no cover while other taxa, particularly cottids and bathymasterids, were encountered in more varieties of habitat including areas covered with rocks and boulders. Significant differences in species composition were found among habitats and stratified depth ranges. Similarity analyses showed that different taxa were responsible for these differences, but within each habitat type and depth range, two to five species contributed to 90% of the average similarity. Some ROV dives were paired with bottom trawls in the same general locations. Species compositions of the ROV observations were significantly correlated with that of the corresponding bottom trawl catch compositions. Overall, we believe that in situ observations provide useful information on fish habitats and behaviors not readily available from conventional trawling surveys.

Carlson, P.R., H.A. Karl and K.A. Johnson. 1981. Morphology, sedimentology, and genesis of three large submarine canyons adjacent to Navarin Basin, Bering Sea. American Association of Petroleum Geologists Bulletin, 65(5): 909-909.

Carlson, P.R., H.A. Karl and B.D. Edwards. 1982. Puzzling mass movement features in the Navarinsky Canyon head, Bering Sea. Geo-Marine Letters 2(3-4): 123-127.

Abstract. Two types of morphologic features in the head of Navarinsky Canyon are attributed to mass movement of near-surface sediment. A series of pull-aparts is located downslope of large sand waves. These pull-aparts, possibly induced by liquefaction, affect the upper 5 to 10 m of sandy sediment (water depths 350 to 600 m) on a 1° slope. A hummocky elongate mound of muddy sand (water depths 550 to 800 m) contains chaotic internal reflectors to a subbottom depth of 30 to 40 m and possibly is the product of a shallow slide. We speculate that Holocene seismicity is the likely triggering mechanism.

Carlson, P.R., H.A. Karl and P.J. Quinterno. 1982. Sedimentologic processes in world's largest submarine canyons, Bering Sea, Alaska. *In* Braunstein, Jules, and A.F. Thomson, chairperson, 95th annual meeting, The Geological Society of America: Geological Society of America Abstracts with Programs, 14(7): 459-460.

Carlson, P.R., J.M. Fischer and H.A. Karl. 1983. Two newly discovered submarine canyons on the Alaskan continental margin of Bering Sea. U.S. Geological Survey Open-File Report 83-0024, 38 pp.

Carlson, P.R. and H.A. Karl. 1984. Discovery of two new large submarine canyons in the Bering Sea. Marine Geology 56(1-4): 59-179.

Abstract: The Beringian continental margin is incised by some of the world's largest submarine canyons. Two newly discovered canyons, St. Matthew and Middle, are hereby added to the roster of Bering Sea canyons. Although these canyons are smaller and not cut back into the Bering shelf like the five very large canyons, they are nonetheless comparable in size to most of the canyons that have been cut into the U.S. eastern continental margin and much larger than the well-known southern California canyons. Both igneous and sedimentary

rocks of Eocene to Pliocene age have been dredged from the walls of St. Matthew and Middle Canyons as well as from the walls of several of the other Beringian margin canyons, thus suggesting a late Tertiary to Quaternary genesis of the canyons. We speculate that the ancestral Yukon and possibly Anadyr Rivers were instrumental in initiating the canyon-cutting processes, but that, due to restrictions imposed by island and subsea bedrock barriers, cutting of the two newly discovered canyons may have begun later and been slower than for the other five canyons.

Carlson, P.R., and H.A. Karl. 1984. Rates of sediment accumulation. *In* Carlson, P.R., and H.A. Karl, eds., Surface and near-surface geology, Navarin Basin province; results of the 1980-81 field seasons: U.S. Geological Survey Open-File Report 84-0089, p. 21-27.

Carlson, P.R., M. Golan-Bac, H.A. Karl and K.A. Kvenvolden. 1985. Seismic and geochemical evidence for shallow gas in sediment on Navarin continental margin, Bering Sea: American Association of Petroleum Geologists Bulletin 69(3): 422-436.

Abstract. Marine seismic studies coupled with geochemical investigations demonstrate that hydrocarbon gases are ubiquitous in the near-surface (less than or approximate to 250 m or 820 ft depth) sediment of the Navarin continental margin in the northern Bering Sea. Three types of acoustic anomalies appear to be related to the presence of gas in the sediment. These anomalies are most prevalent in the northern half of the Navarin Basin. Acoustic anomalies attributed to gas hydrates and to diagenetic boundaries are present on seismic records of the lower slope between Navarinsky and Zhemchug canyons.

Carlson, Paul R., and H.A. Karl. 1988. Development of large submarine canyons in the Bering Sea, indicated by morphologic, seismic, and sedimentologic characteristics. Geological Society of America Bulletin, 100(10): 1594-1615.

Abstract. Seven large submarine canyons cut the Beringian continental margin. Three of these are among the world's largest submarine canyons. Bering is 400 km long, Navarinsky and Zhemchug are each 100 km wide at the shelf break, and volumes of sediment removed from these three canyons range from 4,300 to 5,800 km super(3), an order of magnitude larger than any submarine canyons incised in the margin of the lower 48 states. Two major events set the stage for the development of the Beringian margin and the dissection of these canyons: (1) the jump of the subduction zone to the Aleutian trench in Late Cretaceous-early Tertiary time that changed the margin from active to passive and (2) the low stands of sea level during the Cenozoic glacial stages.

Carlson, Paul R., H.A. Karl and B.D. Edwards. 1991. Mass sediment failure and transport features revealed by acoustic techniques, Beringian margin, Bering Sea, Alaska. Marine Geotechnology, 10(1-2): 33-51.

Abstract: GLORIA sidescan sonar imagery and seismic-reflection profiles show pervasive evidence for a wide variety of slides and slumps associated with the large canyons of the 1400-km-long Beringian margin. Styles of failure include mud and debris flows, slumps, and massive block slides. A 100-km-long shelf-edge segment on the northern margin is characterized by a series of scalloped slide scars and incipient scars associated with sedimentary blocks, 1-2 km across, that seem to be the initiators of a series of small canyons. Some of the largest single slide masses, including huge blocks tens of kilometers wide, occur on the rise of the central margin. Sliding of these blocks may have initiated the incision of some of the world's largest submarine canyons, a prime example of which is the massive

Zhemchug Canyon. Mass movement along the southern margin is widespread at the edges of Umnak Plateau. One mass failure, particularly well defined by GLORIA, is 55 km long. This slide and others along the plateau are associated with diapiric-like structures indicative of relatively recent tectonism.

Carlson, P.R., H.A. Karl, B.D. Edwards, J.V. Gardner and R. Hall. 1993. Mass movement related to large submarine canyons along the Beringian margin, Alaska. *In* Schwab, W.C., H.J. Lee and D.C.Twichell, eds., Submarine landslides; selected studies in the U.S. Exclusive Economic Zone: U.S. Geological Survey Bulletin 2002, p. 104-116.

Edwards, B.D., and H.J. Lee. 1984. Summary of Navarin Basin geotechnical characteristics. *In* Carlson, P.R. and H.A. Karl, eds., Surface and near-surface geology, Navarin Basin province; results of the 1980-81 field seasons: U.S. Geological Survey Open-File Report 84-0089, p. 39-54.

Evsyukov, Y.D., and L.P. Volokitina. 1985. Main results of geomorphological studies in the Navarin Canyon area (the northwestern Bering Sea). Okeanologiya 25(2): 254-257. Moscow.

Abstract. On the basis of a 2000 mile echo-survey performed in the polygon of about 44,300 km super(2), during the 29th cruise of the R/V "Dmitrij Mendeleev" in 1982, bathymetric and geomorphological charts were constructed. The Navarin Canyon was found to be the main morphological element of the area. The shelf zone was characterized by a smooth relief. The continental slope was of a complicated structure due to erosive and tectonic processes.

Feder, H.M., R.H Day, S.C. Jewett, S.G. McGee and S.V. Schonberg. 1981. Analysis of van Veen grab samples collected during 1979 and 1980 in the northern Bering Sea and southeastern Chukchi Sea. NOAA/OMPA, BOULDER, CO (USA). NOAA/OMPA, BOULDER, CO (USA).

Abstract. The van Veen grab survey for the investigation of infaunal invertebrates was effective, and excellent spatial coverage of most of the study areas was obtained. To date 24 stations from the Navarin Basin lease area, 5 from the vicinity of the Hope Basin lease area, and 1 from the St. Matthew Basin lease area have been sorted and the organisms identified and quantified. Stations from the central Navarin Basin, were dominated by polychaetous annelids, especially maldanids, capitellids, cirratulids, and lumbrinerids. Mollusks were present but not abundant. The stations from the Chukchi Sea (Hope Basin area) appear to be considerably different from those further south in the Bering Sea (Navarin Basin area). In general, mollusks and amphipods were more prevalent in this area.

Field, M.E., P.R. Carlson, and R.K. Hall. 1983. Seismic facies of shelf edge deposits, U.S. Pacific continental margin. *In* Stanley, Daniel Jean and George T. Moore, eds., The shelf break; critical interface on continental margins: Society of Economic Paleontologists and Mineralogists Special Publication 33: 299-313.

Abstract: Pacific-style continental margins, such as that of western N America, are marked by large contrasts in the type of shelf edge sedimentary deposits and the processes that form them. Many of the sediment sources of the NW US and S Alaska feed directly onto swell- and storm-dominated shelves. On such narrow unprotected shelves, sediment has a short residence time in submarine deltaic deposits before being remobilized and dispersed to outer-shelf and upper-slope environments. Through study of high-resolution seismic-reflection profiles, we have identified four principal types of shelfedge deposits: 1) starved, 2) draped, 3) prograded, and 4) upbuilt and outbuilt. Each type of shelfedge deposit results from a characteristic balance between sedimentation rate and distributive energy (waves and currents) and is, therefore, characterized by distinctive seismic facies and bedding patterns.

Fischer, J.M., P.R. Carlson and H.A. Karl. 1982. Bathymetric map of Navarin Basin Province, northern Bering Sea. U.S. Geological Survey Open-File Report 82-1038. 11 pp.

Galloway, B. K., S.L. Klemperer and J.R. Childs. 1994. New seismic coverage of the continental crust and moho, Bering and Chukchi Seas Transect, Alaska. EOS, Transactions, American Geophysical Union 75 (44 suppl.): 642.

Abstract. Stanford University, in conjunction with the USGS, conducted deep seismic investigations of the continental crust beneath the Bering and Chuckchi Seas, Alaska, during the month of August, 1994. The data was recorded to two-way travel-times of 15 to 23 seconds, with 50 to 75 meter shot spacing. Two north-south transects were profiled. The eastern transect extended from 58d 50m N, 169d 32m W, well within the continental shelf of the Bering Sea, north of the Pribilof Islands, to just south of the shelf edge north of Barrow, Alaska, at 71d 49m N, 154d 33m W. Ice prevented continuation of the line beyond the shelf edge. The western transect extended from the central Chukchi Sea, within the shelf at 71d 30m N, 163d 00m W, into the Aleutian basin at 58d 00m N, 178d 30m W, near the Navarinsky Canyon. An additional short line crossing over the Beringian margin a second time was recorded near Zemchug Canyon east of the western transect. Constant-offset sections were plotted on board the ship during acquisition. These plots exhibit large differences in lower crustal reflectivity across the breadth of the continental crust. The profiles cross important strike-slip faults, possible terrane boundaries, two continental margins, and several Cretaceous/Tertiary sedimentary basins (Norton, Hope, Chuckchi, Navarin Basins). Together with the preceding cruise EW94-09, led by Sue McGeary, the profiles provide a continuous transect across the North American continent, from the Pacific to the Arctic Ocean. Most of the multi-channel seismic data is generally of high quality. Gravity, magnetic, and sonobuoy data were also recorded along the profiles. Wide-angle recording was done in conjunction with the seismic profiling, at recording sites located along the central west coast of Alaska and the Chukchi Peninsula, as well as on islands in the Bering Strait and Bering Sea.

Gardner J.V. and T.L Vallier. 1977. Areas of faulting and potentially unstable sediments in the St. George Basin Region, Southern Bering Sea. *In* Environmental assessment of the Alaskan continental shelf: Principal investigators' reports 17(hazards): 230-241.

Abstract. Preliminary analyses of seismic and sediment data collected during the 1976 field year in the St. George Basin region of the southern Bering Sea continental margin, indicate that the large submarine canyons in the region, the Pribilof and Bering Canyons, exert a profound influence on the sediment distribution and dynamics of the adjacent outer continental shelf region including St. George and Amak Basins. In addition data show that the upper continental slope and shelf break are areas of mass movement of sediment (creeping, slumping, and catastrophic movement as shown by steep scarps). The effects of the canyons on the distribution of sediment and the near-bottom dynamics must be known before man-made structures, whether they be offshore rigs, underwater completion systems, storage facilities, or pipelines, are placed in this area. An investigation of slumping along the continental margin should allow an estimate of the present rate of sediment flux over the outer continental shelf region and what it has been in the past. This study focuses on faulting and potential sediment instability by describing the types and distribution of faults and by outlining areas where potentially unstable sediment masses occur.

Gardner, J.V., H.A. Karl and Q. Huggett. 1986. Origin and development of Zhemchung Canyon (Bering Sea), adjacent continental margin, and abyssal plain as revealed by GLORIA (long-range side-scan sonar) and seismic data. EOS, Transactions, American Geophysical Union 67(44): 1229.

Kaplan I.R., W.E. Reed, M.W. Sandstrom and M.I. Venkatesan. 1977. Characterization of organic matter in sediments from Gulf of Alaska, Bering and Beaufort Seas. *In* Environmental assessment of the Alaskan continental shelf: Principal investigators' reports 13; contaminant baselines: p. 751-838.

Abstract. The paraffin fraction of the high molcular weight hydrocarbons have been identified from sediment samples from the Eastern Gulf of Alaska and the Eastern Bering Sea. In general it has been shown that: The concentrations of total hydrocarbons in surface sediments from both areas, with the exception of one sample near Pribilof Canyon, is low compared to recent marine sediments from other environments; the hydrocarbons in the sediments appear to be derived from a mixture of terrigenous and marine sources. In the Bering Sea, a terrigenous source predominates, while in the Gulf of Alaska, contribution from marine and terrigenous sources is approximately equal; a series of n-alkanes and unresolved hydrocarbons in the n-C21 to n-C23 molecular weight range occurs in some samples from the Bering Sea and many of the sediments of the Gulf of Alaska. The source of these hydrocarbons may be either from petroleum or from unidentified marine organisms; and sediments near the head of Pribilof Canyon appear to contain petroleum derived hydrocarbons. This is in contrast to most other samples of the Bering Sea which have no indications of petroleum addition. Several of the Gulf of Alaska sediments analyzed seem to indicate some petroleum contribution.

Karl, H.A., P.R. Carlson and D.A. Cacchione. 1981. Factors influencing sediment transport at shelf break. American Association of Petroleum Geologists Bulletin, 65(5): 943-943.

Karl, H.A., and P.R. Carlson. 1982. Location and description of sediment samples: Navarin Basin Province, Bering Sea, 1980-81. U.S. Geological Survey Open-File Report 82-0958. 6 pp.

Karl, H.A., and P.R. Carlson. 1982. Large sand waves in Navarinsky Canyon head, Bering Sea. Seafloor stability of continental margins research conference: Geo-Marine Letters 2(3-4): 157-162.

Karl, H.A., P.R. Carlson and David A. Cacchione. 1983. Factors that influence sediment transport at the shelfbreak. *In* Stanley, Daniel Jean and George T. Moore, eds., The shelfbreak; critical interface on continental margins: Society of Economic Paleontologists and Mineralogists Special Publication 33: 219-231.

Abstract: Because the shelf edge bridges shallow and deep ocean environments, sedimentary processes characteristic of each of these provinces interact at the shelfbreak to influence sediment transport in the benthic boundary layer. Sophisticated instruments deployed for long periods of time are necessary to acquire data adequate for an assessment of the forcing mechanisms that control sediment transport. The few existing measurements of this type support the concept that shelfedge processes differ with place and time among continental margins and on any given continental margin.

Karl, H.A., and P.R. Carlson. 1984. Geologic hazards. *In* Carlson, P.R. and H.A. Karl, eds., Surface and near-surface geology, Navarin Basin province; results of the 1980-81 field seasons. U.S. Geological Survey Open-File Report 84-0089, p. 11-14.

Karl, H.A. and P.R. Carlson. 1984. Textural variations of surficial bottom sediment. *In* Carlson, P.R., and H.A. Karl, eds., Surface and near-surface geology, Navarin Basin province; results of the 1980-81 field seasons: U.S. Geological Survey Open-File Report 84-0089, p. 15-20.

Karl, H.A., P.R. Carlson and K.H. Johnson. 1984. Sediment distribution on the outer continental margin of an epicontinental sea; Bering Sea, Alaska. *In* Society of Economic Paleontologists and Mineralogists first annual midyear meeting: Society For Sedimentary Geology Midyear Meeting Abstracts 1: 41-41.

Karl, H.A., D.A. Cacchione and P.R. Carlson. 1986. Internal-wave currents as a mechanism to account for large sand waves in Navarinsky Canyon head, Bering Sea. Journal of Sedimentary Petrology 56(5): 706-714.

Abstract. Sand waves average 5m in height and about 650m in wavelength, with crests oriented subparallel to isobaths and almost perpendicular to the axes of the 2 main branches of the canyon. Speculates that inter-wave currents are responsible for the sand waves. However, the sand waves could have originated in the Pleistocene when Navarinsky Canyon headed in a shallow embayment that was receiving large quantities of sediment discharged by glacial meltwater streams.

Karl, H.A., and P.R. Carlson. 1987. Surface current patterns suggested by suspended sediment distribution over the outer continental margin, Bering Sea. Marine Geology 74(3-4): 301-308.

Abstract. Samples of total suspended matter (TSM) were collected at the surface over the northern outer continental margin of the Bering Sea during the summers of 1980 and 1981. Volume concentrations of surface TSM averaged 0.6 and 1.1 mgl super(-1) for 1980 and 1981, respectively. Organic matter, largely plankton, made up about 65% of the near-surface TSM for both years. Distributions of TSM suggested that shelf circulation patterns were characterized either by meso- and large- scale eddies or by cross-shelf components of flow superimposed on a general northwesterly net drift. These patterns may be caused by large submarine canyons which dominate the physiography of this part of the Bering Sea continental margin.

Karl, H.A., P.R. Carlson, K.H. Johnson and D.M. Rearic. 1987. Grain-size parameters and constituent grain composition of surface sediment in Navarin Basin Province, Bering Sea. U.S. Geological Survey Open-File Report 87-0064, 26 pp.

Kotenev, B. N. 1964. Sea valleys in the continental slope of the Bering Sea. Pages 23-32 *in* P. A. Moiseev (ed.). Soviet fisheries investigations in the Northeast Pacific. Part IV. Sovetskie rybokhozyaistvennye issledovaniya v severo-vostochnoi chasti Tikhogo okeana. Translated from Russian by Israel Program for Scientific Translations, Jerusalem.

Summary. Geomorphology of the continental slope "seavalleys" of the Bering Sea is described, including the northwest continental slope, northeast continental slope (Navarin, Pervenets, Zhemchug, and Pribilof canyons), and Commander-Aleution slope regions. The large seavalleys of the northeast continental slope are 5-25 miles wide, 50-200 miles long, and begin at 100-150 m depth. The vertical transitions that mark the edges of the upper slope

become most dramatic at depths of 500-700 m. The author states that this zone represents a major demarcation that has a profound influence on water mass circulation and likely causes fronts. This characteristic of the upper slope also influences the success of trawling in these areas, as shallow as 300 m. Zhemchug and Pribilof seavalleys are described as being more complex than Navarin or Pervenets, with continental slope sections having "northwestern and sublatitudinal trends". All seavalleys of the northeast slope are troughlike in shape at their heads and resemble canyons in the middle part of the slope.

Kowalik, Z., and P. Stabeno. 1999. Trapped motion around the Pribilof Islands in the Bering Sea. Journal of Geophysical Research 104(C11): 25667-25684.

Abstract. Observations in the region of the Pribilof Islands and Canyon (PIC) reveal a clockwise circulation around the group of islands and around each of the two largest islands, St. Paul and St. George. Six current meters deployed around St. Paul Island revealed a steady clockwise flow around the island, which was strongest south of the island and weakest to the east. We use a high-resolution tidal model in the PIC region to show that this flow pattern results from tidal rectification over the shallow topography tides. Tidal residual currents of 10-15 cm s[-1] were predicted by the model, compared to mean currents of 5-20 cm s[-1] observed at the mooring sites. Both diurnal and semidiurnal tidal oscillations contribute to the clockwise circulation around the islands. In the diurnal band the enhanced currents occur also at the shelf slope where a tidal wave generates a shelf wave due to resonance with topography. In the PIC region the main shelf wave occurs in the Pribilof Canyon where both observations and measurements show enhancement of the diurnal tidal currents.

Lus, V. Y. 1970. Quantitative distribution of benthos on the continental slope of the eastern part of the Bering Sea. Pages 116-124 *in* P. A. Moiseev (ed.). Soviet fisheries investigations in the Northeast Pacific. Part V. Sovetskie rybokhozyaistvennye issledovaniya v severo-vostochnoi chasti Tikhogo okeana. Translated from Russian by Israel Program for Scientific Translations, Jerusalem.

Summary. As part of the USSR Bering Sea Expedition from 1958-60, benthic grab samples were collected across the continental slope. Samples were collected at 102 stations using 0.25 m2 grabs covering depths of 150 - 3045 m. Cruise transects were perpendicular to isobaths, placed at even along the eastern continental slope, with one additional transect extending north from Island of Four Mountains. Dominant taxa from all eastern slope stations combined (average biomass 27 g / m2) were from four groups: polychaetes (26 %), echinoderms (primarily ophiuroids), sponges (23 %), and mollusks (16 % mostly bivalves). The southern slope transect differed markedly from those on the eastern slope (average biomass 626 g / m2) and was primarily composed of sponges (84 %, 527 g / m2) and soft corals (12 %, 76 g / m2). Vertical zonation of overall biomass was observed, decreasing with increasing depth, on all transects. The northern transects contained a zone of high biomass at shallow depths, with the zone expanding and descending to deeper depths at southern transects. In certain transects, biomass was "markedly depleted" over extents as much as 1000 m.

McLean, H. 1979. Pribilof segment of the Bering Sea continental margin: A reinterpretation of Upper Cretaceous dredge samples. Geology 7(6): 307–310.

Abstract. Samples of an Upper Cretaceous sandstone dredged from Pribilof Canyon, Bering Shelf margin, do not compare well with rocks of the Shumagin Formation of presumed Late Cretaceous age on Sanak Island. Contrary to repeated published inferences, the rocks from Pribilof Canyon do not appear to be strongly deformed. They show no evidence of slaty cleavage or penetrative deformation and were probably deposited in a shelf environment at neritic or possibly upper bathyal depth rather than in a trench or deep continental slope basin. The presence of shelf-facies rocks in Pribilof Canyon at the edge of the Bering Shelf leaves little room for a subduction-related accretionary terrane such as exists along the Shumagin shelf near Sanak Island. The concept of strongly folded deep-water trench-facies rocks in Pribilof Canyon has led to the development of Late Cretaceous subduction-related scenarios that include magmatic arcs parallel to the hypothetical subduction zone. Alternative hypotheses include a strike-slip plate boundary along the Pribilof segment of the Bering margin, which is consistent with the petrographic character of the Pribilof Canyon rocks, or a transitional trench-transform boundary–for example, the modern central to western Aleutian Trench.

Normark, W.R., and P.R. Carlson. 2003. Giant submarine canyons: Is size any clue to their importance in the rock record? Geological Society of America Special Paper 370. 16 pp.

Abstract. Submarine canyons are the most important conduits for funneling sediment from continents to oceans. Submarine canyons, however, are zones of sediment bypassing, and little sediment accumulates in the canyon until it ceases to be an active conduit. To understand the potential importance in the rock record of any given submarine canyon, it is necessary to understand sediment-transport processes in, as well as knowledge of, deep-sea turbidite and related deposits that moved through the canyons. There is no straightforward correlation between the final volume of the sedimentary deposits and size of the associated submarine canyons. Comparison of selected modern submarine canyons together with their deposits emphasizes the wide range of scale differences between canyons and their impact on the rock record. Three of the largest submarine canyons in the world are incised into the Beringian (North American) margin of the Bering Sea. Zhemchug Canyon has the largest cross-section at the shelf break and greatest volume of incision of slope and shelf. The Bering Canyon, which is farther south in the Bering Sea, is first in length and total area. In contrast, the largest submarine fans—e.g., Bengal, Indus, and Amazon—have substantially smaller, delta-front submarine canyons that feed them; their submarine drainage areas are one-third to less than one-tenth the area of Bering Canyon. Some very large deep-sea channels and turbidite deposits are not even associated with a significant submarine canyon; examples include Horizon Channel in the northeast Pacific and Laurentian Fan Valley in the North Atlantic. Available data suggest that the size of turbidity currents (as determined by volume of sediment transported to the basins) is also not a reliable indicator of submarine canyon size.

Palacios, R. 1987. Community structure of the macro epifauna of the Pribilof Islands. Ph.D. Dissertation, University of Washington, School of Fisheries, Seattle, WA. 112 p.

Abstract. The macrobenthos of the Pribilof Islands was surveyed on three cruises of the R/V MILLER FREEMAN in May and August 1983 and April 1984. Information on the dominant species as numbers per hectare was used to perform cluster analyses to investigate the community structure. Using the Bray-Curtis coefficient and flexible sorting strategy (B = -0.5) 3 groups of stations were defined throughout the cruises. Cluster Group 1composed stations located nearshore, around St. Paul Island and east of St. George Island. Characteristics of these stations were rocky bottoms with large deposits of shellhash. Dominant species included sea urchins (*Strongylocentrotus droebachiensis*), several bivalves (*ChlamysI* sp., *Pododesmus macrochisma*, and Mytillid mussels), the gastropod *Fusitriton oregonensis*, starfish *Henricia* sp., sea cucumber *Cucumaria* sp., barnacles, hermit crab *Elassochirus cavimanus*, *Cancer oregonensis* crab and juvenile blue king crab (*Paralithodes platypus*). Stations in Cluster Group 3 were found in the basin between the two main islands over sand-mud bottoms. Dominant species were Tanner crab (*Chionoecetes* sp.)hermit crabs (*Labidochirus splendescens* and *Pagurus ochotensis*), adult blue king crab (*P. platypus*), gastropods of the genus *Neptunea* sp. and the flatfishes *Lepidopseta bilineata* and *Hippoglossoides elassodon*. Stations in Cluster Group 2 were intermediate between the other two groups both in their geographic location, substrate characteristics, and dominant species.

Reed, R.K. 1991. Circulation and Water Properties in the Central Bering Sea During OCSEAP Studies, Fall 1989-Fall 1990. NOAA Technical Report ERL 446.

Abstract. Data from three CTD surveys conducted during Outer Continental Shelf Environmental Assessment Program (OCSEAP) cruises in the central Bering Sea during fall 1989, spring 1990, and fall 1990 are used to examine circulation and property distributions. Geostrophic flow was quite variable, except in Pribilof and Zemchug Canyons where it was consistently westward. The variability of flow and small transports are difficult to reconcile with any permanent current system. The relatively cold temperatures near the temperature maximum suggest the absence of inflow through Amukta Pass near 172 degree W. The distributions of nutrients in fall 1989 and spring 1990 are also presented and discussed.

Schumacher, J. D. and R. K. Reed. 1992. Characteristics of currents over the continental slope of the eastern Bering Sea. Journal of Geophysical Research- C Oceans 97(6): 9423-9433.

Abstract. Between September 1989 and 1990, twenty-six current records were collected by instruments on eight moorings located in Pribilof and Zhemchug canyons, and at a site midway between these features. These records provide the first long-term Eulerian measurements from the slope and mid-slope of the eastern Bering Sea. Results from the current records, together with water property observations, permit a characterization of the Bering Slope Current. Moderate flow (similar to 2 to 18 cm/s) followed the bathymetry toward the northwest and existed primarily in the upper 300 m. Wind and current energy increased in winter, but vector mean current did not increase at all sites. Wind forcing accounted for only a small fraction of the current fluctuations. At one mid-slope location in Pribilof Canyon, bathymetry resulted in rectification of the strong daily tidal current. Estimates of heat and salt fluxes indicate some significant shoreward transport; however, this flux did not occur preferentially in the canyons.

Starratt, S. W. 1993. Late Quaternary paleoceanography of the Pervenets Canyon area of the Bering Sea: evidence from the diatom flora. Diatom Research 8(1): 159-170.

Abstract. Sediments from three gravity cores from an east-west shelf-to-slope transect along the axis of Pervenets Canyon in the northern Navarin basin, Bering Sea were analyzed for diatoms. The diatom floras present in the cores were divided into four assemblages following Sancetta (1981). The Bering Basin (deep water open ocean) and Sea Ice (ice cover at least six months per year) Assemblages were dominant in each core. The taxa that comprise the Bering Shelf Assemblage (continental shelf) indicate that downslope transport plays only a minor part in the development of the thanatocenoses. The presence (up to 10% of the total valve count) of the Productivity Assemblage, which consists mainly of poorly silicified, easily dissolved taxa, indicates that nutrient flux is relatively high in the region

Starratt, S. W. 1995. Latest Quaternary foraminifers and sediment transport in Pervenets Canyon, Bering Sea. Marine Micropaleontology 26(1-4): 233-243.

Abstract. A combination of microfossil and sediment analysis has been used in an attempt to understand oceanographic processes and the late Quaternary history of the Pervenets Canyon region. The primary sedimentation process in Pervenets Canyon is downslope transport. Near the shelfbreak, there is evidence of turbidite and debris-flow activity, but at the distal end of the upper canyon and on the continental slope there is nomacroscopic evidence for these processes. Analysis of the foraminiferal assemblages shows that the fauna is 97.6% from the Suborder Rotaliina and about 2.0% from the Suborder Textulariina. The Suborder Miliolina accounts for approximately 0.4% of the fauna. The Pervenets Canyon fauna is most similar to other faunas from the Bering Sea, indicating a North Pacific Ocean influence on the fauna. Foraminiferal abundance and species diversity vary widely in the samples studied. The major factors controlling these values are downslope transport of sediment, disintegration of arenaceous taxa, dissolution of calcareous taxa, and diversity limited by low-oxygen bottom waters. Downslope transport of shelf species is indicated by the presence of Elphidium clavatum and E. Excavatum. Shallow-shelf and low-oxygen foraminiferal faunas are often intermixed in the samples. The distribution of these low-oxygen faunas in Core 81-65 suggests that the oxygen-minimum zone fluctuated with sea level.

Shin, K.-H., and N. Tanaka. 2004. Distribution of dissolved organic matter in the eastern Bering Sea, Chukchi Sea (Barrow Canyon) and Beaufort Sea. Geophysical Research Letters 31(24).

Abstract. The distribution of dissolved organic carbon (DOC) in the western Arctic Ocean is greatly influenced by conservative riverine DOC flux into the northern Bering Sea, Bering Strait and Beaufort Sea, as indicated by an inverse correlation with salinity. Based on the relations between DOC, salinity and seawater temperature, several water masses could be identified. These included riverine water, ice-melt water, surface mixed water, cold and saline shelf water, and Atlantic Ocean water. High concentrations of chlorophyll *a* and DOC were found in some parcels of dense shelf water in Barrow Canyon. In addition, labile DOC compounds, such as polyunsaturated fatty acids (PUFA), were found in the dense shelf water, suggesting the dense shelf water contains a product (marine organic matter) of the biological CO_2 pump.

Swartzman, G., J. Napp, R. Brodeur, A. Winter, and L. Ciannelli. 2002. Spatial patterns of pollock and zooplankton distribution in the Pribilof Islands, Alaska nursery area and their relationship to pollock recruitment. ICES Journal of Marine Science 59(6): 1167-1186.

Abstract. Data from six years, September 1994-1999, of bio-acoustic surveys near the Pribilof Islands, Alaska, (AK), from which age-0 walleye pollock (Theragra chalcogramma) school and zooplankton patch locations have been extracted, were analysed using image-processing methods. Multiple passes along four transects in this major pollock nursery area were examined. The data showed high year-to-year variability in overall abundance of both fish and plankton, but consistent abundance differences between the transects. Juvenile pollock abundance was generally highest in the shallow shelf region to the north of the Pribilof Islands and lowest in the mouth of the Pribilof Canyon to the south. Plankton biomass patterns tended to be the reverse. Fronts and regions within the transects were identified based on changes in hydrography (e.g. vertical stratification) and bathymetry. Diel migration patterns of pollock and zooplankton within these regions appear to depend on the degree of stratification, the depth, the size of the pollock and the relative abundance of the pollock and zooplankton. Several hypotheses are also discussed concerning the relationship of pollock recruitment year-class strength to large year classes including differences in the environmental conditions, the pervasiveness of the pollock, the size of juvenile pollock and the density of predators.

Wilson, M.T., A.H. Andrews, A.L. Brown and E.E. Cordes. 2002. Axial rod growth and age estimation of the sea pen, *Halipteris willemoesi* Kölliker. Hydrobiologia 471: 133–142.

Abstract. *Halipteris willemoesi* is a large octocoral commonly found in the Bering Sea. It is a member of a ubiquitous group of benthic cnidarians called sea pens (Octocorallia: Pennatulacea). Sea pens have a skeletal structure, the axial rod, that in cross section exhibits growth rings. Pairs of adjacent rings, or ring couplets, were assumed to be annuli and were used to estimate the age and growth of *H. willemoesi*. Twelve axial rods, extracted from *H. willemoesi* collected in the Bering Sea, were selected to represent small (25–29 cm total length), medium (97–130 cm TL) and large (152–167 cm TL) colonies. Each rod resembled a tapered dowel; the thickest part (0.90–6.75 mm in diameter) was at about 5–10% of total length from the base tip, the distal part was more gradually tapered than was the base. The number of ring couplets increased with rod size indicating their utility in estimating age and growth. Estimated age among rods was based on couplet counts at the thickest part of each rod; the average estimated age (±SE) was 7.1 ±0.7, 19.3 ±0.5, and 44.3 ±2.0 yr for small, medium and large-size rods, respectively. Based on these estimated ages, average growth rate in total length was 3.9 ± 0.2, 6.1 ± 0.3, and 3.6 ± 0.1 cm yr−1 for small, medium, and large-size colonies. The average annual increase in maximum rod diameter among all colonies was 0.145 ± 0.003 SE mm yr−1; therefore, age prediction from maximum rod diameter was calculated (estimated age (yr) = 7.0 * (maximum rod diameter, mm) −0.2; *R*2 = 0.99). At maximum diameter, the average couplet width was relatively constant among the three colony sizes (0.072 ± 0.05 mm). X-ray diffraction and electron microprobe analyses revealed that the inorganic portion of the rod is composed of a high-magnesium calcite. Radiometric validation of these age and growth rate estimates was attempted, but high amounts of exogenous 210Pb precluded using the disequilibria of 210Pb:226Ra. Instead, 210Pb activities were measured in a series of cores extracted along the axial rod. These activities ranged from 0.691 ± 0.036 (SE) to 2.76 ± 0.13 dpm g−1, but there was no pattern of decay along the length of the rod; therefore, the growth rates and corresponding ages could not be validated. Based on estimated age from ring couplet counts, growth in total rod length is slow at first, fastest at medium size, and slows toward maximum size, with an estimated longevity approaching 50 yr.

Contributors

RACE: R. McConnaughey (lead), M. Amend, M. Busby, J. Hoff, D. Nichol, C. Rose, K. Smith

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Appendices attached as follows:

Appendix 1 – Skate Nurseries
Appendix 2 – Brodeur (2001)
Appendix 3 – Wilson *et al.* (2002)
Appendix 4 – Busby *et al.* (2005)

AGENDA D-3
Supplemental
APRIL 2007

Pribilof Islands Stewardship Program
P.O. Box 938
St. George Island, AK 99591
907-859-2233
907-859-2297 fax

19 March 2007

Stephanie Madsen, Chair
North Pacific Fishery Management Council
605 W. 4th Ave.
Anchorage, AK 99501

RECEIVED
MAR 2 2007
N.P.F.M.C.

RE: Bering Sea Habitat Conservation, Agenda Item D-3

Dear Madame Chair and Members of the Council,

We understand that the Council has removed canyons from the Bering Sea Habitat Environmental Assessment. This is of great concern because of the importance of the Pribilof Canyon to our fisheries and other marine life we depend on for our traditional way of life and local commercial fisheries. We strongly recommend that you consider protection measures for the Pribilof Canyon. If not in this analysis, we request that you do so in a separate follow up action.

Being subsistence users of the local marine resources, the residents of St. George/St. Paul are directly affected by large scale fisheries that take place in and around our islands and whole the Bering Sea. We are concerned about the effects of bottom trawling on the health of the ocean and habitats. The Pribilof Canyon is an engine for the productivity of all marine life in our area. The health of the canyon is critical to the health of our island, not only for people and fisheries, but for our seals and seabirds as well. It is important that we maintain a healthy ecosystem so that we have something to pass on to our young people.

The damaging effects of bottom trawling on sensitive habitats are well established. The canyons contain habitat characteristics that need to be protected from gear dragged on the seafloor. For the same reasons that the Council protected habitats in the Aleutian Islands, we request that you consider a bottom trawl closure for the Pribilof Canyon. This would not preclude fisheries from continuing there but it would protect seafloor habitats from unnecessary damage.

Sincerely,

Karin Holser
Coordinator

ALEUT COMMUNITY OF ST. PAUL ISLAND
TRIBAL GOVERNMENT

President
Robert Melovidov, Sr.
Vice President
Vladimir Melovidov
Secretary-Treasurer
Jessica Mata Rukovishnikoff
Council Members
Thomas Bourdukofsky
Maxim Buterin, Jr.
Dustin Jones
Carol Melovidov

March 21, 2007

RECEIVED
MAR 2007
N.P.F.M.C.

Stephanie Madsen, Chair
North Pacific Fishery Management Council
605 W. 4th Avenue
Anchorage, Alaska 99501

RE: Bering Sea Habitat Conservation, Agenda Item D-3

Dear Madame Chair and Members of the Council,

The Council is considering management measures for the conservation of important habitats in the Bering Sea. We understand that the Council has removed canyons from the Bering Sea Habitat Environmental Assessment. This is of great concern because of the importance of the Pribilof and Zemchug Canyons to our fisheries and other marine life we depend on for our local commercial fisheries and traditional way of life. We strongly recommend that you consider protection measures for the Pribilof and Zemchug Canyons. If not in this analysis, we request that you do so in a separate follow up action.

As commercial fishermen, subsistence fishers and hunters, and residents of St. Paul Island, we are directly affected by large scale fisheries that take place in our region of the Bering Sea. We are concerned about the effects of bottom trawling on the health of the ocean and habitats. The Pribilof and Zemchug Canyons are engines for the productivity of all marine life in our area. The health of the canyons are critical to the health of our island, not only for our people and fisheries, but for our fur seals, sea lions, harbor seals, and seabirds as well.

The damaging effects of bottom trawling on sensitive habitats are well established. The canyons contain habitat characteristics that need to be protected from gear dragged on the seafloor. For the same reasons that the Council protected habitats in the Aleutian Islands, we request that you consider a bottom trawl closure for the Pribilof and Zemchug Canyons. This would not preclude fisheries from continuing there but it would protect seafloor habitats from unnecessary damage.

Qaĝaalakux...Thank you,

Robert W. Melovidov, Sr.
President

Cc. Phillip A. Zavadil and Aquilina D. Lestenkof, Co-Directors, ACSNP-TG-Ecosystem Conservation Office
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