AGENDA D-2(b)
OCTOBER 2009

MEMORANDUM

TO: Council, SSC and AP Members

FROM: Chris Oliver
Executive Director

DATE: September 24, 2009

SUBJECT: GOA Chinook salmon and Tanner crab bycatch

ESTIMATED TIME 6 HOURS ALL D-2 ITEMS

ACTION REQUIRED

(b) Review discussion paper on GOA Chinook salmon and Tanner crab bycatch

BACKGROUND

In June 2008, the Council asked staff to update a discussion paper on salmon and crab bycatch in the GOA groundfish fisheries, and focus specifically on particular species and areas with potentially high bycatch levels: Chinook salmon and *Chinoecetes bairdi* Tanner crab, in the central and western GOA. Also, the Council asked staff to identify strawman closure areas as bycatch reduction measures for Chinook salmon and Tanner crab. The discussion paper was updated and reviewed by the Advisory Panel in December 2008, but the Council was not able to take up the agenda item at that meeting. The discussion paper was modified slightly, and sent again to the Council in mid-September.

The discussion paper was mailed to you on September 14, 2009. Staff will provide a general overview of bycatch levels of Chinook and bairdi crab in groundfish fisheries, Chinook and bairdi directed fisheries, and species abundance. As requested, an explanation of the procedures used for estimating Chinook and bairdi bycatch in the GOA groundfish fisheries is also included. In previous iterations of this discussion paper, preliminary alternatives have been proposed for bycatch management measures, and they are included here, along with strawman closures representing areas with high bycatch.

The discussion paper that is being reviewed at this meeting is basically similar to the one from November 2008 (which was reviewed by the AP) and that from March 2009. The main difference is that in the November 2008 draft, the maps of bycatch rate (number of Chinook or crab per mt of total catch) were inaccurate, because the dataset for the November 2008 paper included only tows/sets with Chinook or bairdi bycatch, and did not include all tows/sets within each area (i.e., 'clean' tows/sets). For the March and September 2009 versions, the maps were updated with data from 2001 to 2008. We retained the strawman created using the 2003-2007 data, from the November 2008 draft, but compared them with 2001-2008 bycatch distribution.

At this meeting, the Council is scheduled to review the discussion paper, and if appropriate, initiate an analysis, with a problem statement and alternatives. The AP reviewed this discussion paper in December 2008, and their minutes are attached as <u>Item D-2(b)(1)</u>. The SSC last reviewed an iteration of this discussion paper in April 2008, and their minutes are attached as <u>Item D-2(b)(2)</u>.

EXCERPT – ADVISORY PANEL MINUTES
North Pacific Fishery Management Council
December 8 – December 12, 2008, Anchorage Hilton Hotel

Approved_______________________________ Date___________

The following members were present for all or part of the meeting:

Joe Childers	Tim Evers	Matt Moir
Mark Cooper	Bob Gunderson	John Moller
Craig Cross	Jan Jacobs	Rex Murphy
John Crowley	Bob Jacobson	Ed Poulsen
Julianne Curry	Simon Kinneen	Michelle Ridgway
Jerry Downing	Chuck McCallum	Beth Stewart
Tom Enlow	Mike Martin	Lori Swanson

D-2 (d) GOA salmon and crab bycatch

Whereas the GOA Chinook salmon and bairdi bycatch levels reported thusfar do not appear to have significant impacts on conservation of those stocks, the AP acknowledges that further analysis of these issues may provide insights regarding how we may improve our continuing efforts to minimize bycatch in federal fisheries for which the Council is responsible.

Toward this end, the AP recommends that the Council request staff to develop a refined discussion paper that addresses the following alternatives and concepts.

Chinook Salmon

Alternative 1: Status quo (no bycatch controls).

Alternative 2: Trigger bycatch limits for salmon. Specific areas with high bycatch (or high bycatch rates) are closed seasonally (could be for an extended period of time) if or when a trigger limit is reached by the pollock fishery.

Alternative 3: Seasonal closure to all trawl fishing in areas with high bycatch ~~or~~ **and** high bycatch rates.

Alternative 4: Voluntary bycatch cooperative for hotspot management.

C. bairdi

Alternative 1: Status Quo (no bycatch controls).

Alternative 2: Trigger bycatch limits for Tanner crab. Specific areas with high bycatch (or high bycatch rates) are closed for the remainder of the year if or when a trigger limit is reached by:

Options: a) trawl flatfish fishery
b) all bottom trawling
c) groundfish pot

Alternative 3: Year-round closure in areas with high bycatch ~~or~~ **and** high bycatch rates of Tanner crab by gear type.

Alternative 4: Voluntary bycatch cooperative for hotspot management.

OPTION: require 100% observer coverage for all pot and trawl vessels operating in the federal waters with tanner crab strawman closure areas.

The AP also recommends the Council make funding for genetic testing on salmon bycatch a priority.
Motion passed 19/0

EXCERPT FROM THE DRAFT REPORT of the SCIENTIFIC AND STATISTICAL COMMITTEE to the NORTH PACIFIC FISHERY MANAGEMENT COUNCIL
March 31 to April 2, 2008

The SSC met during March 31 to April 2, 2008 at the Hilton Hotel, Anchorage, Alaska. Members present were:

Pat Livingston, Chair
NOAA Fisheries—AFSC
Keith Criddle, Vice Chair
University of Alaska Fairbanks
Robert Ames
Oregon Department of Fish and Wildlife
Bill Clark
International Pacific Halibut Commission
Sue Hills
University of Alaska Fairbanks
Anne Hollowed
NOAA Fisheries—AFSC
George Hunt
University of Washington
Kathy Kuletz
US Fish and Wildlife Service
Seth Macinko
University of Rhode Island
Franz Mueter
SigmaPlus Consulting
Lew Queirolo
NMFS—Alaska Region
Terry Quinn II
University of Alaska Fairbanks
Doug Woodby
Alaska Department of Fish and Game

Members absent were:

Gordon Kruse
University of Alaska Fairbanks
Farron Wallace
Washington Dept of Fish and Wildlife

D-1 (b) GOA Crab and Salmon Bycatch

Diana Stram (NPFMC) reported on a discussion paper on Gulf of Alaska salmon and crab bycatch in groundfish fisheries. This issue was originally included in the GOA Rationalization EIS and only recently has been elevated as an independent issue. The last time the SSC reviewed this issue was in 2005. Further action on this issue is dependent on a request from the Council. The current analysis is dated. Some aspects of the analysis will be updated, if the Council requests further action on this issue. The present document does include additional information on actual observed coverage levels in the GOA groundfish fisheries, based on new information provided by Jennifer Hogan (NMFS). Public comment was provided by Julie Bonney (Alaska Groundfish Databank), John Gauvin (Head and Gut Workgroup), and Therese Peterson (Alaska Marine Conservation Council).

The report shows bycatches of Tanner crab and Chinook salmon have increased in recent years. The majority of Tanner crab is taken in the flatfish and cod fisheries. The majority of Chinook is taken in the pollock fisheries. In the case of Pacific cod and flatfish, a large fraction of the fleet has been unobserved, making accurate bycatch accounting problematic. The proposed alternatives currently included in the discussion paper are the same as those considered in the BSAI salmon bycatch initiative. **The SSC concludes that the document does not provide sufficient information to assess whether current trends in salmon or crab bycatch are either a conservation or an economic concern. The SSC recommends adding the following information to improve the analysis, in the event that the Council chooses to have this analysis go forward.**

Where possible, the SSC requests that bycatch trends should be compared to trends in stock status and the target fishery, to differentiate between an increase in fishing mortality and an increase in encounter rates with PSCs. For example, it is not clear whether the increase in Tanner crab bycatch is a result of unrepresentative expansion of a small number of observed catch records, recovery of crab populations in the GOA, or a change in the groundfish target species. To aid in differentiating between these factors, the SSC requests a table showing ADF&G's trawl survey crab abundance data and a summary of salmon run size relative to escapement goals.

The SSC does not recommend using CPUE to assess chum salmon abundance. This estimator could be biased. Also, SSC requests that Table 7 be edited to include units of measurement.

The SSC is concerned about the low levels of observer coverage in the GOA groundfish fisheries. There appear to be high levels of uncertainty in the bycatch estimates of salmon and crab in the GOA, and this should be discussed relative to the ability to properly identify the impacts of alternatives. Furthermore, implementation of a trigger-dependent bycatch program is likely to be ineffective, due to the large portion of the fleets that are unobserved.

If this analysis goes forward, the Council may want to consider splitting the alternatives or the amendment to separate the crab analysis from the analysis for salmon. This might be necessary in order to account for the differences in crab and salmon behavior and thus differences in mitigation measures needed to reduce bycatch for each species.

AGENDA D-2(b)
Supplemental
OCTOBER 2009

Eric Olson, Chair
North Pacific Management Council
605 W Fourth Ave.
Anchorage AK 99501

Steve Branson
Crewmen's Association
Box 451
Kodiak, AK 99615

RE; GOA Tanner Crab discussion paper

Dear Chairman Olson,

As a serial participant in the Kodiak tanner crab fishery I appreciate the Councils actions to gather information on the bycatch of Bairdi in the GOA groundfish fishery. During the 2009 tanner season, in front of Ugak and Kiluda bays, I personally observed numerous crabs adorned with trawl chafing gear on their carapaces, as well as a high rate of missing legs. Similar reports I heard from other fishermen convince me bottom trawling and intensive groundfish pot fishing in areas of high crab abundance is detrimental to the rebuilding of our collapsed stocks.

I hope that in developing alternatives for analysis the Council considers options that will reduce groundfish effort in tanner grounds and increase bycatch reduction measures in the trawl and pot sectors.

Thank you for your time

Steve Branson

Polar Star, Inc.

Patrick J. Pikus, President
P.O. Box 2843 Kodiak, AK 99615
907-486-5258 pikus@acsalaska.net

September 28, 2009

Eric Olson, Chair
North Pacific Fishery Management Council
605 W. 4th Ave. Suite 306
Anchorage, AK 99501

RE: Agenda item D2b, Discussion Paper on GOA Tanner and Chinook Bycatch.

Dear Chair Olson:

I own and operate the 58-foot F/V Polar Star, which fishes for salmon, halibut, sablefish, p-cod and tanner crab here in the Gulf of Alaska. I have fished here since 1972, and all of these fisheries are important to my livelihood. The tanner crab fishery has historically been a vital part of the GOA fisheries; I and many others here would like to see the Tanner crab stocks rebuild to the point where we can have a successful Tanner crab fishery again.

I would like to encourage the council to move forward with an analysis of options to limit Tanner crab bycatch here in the Gulf of Alaska. We must first get a handle on the bycatch of Tanner crab if we are ever to truly see these important stocks rebuild to historic levels.

Thank you for your consideration.

Sincerely,

Patrick J. Pikus
Polar Star, Inc.

Alaska Marine Conservation Council

September 28, 2009

Eric Olson, Chair
North Pacific Fishery Management Council
605 W. Fourth Ave.
Anchorage, AK 99501

RE: Agenda Item D-2 (b) Discussion paper on GOA Tanner and Chinook bycatch

Dear Chairman Olson,

Since 2004 the Council has received multiple letters each signed by at least 100 Kodiak Island fishermen requesting management measures to protect Tanner crab. Included in this packet is an additional sign on letter addressing the same issue. Fishermen are concerned about increasing trawl effort in areas important for Tanner crab. We appreciate the Council's effort to develop information about the interaction between groundfish fisheries and Tanner crab through a series of discussion papers. We believe the time has come to move forward with an analysis of alternatives that reduce trawling in important Tanner crab grounds and reduce bycatch in both trawl and pot gear sectors.

1. The Tanner crab fishery is important for the diversified local fishing fleet on Kodiak Island.

   Stock assessment surveys around Kodiak Island indicate the Tanner crab population is rebuilding presumably due to favorable environmental conditions. The total allowable catch for the directed Tanner crab fishery around Kodiak Island for 2009 is 400,000 pounds, down 100,000 pounds from 2008, and down for a fourth consecutive year. However, area crab biologists project promising recruitment and harvest 2-3 years from now. Present action is needed to support the anticipated population trend, particularly as crab move offshore. As the Council has addressed trawl fleet requests that have the effect of expanding opportunity in the flatfish fisheries (e.g. higher MRA in the arrowtooth flounder fishery; transferring of halibut bycatch savings from rockfish to flatfish), the pot fleet has asked for measures to moderate trawl impact on Tanner crab. Management measures are needed that balance benefit for everyone and the community as a whole.

2. The Tanner crab discussion papers show there are significant gaps in observer data.

   There is large variability in the numbers that is not likely to reflect accurate encounters with Tanner crab. While this is the best available bycatch data, it may not be especially useful in establishing bycatch caps. Perhaps even more importantly, low observer coverage stymies monitoring of bycatch caps since most of the vessels are observed only 30% of the time or not at all.

(over)

PO Box 101145 Anchorage, AK 99510 907-277-5357 907-277-5975 www.akmarine.org amcc@akmarine.org

In 2008 AMCC and the Groundfish Data Bank pursued an intensive observer program to generate accurate information for one designated area. However, the mechanics of implementing the plan eluded us as the cost of observer coverage above what is required by regulation appeared to be quite high and funding was not available. In order to implement such a plan there would need to be a commitment from ADFG and/or NMFS Observer Program which was not forthcoming at that time given the short timeframe that we wanted to put a significant program into effect. We sincerely hope management agencies, industry and AMCC can collaborate in the future as there is good will among all parties to resolve observer program issues.

3. <u>As the Council pursues improvements to the Gulf observer program, conservation of Tanner crab remains a problem needing a solution.</u>

   Currently there are no conservation measures designed for Tanner crab in the Gulf of Alaska. The Red King Crab Type I and II areas and the state water bottom trawl closure around Kodiak Island provide some shelter for Tanner crab but there are distinct areas of biological concern in federal waters that remain unaddressed. Recently ADFG made a decision to prohibit fishing by the directed Tanner crab pot fishery in inner bays to address conservation concerns of fishing effort on rebuilding crab stocks. It is time to develop measures specific and appropriate for trawl and pot sectors targeting groundfish.

4. <u>Measures to protect Tanner crab should consider habitat impact and bycatch.</u>

   In 2005 the Council adopted certain measures to protect EFH based on a determination that bottom trawl gear has the most impact on seafloor habitat. Reinforcing that determination is a study conducted by scientists at the NMFS Auke Bay Lab that measured differences between two Type I trawl closures around Kodiak Is. compared to adjacent areas open to trawling. In this study they found the open areas to have less epifaunal abundance and diversity and less abundance of biogenic structures. "Evidence exists that bottom trawling has produced changes to the seafloor and associated fauna…." (Stone, R., M.M. Masuda, and P.W. Malecha. 2005. Effects of bottom trawling on soft sediment epibenthic communities in the Gulf of Alaska. In: P.W. Barnes and J.P. Thomas (editors), Benthic Habitats and the Effects of Fishing. Am. Fish. Soc. Symposium 41. pp. 461-475.) (See attached.)

   In developing alternatives for analysis, we urge the Council to consider options that reduce trawl effort in important Tanner crab grounds as well as bycatch controls in the trawl and pot gear sectors.

Sincerely,

Theresa Peterson

Theresa Peterson
Kodiak Outreach Coordinator

American Fisheries Society Symposium 41:461–475, 2005

Effects of Bottom Trawling on Soft-Sediment Epibenthic Communities in the Gulf of Alaska

ROBERT P. STONE,[1] MICHELE M. MASUDA,[2] AND PATRICK W. MALECHA[3]
Auke Bay Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, 11305 Glacier Highway, Juneau, Alaska 99801-8626, USA

Abstract. The goal of this study was to determine if chronic bottom trawling in some of the more heavily trawled areas in the central Gulf of Alaska has altered soft-bottom marine communities. Spatial distribution and abundance of epifauna were examined at two sites that overlapped areas open to trawling and closed areas where bottom trawling had been prohibited for 11–12 years. Video strip transects of the seafloor were collected at each site from a manned submersible. Transects were bisected by the boundary demarcating open and closed areas. The positions of 155,939 megafauna were determined along 89 km of seafloor. At both sites, we detected general and site-specific differences in epifaunal abundance and species diversity between open and closed areas, which indicate the communities in the open areas had been subjected to increased disturbance. Species richness was lower in open areas. Species dominance was greater in one open area, while the other site had significantly fewer epifauna in open areas. Both sites had decreased abundance of low-mobility taxa and prey taxa in the open areas. Site-specific responses were likely due to site differences in fishing intensity, sediment composition, and near-bottom current patterns. Prey taxa were highly associated with biogenic and biotic structures; biogenic structures were significantly less abundant in open areas. Evidence exists that bottom trawling has produced changes to the seafloor and associated fauna, affecting the availability of prey for economically important groundfish. These changes should serve as a "red flag" to managers since prey taxa are a critical component of essential fish habitat.

Introduction

Diverse benthic communities on the continental shelf and upper slope of the Gulf of Alaska (GOA) support important commercial fisheries for demersal fishes (i.e., groundfish; Mueter and Norcross 2002). Combined groundfish landings from bottom trawl and longline fisheries averaged more than 202,000 metric tons per year from 1963 to 2000 (NPFMC 2000). Understanding the effects of this level of fishing effort on seafloor habitats can aid fisheries managers in developing strategies to manage fishing effects on fish habitat. The focus on fish habitat is pursuant to the essential fish habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (U.S. Department of Commerce 1996).

Previous studies worldwide have determined that bottom trawling alters seafloor habitat and directly and indirectly affects benthic communities (Jones 1992; Auster et al. 1996; Auster and Langton 1999). In addition to removing target species, bottom trawling incidentally removes, displaces, or damages nontarget species (Ball et al. 2000), changes the sedimentary properties of the seafloor (Churchill 1989), and reduces habitat complexity by physically altering biogenic structures on the seafloor (Schwinghamer et al. 1998). Such changes can lead to population level effects on species of economic importance (Lindholm et al. 1999). Ultimately, the combination of effects may result in wide-scale ecosystem change (Gislason 1994; Goñi 1998). The degree of alteration likely depends on many factors, including (1) gear type, (2) spatial and temporal intensity of trawling, (3) substrate characteristics, (4) oceanographic conditions near the seafloor, and (5) the resilience of components of benthic communities (Jones 1992; Auster and Langton 1999). These factors may be geographically specific, so generalizing the effects of trawling over broad geographical areas may not be prudent.

Gulf of Alaska bottom trawl fisheries use only otter trawls, and the gear is quite variable depending on vessel size and target species. Gear consists of five major components that either contact or potentially con-

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tact the seafloor: (1) the wings and bridles, (2) otter boards or doors, (3) sweeps, (4) footrope, and (5) the cod end. Door spread (i.e., total width of trawl system when fishing) may reach 110 m, but the area of the seafloor and associated epifauna contacted by the gear depends on the design of the otter boards and the configuration of protective gear (e.g., rubber disks, bobbins, chafing gear) used on the sweeps, footrope, and cod end. The morphology, behavior, and spatial distribution of epifauna are also important determinants in this interaction.

Chronic effects of fishing disturbances are difficult to distinguish from natural changes due to a lack of potential reference sites where bottom trawling has not occurred for any significant period. In April 1987, the North Pacific Fishery Management Council closed two areas near Kodiak Island, Alaska, to bottom trawling year-round (Type 1 areas). Use of scallop dredges is also prohibited in Type 1 areas. The closures are intended to rebuild severely depressed stocks of Tanner crab *Chionoecetes bairdi* (also known as southern Tanner crab) and red king crab *Paralithodes camtschaticus* by protecting juvenile habitat, areas used during molting, and migratory corridors. In addition to crab resources, the closed areas and areas immediately adjacent to them support rich stocks of groundfish including flathead sole *Hippoglossoides elassodon*, butter sole *Pleuronectes isolepis*, Dover sole *Microstomus pacificus*, rex sole *Errex zachirus*, Pacific halibut *Hippoglossus stenolepis*, arrowtooth flounder *Atheresthes stomias*, Pacific cod *Gadus macrocephalus*, walleye pollock *Theragra chalcogramma*, and several species of rockfish *Sebastes* spp. (Martin and Clausen 1995). Consequently, in areas immediately adjacent to the closed areas, bottom trawling occurs year-round, with peak activity occurring in the spring, summer, and fall for flatfish and Pacific cod and during the summer for walleye pollock.

The proximity of the closed and open areas provided a rare opportunity to investigate chronic effects of bottom trawling on a productive, deep-water (>100 m), soft-bottom marine community located on Alaska's continental shelf. Our goal was to determine if fine-scale differences in community structure exist between areas that were trawled each year and areas where bottom trawling had been prohibited for 11–12 years. Additionally, since the areas open to trawling at the study sites are among the more heavily trawled sites in the GOA (Rose and Jorgensen 2005, this volume), effects observed could be considered a "worst case scenario" for this habitat type in the GOA. In 1998 and 1999, studies were initiated to determine if changes had occurred to the infauna and epifauna community structure and the sedimentary, chemical, and biogenic properties at three sites open to bottom trawling. Previous analyses indicated that the sedimentary and chemical properties of the seafloor in areas open to trawling differed from those in the closed areas, but differences in infauna abundance and species diversity were not detected (Stone and Masuda 2003). Here, we report our findings specific to trawl-induced changes to epifaunal community structure and biogenic structures on the seafloor.

Methods

Study Area

Study sites were established along the boundaries of two area closures (Figure 1). Study sites were chosen based on two criteria: (1) the seafloor consisted of a soft-bottom substrate (i.e., sand, silt, or clay) that was relatively uniform in depth, and (2) trawling had occurred immediately adjacent to the closed area each of the preceding 5 years. The first criterion was considered necessary to reduce variation in habitat and community structure associated with depth differences between the open and closed areas at a site.

Site 1 was located in Chiniak Gully near the northeastern side of Kodiak Island (Figure 1). Commercial trawling intensity during the period 1993–1997 was estimated using the methods described in Stone and Masuda (2003) and is calculated as the maximum percentage of seafloor trawled at least once per year during that period. The estimate includes only the area of the seafloor potentially contacted by the footrope and, therefore, can be considered a conservative estimate. Maximum trawl intensity at Site 1 was estimated at 29.4% of the seafloor per year (Stone and Masuda 2003). At this site, the area open to trawling was also open to scallop dredging, and the maximum percentage of seafloor in the study area that was dredged for scallops at least once per year was estimated for the period 1993–1998. Seventeen percent was dredged in 1993, steadily declining to less than 1% in 1998 (G. Rosenkranz, Alaska Department of Fish and Game, personal communication). Strong bottom currents flow predominately from the northwest and southeast. Maximum bottom currents measured during a neap tide period in August 2001 were 0.28 m/s (R. P. Stone, unpublished data). Depth within the transect area ranged from 105 to 151 m, and the maximum depth differential along any transect was 18 m. The substrate consisted of moderately sorted, medium and fine sand (Stone and Masuda 2003).

Site 2 was located in the Two-Headed Gully southeast of Kodiak Island (Figure 1). Maximum trawl intensity was estimated at 19.4% of the seafloor per year (Stone and Masuda 2003). Moderate to light bottom currents (e.g., less than 0.28 m/s) characterize this site. Depth within the transect area ranged from 125 to 157 m, and the

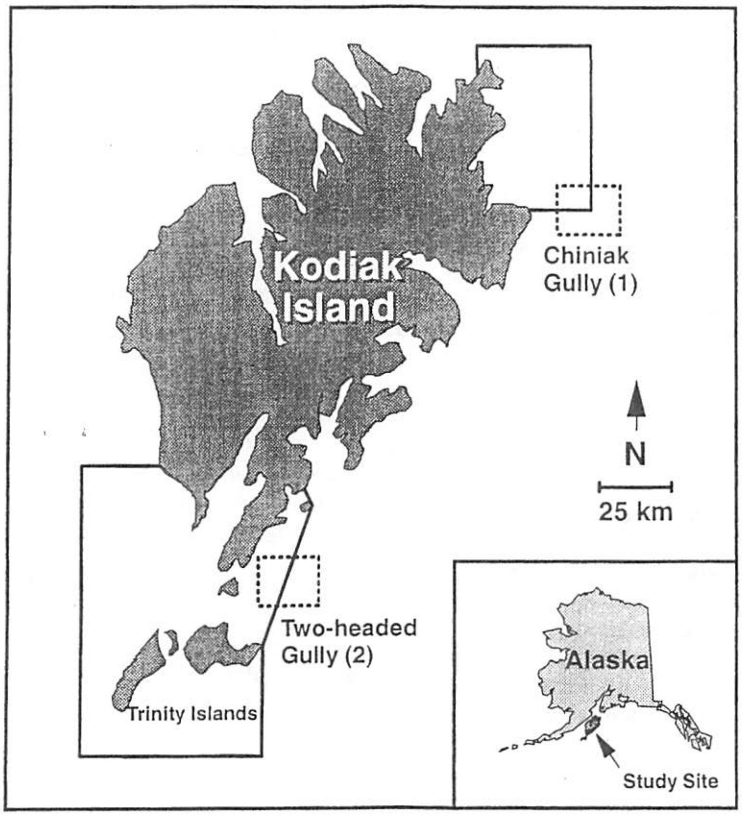

Figure 1. Map of Kodiak Island, Alaska, showing the two study sites (dashed lines) and closed areas (solid lines) where nonpelagic trawling is prohibited year-round. Site 1 is located at the Chiniak Gully. Site 2 is located at the Two-Headed Gully.

maximum depth differential along any transect was 15 m. The substrate consisted of moderately sorted, very fine sand (Stone and Masuda 2003).

Experimental Design

Two cruises aboard the Alaska Department of Fish and Game RV *Medeia* were conducted from 4 to 15 June 1998 and from 13 to 23 August 1999. The submersible *Delta* was used to record 10 video transects of the seafloor that traversed adjacent open and closed areas to bottom trawling. Ten seafloor transects were surveyed at Site 1 during both the 1998 and 1999 cruises, and 10 seafloor transects were surveyed at Site 2 in 1998. Transects were bisected by the boundary demarcating open and closed areas, parallel, 500 m apart, and 3,000 m in length. At Site 1, transects were 500 m apart each year and 250 m apart when years were combined. Transects 3 and 10 at Site 1 in 1998 were approximately 2,500 m long. Transects were purposely oriented along isobaths to minimize any biotic variation attributable to depth differences along transects. Site 1 encompassed an area of approximately 12.9 km^2, of which 14,500 m^2 and 23,500 m^2 of seafloor (0.3% of the total area) were video recorded in 1998 and 1999, respectively. Site 2 encompassed an area of approximately 10.2 km^2, of which 15,900 m^2 of seafloor (0.16% of the total area) was video recorded.

The submersible *Delta*, occupied by a pilot and scientific observer, was equipped with external halogen lights, internal and external video cameras, gyro and magnetic compasses, and sub-to-tender vessel communication. The submersible was also equipped with an acoustic transponder that allowed tracking of the submersible by the tender vessel with differential global positioning and ultra-short baseline acoustic tracking.

The submersible followed a predetermined bearing at speeds of 0.27–0.82 m/s along each transect, and its course was modified when necessary via communication with the tender vessel. Continuous contact with the seafloor maintained the external camera lens at a near constant altitude (≈80 cm). The camera was oriented with the imaging plane directed at a shallow angle of approximately five degrees from vertical. Width of the image area was approximately 0.53 m in 1998, 0.85 m for Transects 1–7 at Site 1 in 1999, and 0.63 m for Transects 8–10 at Site 1 in 1999. Image widths, recorded at the start and end of each transect and at 500-m intervals, were averaged for each transect. Images were continuously recorded on a Hi-8 videocassette recorder. The scientific observer aboard the submersible viewed the image area laterally and recorded voice observations. Data continuously displayed on the video images included real time, depth (m), and height of the camera lens above the seafloor (cm). In addition, the video camera recorded two parallel laser marks 20 cm apart, projected onto the seafloor to provide calibration for measurements of the width of the image area (i.e., transect width) and size of fauna.

In the laboratory, all epifauna (approximately more than 4 cm in any dimension) partially or fully viewed on video footage were enumerated. Epifauna abundance at Site 1 was assessed with density (number of animals per square meter), making transects of differing widths comparable. Epifauna were collected in 1999 with a 6-m shrimp trawl towed on the seafloor just outside the study sites. Trawl collections were used to confirm taxonomic identifications. Fauna were classified to species if consistent video identifications were possible (20 of 35 taxa); otherwise, epifauna were grouped at higher taxonomic levels (Table 1). Similar species could not always be distinguished from one another on video footage, and those taxa were grouped. All sea whips greater than 20 cm in height were recorded as *Halipteris willemoesi*, although some of the smaller specimens (<50 cm) were possibly *Stylatula* sp. Naticidae included both pale moonsnail *Euspira pallida* and *Crytonatica russa*. Caridea included at a minimum the following 10 species of shrimp listed in order of decreasing relative abundance: (1) arctic eualid *Eualus fabricii*, (2) Arctic argid *Argis dentata*, (3) gray shrimp *Neocrangon communis*, (4) yellowleg pandalid *Pandalus tridens*, (5) ridged crangon *Crangon dalli*, (6) barbed eualid *Eualus barbatus*, (7) Townsend eualid *Eualus townsendi*, (8) beaked eualid *Eualus avinus*, (9) Okhotsk lebbeid *Lebbeus schrencki*, and (10) Rathbun blade shrimp *Spirontocaris arcuata*. Paguridae included at least five species of hermit crabs: (1) Alaskan hermit *Pagurus ochotensis*, (2) knobbyhand hermit *P. confragosus*, (3) bluespine hermit *P. kennerlyi*, (4) armed hermit *P. armatus*, and (5) splendid hermit *Labidochirus splendescens*. Pleuronectidae (>15 cm) included Pacific halibut, flathead sole, arrowtooth flounder, butter sole, Dover sole, rex sole, and at Site 2 only, petrale sole *Eopsetta jordani*. Pleuronectidae (<15 cm) included flathead sole, arrowtooth flounder, and rex sole. Psychrolutidae included two species of fathead sculpins, tadpole sculpin *Psychrolutes paradoxus* and *Malococottus* sp.

Taxa were further assigned to mobility groups (sedentary, low mobility, and high mobility) based on their observed mobility (Table 1). Seven taxa were identified as prey items (Table 1) based on analysis of stomach contents of 10 species of groundfish commercially harvested in the study areas (Stone, unpublished data). Abundance of other key taxa was analyzed separately based on their potential importance as biotic habitat (i.e., *Protoptilum* sp. and *H. willemoesi*) or bioturbators (Paguridae). Juvenile Tanner crabs were also identified as a key taxon since their spatial distribution might provide insights into the effectiveness of the 1987 area closures.

Three types of biogenic structures (i.e., structures produced by the activity of fauna), specifically (1) burrows, (2) foraging or shelter pits, and (3) elevated feeding mounds were enumerated on 10 randomly selected segments of strip transect from each of the closed and open areas at Site 1 (1999) and Site 2. Segments were nonoverlapping and of uniform area (8.5 m^2 at Site 1 [1999], 10.6 m^2 at Site 2). Structures to be enumerated were selected *a posteriori* based on in situ observations of their use by prey species as refuge. Prey animals previously enumerated were tallied for each segment to assess their spatial relationships with biogenic structures. Biogenic structures were not enumerated at Site 1 (1998) since the relatively low numbers of prey animals observed there precluded meaningful statistical analyses.

Statistical Analysis

Epifauna Abundance and Species Diversity

Areas open and closed to bottom trawling were compared for differences in animal abundance and community structure. Total abundance of megafauna and abundances of key taxa (*Protoptilum* sp., *H. willemoesi*, Tanner crab, and Paguridae) and functional groups (S, L, H, and P; see Table 1) were compared between open and closed areas. We assessed community structure by analyzing the two components of species diversity: species richness and relative abundance of species (Magurran 1988). We used Margalef's index, a function of total numbers of species and individuals, as a measure of species richness and Simpson's index of dominance as a measure of the relative abundance of species (Clarke and Warwick 1994). Magurran (1988) notes that species richness and dominance indices are informative in environmental studies and cites several studies that demonstrated reduced species richness and

Table 1. Total number of each megafauna taxon observed on seafloor transects at Site 1 and Site 2. Taxa were assigned to the mobility groups S (sedentary), L (low mobility), and H (high mobility) based on their mobility and whether they are prey (P) for commercially harvested groundfish. The larger of the numbers by status (open or closed) is in bold.

		Site 1				Site 2	
		1998		1999		1998	
Taxon	Functional group	Closed	Open	Closed	Open	Closed	Open
Cnidaria							
Actinaria (unidentified)	S	76	37	65	37	17	3
Cribrinopsis fernaldi	S	212	248	257	303	192	31
Metridium senile	S	400	309	787	630	69	32
Halipteris willemoesi	S	315	393	1,093	720	143	800
Protoptilum sp.	S	4,935	6,287	14,029	15,627	1,852	1,958
Ptilosarcus gurneyi	S	2	0	0	0	1	0
Nemertinea							
Cerebratulus herculeus	L	27	25	44	38	1	1
Mollusca							
Opisthobranchia (eggs)	S	0	0	0	0	572	383
Tritonia diomedea	L	1	0	0	1	1	3
Naticidae	L	296	244	427	413	340	273
Naticidae (eggs)	S	112	128	277	326	68	122
Patinopecten caurinus	L	133	122	322	242	30	13
Octopus sp.	H	1	0	2	0	4	1
Crustacea							
Chionoecetes bairdi (juvenile)	L, P	123	105	275	353	155	103
Oregonia gracilis	L	9	8	61	33	9	3
Pandalus eous	L, P	499	276	2,705	2,087	2,510	3,013
Caridea (unidentified)	L, P	4,924	4,051	7,055	5,217	3,205	1,733
Paguridae	L	4,948	4,721	10,220	10,513	2,153	1,386
Echinodermata							
Asteroidea (unidentified)	L	2	2	0	0	1	1
Ctenodiscus crispatus	L	9	9	11	13	4	17
Luidia foliolata	H	10	8	93	80	0	0
Pycnopodia helianthoides	H	97	87	140	108	27	20
Solaster dawsoni	H	9	0	3	0	10	7
Gorgonocephalus eucnemis	L	71	128	427	309	24	73
Strongylocentrotus droebachiensis	L	10	57	31	3	27	4
Pisces							
Rajidae	H	10	4	21	5	4	2
Osteichthyes (unidentified, <20 cm)	L	14	3	33	40	27	2
Atheresthes stomias (juvenile)	H, P	0	0	5,480	4,836	0	0
Pleuronectidae (>15 cm)	H	464	344	650	673	392	382
Pleuronectidae (<15 cm)	H, P	838	700	951	959	626	524
Bathyagonus alascanus	L, P	81	69	349	393	81	55
Podothecus accipenserinus	L	17	13	19	22	11	1
Dasycottus setiger	L	1	0	4	2	15	12
Psychrolutidae	L	407	345	323	300	189	154
Lycodes sp.	L, P	389	384	827	992	699	573
Total (status)		19,432	19,107	46,981	45,275	13,459	11,685
Total (site and year)		38,539		92,256		25,144	

increased dominance in stressed communities. Damaged sea whips (i.e., not skeletons but animals with living tissue, including those dislodged from the seafloor) were grouped for all species and analyzed for differences in abundance between open and closed areas. Densities (number of animals per square meter), instead of numbers of animals, were compared at Site 1 to correct for differing transect widths.

Differences in animal abundance and species diversity between open and closed areas were tested with individual analysis of variance (ANOVA) models. The three-factor models included fixed effects status (variable indicating open or closed area), year, and transect (blocking variable) nested within year and the interaction between status and year. Models fit to Site-2 data excluded variable year and the interaction term. Dependent variables (y or $y + 1$) were Box–Cox transformed (Box and Cox 1964; Venables and Ripley 1999) if necessary with a different power parameter (λ) estimated in the range [–2,2] for each variable. Data from the two sites were analyzed separately. First-year and second-year data from Site 1 were analyzed separately if a significant interaction between status and year was detected. One-tailed t-tests were used to test for reduced species richness (Margalef's index) and increased dominance (Simpson's index) in the open area. We chose an α-level of 0.10 over the traditional α-level of 0.05 to protect against type II error (McConnaughey et al. 2000).

Biogenic Structures

First, to determine if the number of biogenic structures was significantly higher in the closed than in the open area, we fit a two-factor submodel of the ANOVA model with fixed factors (status and transect) to the number of biogenic structures. Second, to determine if prey animal abundance was positively related to the abundance of biogenic structures, we fit a two-factor analysis of covariance (ANCOVA) model to the number of prey animals with fixed factors (status and transect) and covariate (number of biogenic structures). Dependent variables (y or $y + 1$) in the two models were Box–Cox transformed (Box and Cox 1964; Venables and Ripley 1999) if necessary, and segments were treated as replicates. One-tailed t-tests of differences in status were performed. The α-level was 0.10.

Spatial Characteristics of Sea Whips

The spatial distribution of sea whips (small: *Protoptilum* sp., and large: *H. willemoesi*) on transects was treated as one-dimensional since transect length (1,500 m in closed or open area) was large compared to transect width (0.53–0.85 m). Neighbor K statistics for one-dimensional data (O'Driscoll 1998), which are based on distances between neighboring individuals, provided both tests of aggregation and spatial descriptions of individuals on transects. The test for spatial randomness of individuals on a one-dimensional transect involves computing the expected number of extra individuals within a specified distance of an arbitrary individual (O'Driscoll 1998). Tests of aggregation were computed for varying scales h in 1-m increments ($h = 1, 2, 3, \ldots, H$, where H is transect length). Significance of tests was measured using Monte Carlo methods (O'Driscoll 1998). A significant aggregation of individuals at scale h indicates individuals have more neighbors within distance h than would be expected if individuals were randomly arranged. Following O'Driscoll (1998), we adopted an unweighted approach to edge bias, assuming no individuals occur beyond the ends of a transect. In addition to a test of spatial aggregation, neighbor K analysis provides a description of one-dimensional spatial patterns in terms of patch length and crowding (O'Driscoll 1998). Patch length is the spatial scale of clustering, and crowding is a measure of the relative number of individuals in a patch. Patch length and crowding were determined from graphs of function $L(h)$, where $L(h)$ represents the average number of extra neighbors observed within distance h of any individual than would be expected under spatial randomness. Values of patch length and crowding, which depend on inter-neighbor distances, may not be comparable among transects of differing widths. Significance of the test for spatial randomness was determined only for values of h up to $H/2$. Since bottom fishing may alter the spatial distribution of animals (Langton and Robinson 1990; Thouzeau et al. 1991; Auster et al. 1996), data from open and closed areas were analyzed separately (H = 1,500 m). Transects were analyzed separately, and only those transects with at least three sea whips in each 1,500-m section were tested for spatial aggregation. The α-level was 0.05.

Animal Abundance in Groves of *Halipteris willemoesi*

In situ observations indicated that large *H. willemoesi* (height > 80 cm) form discrete "groves" on the seafloor and that animal abundance appeared to be high there. To investigate these observations further, the locations of all *H. willemoesi* were mapped at the two study sites to delineate grove boundaries. Densities of prey taxa, large Pleuronectidae, and all taxa combined (excluding large sea whips) were compared inside and outside of groves.

Species Associations with Prey Taxa

Four species or species groups were tested for associations with prey taxa: (1) the sedentary group, (2) small sea whips (height < 20 cm, *Protoptilum* sp.), (3) *H. willemoesi*, and (4) large Pleuronectidae. The four species or species groups were chosen after data collection and prior to data analysis. We hypothesized that prey taxa would be positively associated with the sedentary group and sea whips, since they provide refuge in the form of biotic structure (i.e., structures caused by, produced by, or comprising living organisms but not those produced by the activity of living organisms) and a negative association with large Pleuronectidae based on their predator–prey relationship. Pair-wise associations between prey abundance and the abundances of four species or species groups were measured with Pearson's correlation coefficients (Snedecor and Cochran 1973). Abundance at Site 1 was assessed with density (number of animals per square meter) instead of numbers of animals. Abundance was computed by transect in open and closed areas. To satisfy the assumption of bivariate normality in the correlation test, animal densities at Site 1 were natural log transformed and animal numbers at Site 2 were left untransformed. Yearly data at Site 1 were combined. The α-level was 0.05.

Results

Epifauna Abundance and Species Diversity

We detected general and site-specific differences in epifauna abundance and species diversity between areas open and closed to bottom trawling. The relative positions of 155,939 epifauna were mapped on the seafloor at the two study sites (Table 1). Differences in epifauna abundance and species diversity between open and closed areas were generally similar for the two sites (Table 2). Total animal abundance was significantly lower (13.2%) in the open area than in the closed area at Site 2 (Figure 2) but not at Site 1 (Table 2; Figure 3). Epifauna classified as prey were 16.6% and 17.5% less abundant in the open area than in the closed area at Site 1 and Site 2, respectively (Table 2; e.g., Figure 4). Low-mobility epifauna were also significantly lower in the open area than in the closed area at both sites (10.3% and 21.7% at Site 1 and Site 2, respectively). Differences in abundances of sedentary and high-mobility animals between open and closed areas were not detected at either site (Table 2). We found no interannual differences in animal abundance at Site 1 except for fewer low-mobility animals and more high-mobility animals in the second year. This increase in high mobility animals was likely due to a strong recruitment of juvenile (young-of-year) arrowtooth flounder to the benthos, an event that apparently occurs between June and August. Abundances of two key taxa (*Protoptilum* sp. and *H. willemoesi*) were not significantly different between open and closed areas at either site (Table 2). Abundances of juvenile Tanner crabs (18–45-mm carapace width) and Paguridae were significantly lower (33.5% and 35.6%, respectively) in open than in closed areas at Site 2 but not at Site 1 (Table 2).

No difference in the abundance of damaged sea whips was detected between open and closed areas at either site (Table 2). We observed 504 damaged sea whips (1.96% of the total sea whips observed) in areas open to trawling at both sites and 439 damaged sea whips (1.97% of the total sea whips observed) in areas closed to trawling at both sites. Axial rods (i.e., skeletons) of *H. willemoesi*, however, were disproportionately more common in areas closed to trawling (262 total compared to 30 total).

In terms of species diversity, both sites exhibited significantly lower species richness (e.g., Figure 5) in the open area than in the closed area (Table 2). Simpson's index of dominance was significantly higher in the open area than in the closed area at Site 1 in 1998 only (Table 2). A significantly higher index of dominance was not found in the open area at Site 2 (Table 2). The model of Simpson's index of dominance fitted to Site-1 data had a significant interaction between the variables status and year (ANOVA, $F = 5.53 \sim F_{1,18}$, $P = 0.03$); therefore, an ANOVA model was fit to first-year and second-year data separately. Interannual differences in species diversity indices at Site 1 were not examined since transect widths differed between years, making interannual indices incomparable.

Biogenic Structures

Biogenic structures were significantly more abundant in the closed area than in the open area at Site 1 in 1999 (ANOVA, $|t| = 6.22 \sim$ Student's $t(0.05, 189)$, $P < 0.001$) and at Site 2 (ANOVA, $|t| = 10.69 \sim$ Student's $t(0.05, 189)$, $P < 0.001$) (Figure 6). Multiple R^2 for the model of number of biogenic structures was 53% at Site 1 and 44% at Site 2. Prey taxa abundance was greater in areas with greater numbers of biogenic structures at Site 1 (ANCOVA, $|t| = 2.22 \sim$ Student's $t(0.05, 188)$, $P = 0.02/2 = 0.01$) but not at Site 2 (ANCOVA, $|t| = 0.46 \sim$ Student's $t(0.05, 188)$, $P = 0.64/2 = 0.32$) (Figure 6). Multiple R^2 for this model was 58% at Site 1 and 32% at Site 2.

Spatial Characteristics of Sea Whips

No consistent patterns in spatial characteristics (patch length and crowding) of sea whips were found between open and closed areas at either site, nor between the two sites. Sea whips (*Protoptilum* sp. and *H. willemoesi*) exhibited aggregation on most transects in closed and open areas at both sites (Table 3). Patch lengths of *Protoptilum* sp. in closed and open areas of Site 1 ranged from 2 m to nearly 700 m. Crowding values of *Protoptilum* sp. in closed and open areas of Site 1 ranged from less than 1 to more than 200 sea whips. Patch lengths of *Protoptilum* sp. in closed and open areas of Site 2 ranged from 35 m to nearly 700 m. Corresponding crowding values of *Protoptilum* sp. in closed and open areas of Site 2 ranged from less than 1 to more than 60 sea whips. Median patch length of *Protoptilum* sp. in the open area was greater than in the closed area at Site 1 and vice versa for Site 2. Median crowding of *Protoptilum* sp. was greater in the closed area than in the open area at both sites.

Table 2. Summary statistics for testing differences in status (variable indicating open or closed area) for epifauna abundances and species diversity indices. Statistics include value of the *F* statistic or *t* statistic (in the case of one-tailed tests), degrees of freedom (df), *P*-values, and multiple R^2 (%). The percent decrease is listed in the "Open" column for those taxa that were significantly lower in the area open to trawling; an arrow indicates the direction of the index in the open area. Significance at α = 0.10 is indicated by an asterisk.

	Site 1					Site 2				
Variable	*F* or |*t*|	df	*P*	R^2	Open	*F* or |*t*|	df	*P*	R^2	Open
Grouped taxa										
All individuals	1.32	1, 19	0.27	98		4.76	1, 9	0.06*	79	13.2
Sedentary	0.97	1, 19	0.34	98		1.70	1, 9	0.22	88	
Low mobility	3.71	1, 19	0.07*	97	10.3	31.70	1, 9	<0.001*	92	21.7
High mobility	1.71	1, 19	0.21	89		0.90	1, 9	0.37	72	
Prey	9.92	1, 19	0.005*	97	16.6	17.32	1, 9	0.002*	95	17.5
Individual taxa										
Protoptilum sp.	0.001	1, 19	0.97	97		2.30	1, 9	0.16	96	
Halipteris willemoesi	0.94	1, 19	0.35	93		0.07	1, 9	0.80	76	
Damaged sea whips	0.06	1, 19	0.81	88		1.56	1, 9	0.24	82	
Chionoecetes bairdi (juvenile)	0.04	1, 19	0.84	89		7.34	1, 9	0.02*	86	33.5
Paguridae	0.17	1, 19	0.69	89		60.81	1, 9	<0.001*	97	35.6
Species diversity										
Richness	2.37	19	0.01*	69	↓	2.83	9	0.01*	76	↓
Dominance (1998)	3.06	9	0.007*	90	↑	1.13	9	0.14	64	
Dominance (1999)	0.34	9	0.37	92						

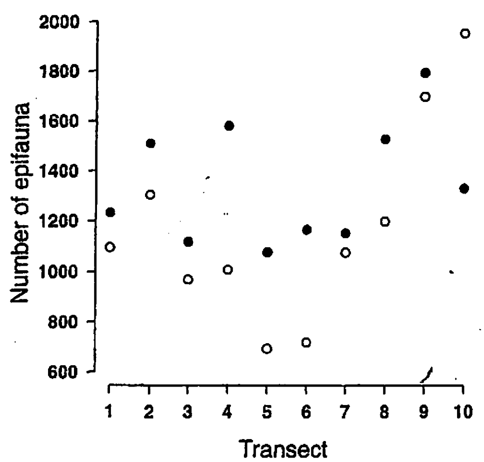

Figure 2. Abundance of megafauna per transect in the areas open (open circles) and closed (closed circles) to bottom trawling at Site 2.

Patch lengths of *H. willemoesi* in closed and open areas of Site 1 ranged from 9 m to more than 400 m. Crowding values of *H. willemoesi* in closed and open areas of Site 1 ranged from less than 1 individual to more than 35 individuals. Patch lengths of *H. willemoesi* in closed and open areas of Site 2 ranged from at least 10 m to more than 500 m. Crowding values of *H. willemoesi* in closed and open areas of Site 2 ranged from approximately 1 individual to more than 100 individuals. Median patch length and crowding of *H. willemoesi* were greater in the closed area than in the open area at Site 1 and vice versa for Site 2.

Animal Abundance in Groves of Halipteris willemoesi

Five groves of *H. willemoesi* were delineated at Site 1 in 1998 and 1999: four were entirely and one was partially within the closed area (Figure 7). Groves ranged from 406 m to 830 m in length. Density of *H. willemoesi* inside the groves (23 individuals per 100 m^2) was nearly 70 times the density outside the groves (0.33 individuals per 100 m^2). Densities of prey taxa, large Pleuronectidae (>15 cm), and all taxa combined were higher inside groves than outside groves (Table 4). Although *H. willemoesi* was fairly common at Site 2 (Table 1), no groves of large individuals (height > 80 cm) were identified there.

Species Associations with Prey Taxa

Pair-wise correlations between prey abundance and the abundances of four other species or species groups were consistently positive or negative for closed and open areas at either site but not between sites (Table 5). At Site 1, prey species abundance was positively correlated with the abundances of sedentary taxa and sea whips. Prey species abundance at Site 1 was not significantly correlated with large Pleuronectidae (>15 cm) abundance in either the closed or open area. At Site 2, no significant correlation was found between prey species abundance and abundances of sedentary taxa and sea whips. Prey species abundance was

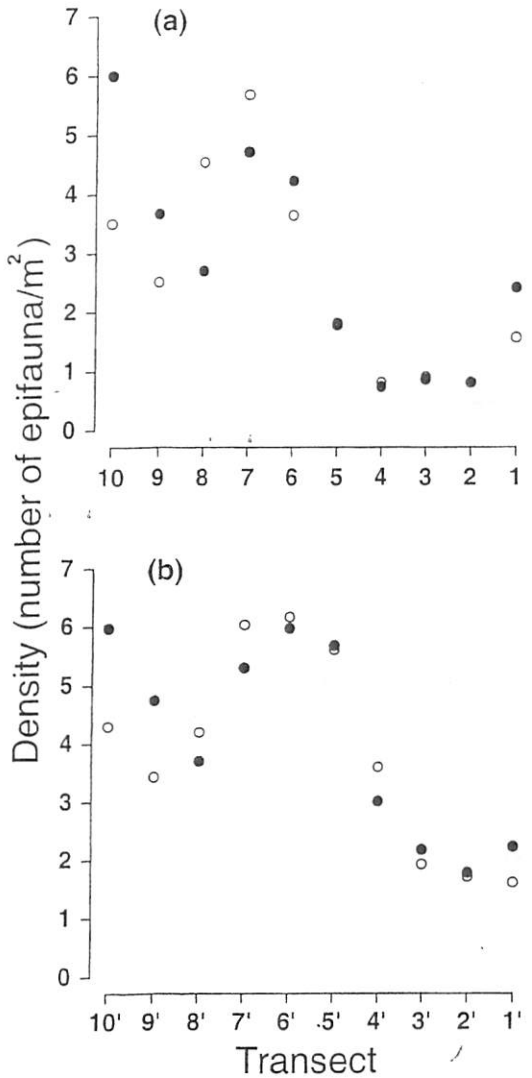

Figure 3. Densities of megafauna per transect in the open (open circles) and closed (closed circles) areas at Site 1 in (a) 1998 and (b) 1999.

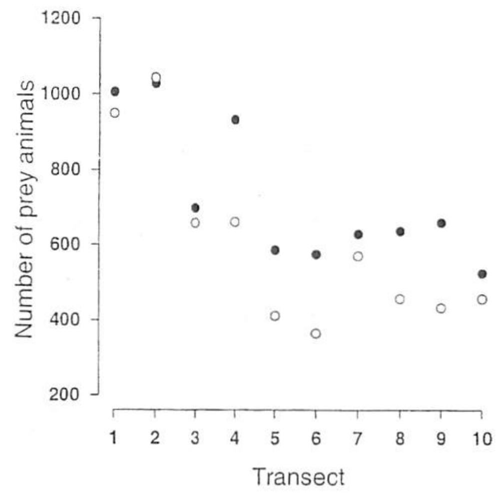

Figure 4. Numbers of prey animals per transect in the open (open circles) and closed (closed circles) areas at Site 2.

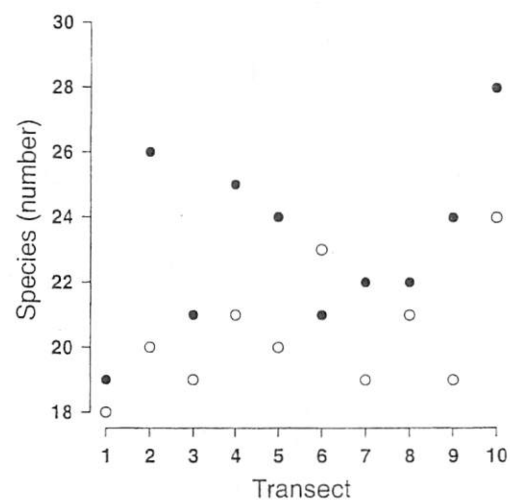

Figure 5. Numbers of species per transect in the open (open circles) and closed (closed circles) areas at Site 2.

negatively correlated with large Pleuronectidae in the open area only at Site 2. Although the correlation coefficient computed between prey abundance and large flatfish abundance in the open area at Site 1 was not significant, the sign of the coefficient was also negative (Table 5).

Discussion

The use of area closures as control comparisons is a growing practice in studying the chronic effects of bottom trawling on seafloor habitat. Our in situ observations demonstrated that differences exist in the abundance and diversity of epibenthos between areas consistently bottom trawled each year and adjacent areas where bottom trawling has been prohibited for 11–12 years. These differences, which may be attributed to chronic, long-term trawling, include decreases in species richness and the abundances of low-mobility and prey species fauna at two sites. Site 1, in 1998, had higher species dominance in areas open to trawling, an indication of a stressed or disturbed community (Shaw et al. 1983). Also, at Site 2, total abundance of epifauna and the abundances of two key taxa (Tanner crab and Paguridae) were reduced in areas

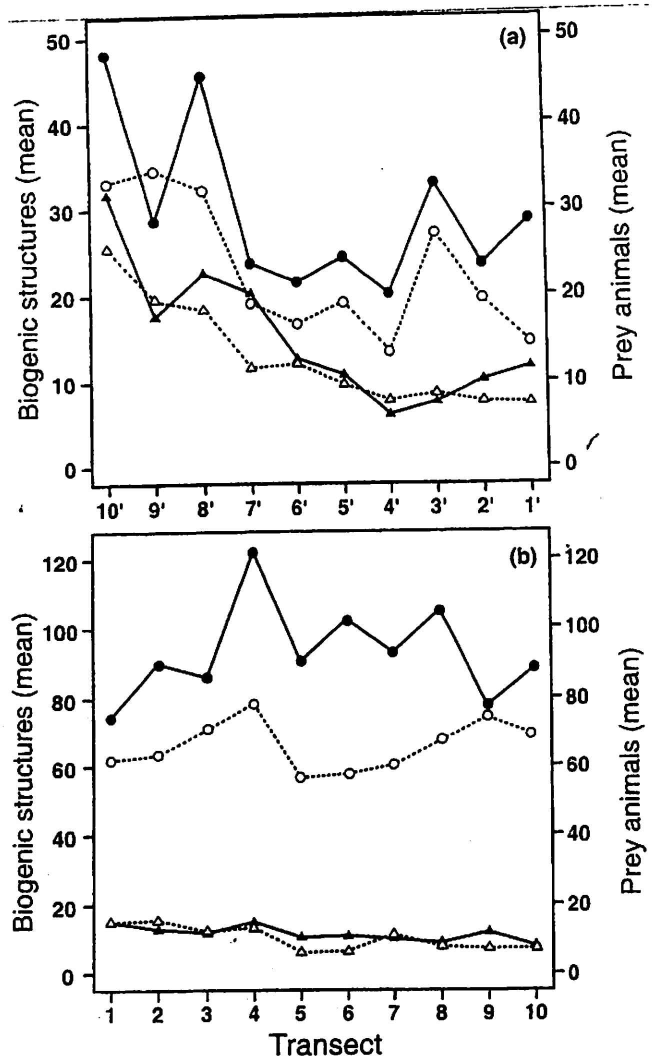

Figure 6. Mean abundance of biogenic structures (circles) in the open (dotted line) and closed (solid line) areas at (a) Site 1 (1999) and (b) Site 2. Mean abundance of prey animals (triangles) in the open (dotted line) and closed (solid line) areas at (a) Site 1 (1999) and (b) Site 2. Structures and prey were enumerated within 20 randomly selected 8.5 m^2-sections and 10.6 m^2-sections of seafloor per transect at Site 1 (1999) and Site 2, respectively.

open to trawling. Detailed examination of the distribution of biogenic structures at Site 1 indicated that the number of these structures was reduced in areas open to trawling, thereby reducing seafloor complexity in these soft-sediment communities. Our findings are in general agreement with other studies on the effects of otter trawls in soft-sediment habitats (Jennings and Kaiser 1998; Collie et al. 2000) and will have important implications in assessing the effects of ambient levels of bottom trawling on essential fish habitat in the GOA.

Our two study sites differed with respect to three factors that contribute to, and can therefore be used to predict, the magnitude of seafloor disturbance and rate of recovery. These factors are (1) fishing intensity, (2) sediment grain-size characteristics, and (3) natural disturbance regime near the seafloor (Jones 1992; Collie et al. 2000). Based on these factors, we correctly predicted that ambient levels of trawling would more adversely affect Site 2, which was characterized by finer-grained sediments in a more stable environment, than Site 1.

Table 3. Transects (% and numbers) that showed aggregation of sea whips and their associated spatial characteristics in closed and open areas. Two-year data from Site 1 were combined.

Species	Site	Area	Percent of transects with aggregation	Patch length (m)		Crowding (number)	
				Median	Range	Median	Range
Protoptilum sp.	1	Closed	95 (19/20)	189	2–712	20.6	0.3–204.0
		Open	89 (17/19)	212	10–697	15.8	0.4–182.4
	2	Closed	90 (9/10)	260	144–403	18.3	4.6–36.8
		Open	100 (10/10)	194	35–676	4.8	0.7–63.1
H. willemoesi	1	Closed	71 (10/14)	191	53–390	8.3	0.7–35.7
		Open	71 (10/14)	86	9–418	4.2	0.4–8.8
	2	Closed	100 (9/9)	52	14–168	1.8	1.1–9.7
		Open	100 (6/6)	234	92–523	22.6	1.6–101.8

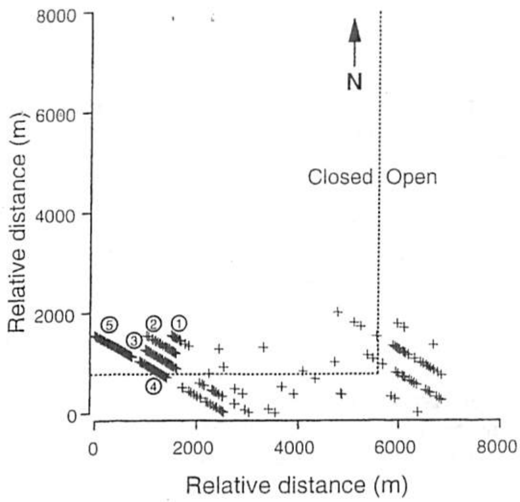

Figure 7. Locations of large (height > 80 cm) *Halipteris willemoesi* (+) on transects within the study area at Site 1 in 1998 and 1999. Five groves of large sea whips, numbered 1–5, were delineated at this site.

We found that low-mobility taxa and prey taxa were less abundant in areas open to trawling. Many of these taxa are highly associated with seafloor structures and use these structures as refuge from predation and benthic currents. We demonstrated that prey taxa are more abundant in areas where both biogenic and biotic structures (sedentary taxa, sea whips, and *H. willemoesi* groves) were more abundant. At Site 1, abundances of prey and biogenic structures were positively associated, indicating that prey taxa may be highly dependent on these seafloor structures for refuge. Similarly, abundances of prey and sedentary taxa, including both *Protoptilum* sp. and *H. willemoesi*, were positively associated, and prey were twice as abundant inside *H. willemoesi* groves than in surrounding habitat. Since prey abundance was significantly lower in areas open to trawling at both sites and biogenic structures were less abundant in areas open to trawling (both sites), trawling may indirectly affect prey species abundance by reducing the number of biogenic structures on the seafloor. Interestingly, we detected no difference in the abundance of biotic structures between open and closed areas at either site.

Mobile fishing gear in contact with the seafloor reduces benthic complexity by leveling biogenic structures and removing the organisms that create these structures (Auster et al. 1996). Of these two mechanisms, we be-

Table 4. Densities (number of animals/m^2) and ratio of *Halipteris willemoesi*, prey taxa, large Pleuronectidae, and all taxa combined (excluding *H. willemoesi*) inside and outside of groves of *H. willemoesi* at Site 1. Densities are from two groves delineated in 1998 and three groves delineated in 1999.

Group	Density		Inside/ Outside
	Inside	Outside	
Halipteris willemoesi	0.23	0.0033	69.95
Prey taxa	2.33	1.12	2.08
Pleuronectidae (>15 cm)	0.13	0.052	2.55
All taxa	5.77	3.31	1.75

Table 5. Pearson correlation coefficients (r) between prey abundance and abundances of four species or species groups in closed and open areas. Two-year data from Site 1 were combined. Significance at $\alpha = 0.05$ is indicated by an asterisk. Site 1: $|r| \geq 0.44$; Site 2: $|r| \geq 0.63$.

Group	Site 1	Site 2
	Closed	
Sedentary taxa	0.69*	–0.48
Protoptilum sp.	0.47*	–0.55
H. willemoesi	0.62*	–0.58
Large Pleuronectidae	–0.02	–0.30
	Open	
Sedentary taxa	0.65*	–0.48
Protoptilum sp.	0.52*	–0.41
H. willemoesi	0.54*	–0.50
Large Pleuronectidae	–0.35	–0.69*

lieve that direct removal of biogenic structures explains the reduced numbers observed in the area open to trawling at Site 1. Our in situ observations of trawl gear striations and increases in surficial total organic carbon (Stone and Masuda 2003) suggest that surface sediments are mixed by components of the trawl system. This action would tend to level sediment structures on the surface of the seafloor. Alternatively, fishing could directly remove or alter the behaviors of the fauna responsible for the structures. We found some evidence that the abundance of one abundant bioturbator (Paguridae) is affected by trawling. The foraging patterns, and hence, rate of pit digging, of Paguridae may also be altered in response to trawling disturbance (Ramsay et al. 1996).

Compared to larger fauna, prey taxa likely experience little direct mortality from bottom trawling (e.g., as bycatch or from delayed mortality due to physical damage) but rather experience mortality indirectly through the modification or removal of biogenic and biotic structures. Prey likely experience increased predation due to loss of refuge and increased exposure immediately after seafloor disturbance. We observed some evidence of the latter after disturbance by the submersible's pressure wave.

Seafloor communities at our two sites were dominated by several species of sea whips that accounted for the majority of biotic structure on the seafloor. At least two species of sea whips (*Protoptilum* sp. and *H. willemoesi*) are present within the study sites at maximum observed densities of $16/m^2$ and $6/m^2$, respectively, and provide vertical structure to this otherwise low-relief habitat. Abundances of all taxa, prey taxa, and predators (large Pleuronectidae) were higher in dense groves of *H. willemoesi* than in adjacent habitat with lower densities of *H. willemoesi*. Pacific cod and walleye pollock, although not enumerated on strip transects because they generally swim or hover just above the seafloor, also appeared to be more abundant in sea whip groves. The ecological importance of this habitat type was similarly noted by Brodeur (2001), who observed high densities of Pacific ocean perch *Sebastes alutus* within sea whip "forests" in the Bering Sea. Brodeur (2001) suggested that sea whips "may provide important structural habitat for Pacific ocean perch in an otherwise featureless environment."

Sea whips are widely distributed in the GOA and, based on bycatch records from trawl and longline fisheries, the probability of interaction with fishing gear is high (Malecha et al. 2005, this volume). Little is known about the distribution and abundance of sea whip groves, however. Furthermore, at least one species, *H. willemoesi*, is estimated to live at least 50 years (Wilson et al. 2002), so recovery time from disturbance may be substantial. We did not detect a significant difference in sea whip abundance between areas closed and open to bottom trawling, indicating that ambient levels of bottom trawling may not have affected their numbers. The spatial and size–frequency distributions (discussed below) of *H. willemoesi*, however, may have been affected by bottom trawling as evidenced by the disproportionate presence of groves in the closed area. Directed studies to determine the resistance and resilience of sea whips to bottom trawling are underway, and results of those studies will be essential to assessing the full effects of fishing on that habitat.

The density of *H. willemoesi* was not significantly different between areas open and closed to bottom trawling. When *H. willemoesi* were classified by height as medium (20–80 cm) or large (>80 cm), however, the large *H. willemoesi* accounted for a greater proportion observed in the closed area than in the open area. The large sea whips (height > 80 cm) comprised 39% (123 of 315) and 29% (313 of 1,093) of *H. willemoesi* in the closed area in 1998 and 1999, respectively, but only 6% (23 of 393) and 15% (109 of 720) of *H. willemoesi* in the open area in 1998 and 1999, respectively. This observation may be an indication that *H. willemoesi* experience reduced survival in the area open to trawling and that a shift in the size–frequency distribution of this species has occurred at this site. This effect has often been noted for targeted mobile species (reviewed in Frid and Clark 2000) but rarely for nontarget sedentary species (Bradstock and Gordon 1983). Detailed analysis of the size–frequency distribution of weathervane scallops at this site revealed that the open area had higher prerecruit abundance relative to recruit abundance than did the closed area (Masuda and Stone 2003), although we should note that *P. caurinus* is the target of a small-scale fishery in the area open to trawling at this site.

We observed little evidence of physical disturbance to the seafloor and associated fauna in the areas open to bottom trawling at Site 1 and Site 2. Obvious trawl-door furrows or striations on the substrate from ground gear were noted infrequently at Site 1 (9 of 20 transects) but more frequently at Site 2 (all transects), where fishing intensity was lower. The prominence of trawl marks on the seafloor appeared less related to trawl intensity and more related to sediment grain-size characteristics and the strength of benthic currents. Other researchers have noted the role these factors play in the rate of seafloor habitat recovery (e.g., Collie et al. 2000). Aside from damaged or dislodged sea whips (1.97% of the total observed), we observed *Metridium senile* drifting near the seafloor, often still attached to bivalve shells. We do not know if trawling activity dislodged them or if this was a previously undocumented transport mechanism for the species. Axial rods (i.e., skeletons) of large *H. willemoesi* were disproportionately more common, compared to live individuals, in areas closed to trawling. We believe that the accumulation of axial rods was simply a result of senescence. Since large *H. willemoesi* were more common in closed areas, their skeletons should tend to accumulate there. The calcified skeletons, typically lying on the seafloor, persist in seawater for at least several years (Stone, personal observations) and tend to accumulate with other debris (e.g., drift algae) within *H. willemoesi* groves. Bottom trawling may remove or bury axial rods.

Some taxa showed highly consistent patterns of abundance and distribution in areas open and closed to trawling (e.g., Paguridae and large Pleuronectidae; Table 1). Many taxa were quite small and would not have been sampled with remote techniques (e.g., trawls). Enumerating small megafauna on video allowed us to reveal important functional roles for several taxa. For example, juvenile arrowtooth flounder were very abundant in 1999 when sampling was conducted in late summer. Although not valued highly as a commercial species, the high ecological value of the species, especially at this life stage, is clear. Paguridae (hermit crabs) were highly abundant at both study sites and, surprisingly, we found no significant difference in abundance between areas open and closed to trawling. We estimate that foraging hermit crabs generated approximately one-third of the biogenic structures (pits) observed on transects at Site 1. Since hermit crabs may have small home ranges (Stachowitsch 1979) and are important bioturbators, their effect on small-scale sediment dynamics can be substantial, especially given their abundance at our two study sites.

This study provides important information that fills an existing gap in the literature on the effects of fishing on benthic habitats (Collie et al. 2000). Although more than 60 studies have been conducted on the effects of fishing on benthic habitats worldwide, few have focused on habitats deeper than 100 m (Collie et al. 2000). Only three studies have been conducted in the eastern Pacific Ocean; two of these were recently completed in Alaska. Freese et al. (1999) investigated acute effects of otter trawls on gravel and cobble habitat in deep water (>200 m) in the eastern GOA, and McConnaughey et al. (2000) examined chronic effects of otter trawls on shallow sand habitat (44–52 m depth) in the eastern Bering Sea.

There are several inherent problems associated with the use of area closures as control comparisons that potentially bias results and confound interpretations to some degree. Three potential sources of bias are specific to the Kodiak Island area closures. Firstly, we compared areas bottom trawled for approximately 30 years to areas closed to bottom trawling for only 11–12 years. Closed areas were trawled to some extent prior to 1987 so we cannot be certain that the epibenthos had stabilized to prefished conditions. Two species (*H. willemoesi* and *P. caurinus*) have life spans greater than 11–12 years, so their current abundance and spatial distribution may have been affected by fishing activity prior to 1987. Secondly, the closure areas prohibit the use of nonpelagic trawls and scallop dredges only. An unknown amount of longlining that occurs in the closure areas could have caused some disturbance to the epibenthos. Thirdly, due to record-keeping limitations of the fisheries observer program, precise locations of hauls within the open areas are unknown (i.e., designated "open" samples may have been collected in areas that were not actually trawled). Two important assumptions of this investigation are that the closed and open areas were identical at the time of the fishery closures in 1987 and that natural disturbances have equally affected those areas.

The 1987 closures in the Kodiak Island area were implemented in response to the collapse of crab stocks in the mid-1980s. For reasons unknown, crab stocks have not yet recovered, so determining the efficacy of the closures in rebuilding these stocks is not possible. We saw no juvenile or adult red king crabs within the study sites. Juvenile Tanner crabs were fairly common at the two sites, and our 2-year counts at Site 1 indicated increased abundance during that period. At Site 2, juvenile Tanner crabs were significantly more abundant in areas closed to trawling. We saw no adult Tanner crabs at the study sites. These observations indicate that at least one species intended to benefit from the habitat closures may be showing signs of recovery and possibly that the habitat closures are providing important sanctuary to that species.

In this study, we investigated the chronic effects from ambient levels of trawling at two sites within a range of soft-bottom habitat. Although we detected significant differences in epifauna abundance and species diversity between areas open and closed to bottom trawling, the magnitude of the differences do not appear to be sufficient to cause broad-scale changes to these communities. Observed differences are similar to those observed in other studies on the effects of otter trawling on soft-bottom habitat (Engel and Kvitek 1998; Prena et al. 1999; McConnaughey et al. 2000; Kenchington et al. 2001; Schwinghamer et al. 2001), but the magnitude of differences appears to be minimal compared to the effects of otter trawling in more complex habitat in the GOA (Freese et al. 1999). Evidence exists, however, that bottom trawling has produced changes to the seafloor and associated biota, affecting the availability of prey for commercially important groundfish. This should serve as a "red flag" to managers since prey taxa are a critical component of essential fish habitat.

Acknowledgments

We thank the following people who helped with this project. Ken Krieger was instrumental in initiating the work, and then he retired. Jon Heifetz, Jeff Fujioka, Jerry Pella, and Phil Rigby helped with the original study design, reviewed this manuscript, and provided many helpful suggestions. John Karinen, Ken Krieger, Jeff Regelin, and Linc Freese assisted with field operations. Dave Csepp assisted with video analysis, Bruce Wing provided taxonomic expertise, and Chris Lunsford helped with trawling intensity estimations. Craig Rose loaned us video equipment that made counting and mapping the positions of 155,939 animals possible. We are also grateful to Captain Wade Loofbourrow and the crew of the Alaska Department of Fish and Game RV *Medeia* and Delta Oceanographics for their assistance and support. The Alaska Fisheries Science Center's Auke Bay Laboratory of the National Marine Fisheries Service funded this research.

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October 2009

Eric Olson, Chair
North Pacific Fishery Management Council
605 W. Fourth Ave.
Anchorage, AK 99501

RE: Agenda Item: Gulf of Alaska Tanner crab discussion paper

Dear Chairman Olson,

Since 2004 the Council has received multiple letters each signed by at least 100 Kodiak Island fishermen requesting management measures to protect Tanner crab. Fishermen are concerned about increasing trawl effort in areas important for Tanner crab. We appreciate the Council's effort to develop information about the interaction between groundfish fisheries and Tanner crab through a series of discussion papers. We believe the time has come to move forward with an analysis of alternatives that reduce trawling in important Tanner crab grounds and reduce bycatch in both trawl and pot gear sectors.

The Tanner crab fishery is important for the diversified local fishing fleet on Kodiak Island.

Stock assessment surveys around Kodiak Island indicate the Tanner crab population is rebuilding presumably due to favorable environmental conditions. Management measures are needed that balance benefit for everyone and the community as a whole.

The Tanner crab discussion papers show there are significant gaps in observer data.

There is large variability in the numbers that is not likely to reflect accurate encounters with Tanner crab.

As the Council pursues improvements to the Gulf observer program, conservation of Tanner crab remains a problem needing a solution.

Currently there are no conservation measures designed for Tanner crab in the Gulf of Alaska. The Red King Crab Type I and II areas and the state water bottom trawl closure around Kodiak Island provide some shelter for Tanner crab but there are distinct areas of biological concern in federal waters that remain unaddressed.

Measures to protect Tanner crab should consider habitat impact and bycatch.

In developing alternatives for analysis, we urge the Council to consider options that reduce effort in important Tanner crab grounds as well as bycatch controls in the trawl and pot sectors.

Sincerely,

PLEASE PRINT CLEARLY—OCTOBER 2009 LETTER TO THE NPFMC—TANNER CRAB BYCATCH

PRINT NAME	SIGNATURE	ADDRESS	VESSEL OR CREW
Julie Miller	[signature]	614 Hillside Kodiak AK 99615	F/V Kona Sue
Kristine Harder	[signature]		
Jerry Bongen	[signature]	P.O. Box 3523 Kodiak AK	F/V Jeanoah
Ken Holland	Ken Holland	P.O. Box 608 Kodiak, AK	F/V Point Omega
Chris Holland	[signature]	P.O. Box 608 Kodiak, AK	F/V Point Omega
Brian Young	[signature]	P.O. box 4356 Kodiak, AK	F/V Heritage
Jim Eufemio	[signature]	PO Box 907 Kodiak	Alpha Centauri
Pete Hannah	[signature]	po box 1803 Kodiak	Mikado

2.

PLEASE PRINT CLEARLY—OCTOBER 2009 LETTER TO THE NPFMC—TANNER CRAB BYCATCH

PRINT NAME	SIGNATURE	ADDRESS	VESSEL OR CREW
Julie Kavanaugh	[signature]	PO Bx 3890 Kodiak	FV Sylvia Star
Leigh Thomet	Leigh Thomet	PO BOX 3258 KODIAK, AK 99615	Setnet
Emily Jean Capjohn	Emily Jean Capjohn	326 Cope St. Kodiak, AK 99615	F/V No Point
Ron Kavanaugh	[signature]	Box 3890 Kodiak. AK 99615	F/V Sylvia Star
Michael Patitucci	[signature]	Box 1511 Kodiak, AK 99615	F/V Denise Marie
Zachary Vickstrom	[signature]	P.O. BOX 318	Shuyak
Oliver Holm	Oliver A. Holm	PO Box 3865 Kodiak, AK 99615	F/V Sulina
MORIAH GAINES	[signature]	P.O. BOX 312 HOMER AK. 99603	F/V LUCKY LADY

3.

PLEASE PRINT CLEARLY - October 2009 Letter to the NPFMC -Tanner crab bycatch

PRINT NAME	SIGNATURE	ADDRESS	VESSEL OR CREW
ALEXUS KWACHKA	[signature]	326 COPE ST. KODIAK AK 99615	"NO POINT"
Stanford Jones	[signature]	614 Hillside Kodiak / 99615	
Margaret Bosworth	[signature]	P.O. Box 1803 Kodiak AK 99615	
CASEY EADS	[signature]	PO BOX 422 KODIAK AK 99615	
Richard E. Collins JR	[signature]	P.O. Box 2780, Kodiak, AK. 99615	
PATRICIA J. Collins	[signature]	P.O. BOX 2780 Kodiak, AK 99615	
PATRICK PIKUS	[signature]	P.O. BOX 2843 Kodiak	Polar star
Deana Pikus	[signature]	Box 2843 Kodiak AK 99615	Polar Star
Randy Lawhead	[signature]	P.O. Box 8625 Kodiak	Polar star

4.

PLEASE PRINT CLEARLY - October 2009 Letter to the NPFMC - Tanner crab bycatch

PRINT NAME	SIGNATURE	ADDRESS	VESSEL OR CREW
RJ Herman	[signature]	Box 3350	WINDWARD
[illegible]	[illegible]	[illegible]	[illegible]
Burt	[signature]	[illegible]	Challenge
Bruce Schactler	[signature]	Kodiak	[illegible]
Greg Wallace		Box 1 Kodiak, Ak	Miss GINA
Mike Tracy		Box 296	Lara Lee
Ben [illegible]	[signature]	[illegible] CA	SUZAN MARIE
Seamus Murphy	[signature]	[illegible] OREGON	
D.J Vanberg	[signature]	3[illegible] Kod AK 99615 salmon/CCO/ Tanner crab/ halibut	

5.

PLEASE PRINT CLEARLY - October 2009 Letter to the NPFMC -Tanner crab bycatch

PRINT NAME	SIGNATURE	ADDRESS	VESSEL OR CREW
Mackenzie Peterson	[signature]	1850 three Sisters way	F/V Patricia Sue
Walter Sargent	[signature]	1830 Mission Rd, Kodiak	F/V Major
LINDA L. SARGENT	[signature]	1830 MISSION RD KODIAK	F/V MAJOR
[signature]		3831 Spruce Cape Kodiak AK	F/V Linnea
Chris Kouremetis	[signature]	1213 Ismailov St Kodiak, AK 99615	Set net
Megan Nugent	[signature]	1213 Ismailov St. Kodiak, AK 99615	Set net
ROBERT MCGARRY	[signature]	POB 8393 KODIAK AK	TANNER FISH F/V NORTH POINT
Bill Harrington	[signature]	BOX 8166 Kodiak AK	Longline F/V Miss Lori
Donald M. Spruck	[signature]	Box 8105 Kodiak AK	Pot Fish F/V Advantage

6.

PLEASE PRINT CLEARLY - October 2009 Letter tp the NPFMC -Tanner crab bycatch

PRINT NAME	SIGNATURE	ADDRESS	VESSEL OR CREW
Don Dunn	[signature]	Box 1723 Kodiak	Horseshoe Bay Set Net Site
Robert Munsey	[signature]	Box 152 Kodiak	Chief Point Setnet
Darius Kasprzak	[signature]	807 Jackson Lane Kodiak AK 99615	F/V MALKA F/V KAVERUA
Dany Stihl	[signature]	Po Box 3373 Kodiak	New Song
Bobbie Farfalla Ivanoff	[signature]	PO B 2394 Kodiak	New Dawn
[signature]		" "	New Dawn
LEIGH G. THOMET	[signature]	PO BOX 3258 KODIAK	Setnet
Clifton Ivanoff	[signature]	P.O Box 2394 Kodiak	New Dawn
Tina Canete	[signature]	718 Thorsheim Street	New Dawn

7.

PLEASE PRINT CLEARLY—OCTOBER 2009 LETTER TO THE NPFMC—TANNER CRAB BYCATCH

PRINT NAME	SIGNATURE	ADDRESS	VESSEL OR CREW
GARRET BROOKS	[signature]	PO BOX 585 HOMER, AK, 99603	F/V LUCKY LADY
Robert Paige	[signature]	Po box 312 Homer AK 99603	F/V Lucky Lady
Tim GOSSETT	[signature]	BOX 4232 KODIAK, AK 99615	F/V LAGUNA STAR
Brad Kutyna	[signature]	Box 8525 Kodiak, AK 99615	F/V ALITAK
Richard Metzger	[signature]	PO Box 5043 AKhiok AK 99697	Subsistance
James Gerrity	[signature]	Po Box 8525 Kodiak AK 99615	F/V Alitak
Wendy Metzger	Wendy L. Metzger	Box 5043 Akhiok, AK 99615	set net
Phillip J. Rastopsoff	[signature]	P.O. 5022 AKHIOK, AK, 99615	set net
Gary Rozelle Sr	[signature]	P.O. Box 5033 AKhiok, AK-99615	Subsistance

8.

PLEASE PRINT CLEARLY - October 2009 Letter to the NPFMC -Tanner crab bycatch

PRINT NAME	SIGNATURE	ADDRESS	VESSEL OR CREW
Timothy W Fomae Jr	[signature]	1424 Mission Rd	Set netter Jigger & Long liner
KEVIN THOMET	[signature]	HOLIDAY ISLAND, KODIAK	SET NET SALMON SITE OWNER LONG LINE CREW
DANA REID	[signature]	Box 8935 Kodiak, AK 99615	Seiner Crab Fisherman Cod Jigger LL Halibut
RONALD BLONDIN	[signature]	1412 Baranof St	Seiner crab Fisherman Halibut Charter
Terry IVANOFF	[signature]	PO 8883 KODIAK AK	New Dawn Set Gillnetter Halibut Set Herring Cod Jig Pot Salmon Tanner Crab
Geoffrey Hirschfeld	[signature]	1863 Wenatchee Valley Rd Montesano, WA 98563	Seine/Longline/Crab fisherman
Lance D. Underwood	[signature]	3295 Woodyway Loop Kodiak, AK, 99615	F/V Compromise, Katie K, many more Crabber / Longliner
David Gray	[signature]	P.O Box 2653 Kodiak, AK 99615	SATUSTTOK LONGLINER CREW CRABBER CREW
Donald E. Combs	[signature]	226 E. 2nd St Apt. 1 Xenia, Oh. 45385	Set Net salmon Long Line
Mark Thomas	[signature]	2249 Selief Ln. Kodiak AK 99615	Long Line crab

PLEASE PRINT CLEARLY—OCTOBER 2009 LETTER TO THE NPFMC—TANNER CRAB BYCATCH

PRINT NAME	SIGNATURE	ADDRESS	VESSEL OR CREW
Charles P Peterson	[signature]	1850 T Horizon Sisters Kodiak	Patrician Sea Capt
Bruce C. Robertson	[signature]	614 Hillside Kodiak AK 99615	Kimberly Ann
David Dennis	[signature]	P.O. Box 4391 Kodiak 99615	Patricia Sue
Dany Stihl	[signature]	PO Box 3373 Kodiak AK 99615	Owner/Operator
Steve Olson	[signature]	"	New Song Deckhand
Cole Brown	[signature]	608 City Park Ave Fort Collins, CO 80525	New Song deckhand
MATT SHADLE	[signature]	P.O. BOX 312 HOMER AK 99603	F/V LUCKY LADY
Dawson M Stone	[signature]	PO BOX 3337 Homer AK 99603	F/V LUCKY LADY

10.

PLEASE PRINT CLEARLY - October 2009 Letter to the NPFMC -Tanner crab bycatch

PRINT NAME	SIGNATURE	ADDRESS	VESSEL OR CREW
Pete Hannah	[signature]	Box 1803	Mikado
TERRY HAINES	[signature]	724 Hillside	
DJ Vinberg	[signature]	[illegible]	[illegible]
MIKE CLARK	[signature]	Bx 2109	Kodiak, AK 99615
THURVALD OLSEN	[signature]	Box 322	VIKING STAR Kodiak, AK 99615
Daniel Miller	[signature]	Box 2865	Kodiak, AK 99615 Owner F/V ANNA D
Theresa Peterson	[signature]	1850 Three Sisters Kodiak	F/V Patricia Sue
Jay Lund	Jay Lund	1597 Monaska	F/V Blue Fox

11.

PLEASE PRINT CLEARLY - October 2009 Letter to the NPFMC -Tanner crab bycatch

PRINT NAME	SIGNATURE	ADDRESS	VESSEL OR CREW
Clayton Weatherly	Clayton W	General Delivery Kodiak	Laguna Sea Crew.
Linda Munsey	L. Munsey	PO Box 152 Kodiak	Chief Point Fisheries
Bruce [illegible]		PO Box 283 Kodiak AK 99615	F/V [illegible]
Rhonda Make		508 W. Marine Way #100 Kodiak, AK 99615	
Liz Janahan		3321 Sheratin #14	

PUBLIC TESTIMONY SIGN-UP SHEET

Agenda Item: D-2(b) GOA Tanner + Chinook Bycatch

	NAME (*PLEASE PRINT*)	TESTIFYING ON BEHALF OF:
1	Theresa Peterson	AMCC
2	ALEXUS KWACHKA	GGFA
3	Bob Krueger	Alaska Whitefish Trawlers
4	Freddie Christiansen	Fisherman
5	TIM MILLER	FISHER
6	Stephen Taufen	for Lu Dochtermann
7	PETER THOMPSON	FISHERMAN
8	Julie Bonney	AGDB
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NOTE to persons providing oral or written testimony to the Council: Section 307(1)(I) of the Magnuson-Stevens Fishery Conservation and Management Act prohibits any person " to knowingly and willfully submit to a Council, the Secretary, or the Governor of a State false information (including, but not limited to, false information regarding the capacity and extent to which a United State fish processor, on an annual basis, will process a portion of the optimum yield of a fishery that will be harvested by fishing vessels of the United States) regarding any matter that the Council, Secretary, or Governor is considering in the course of carrying out this Act.

D-2 (b) Tanner Crab Bycatch in GOA Groundfish Fisheries

Adopt the following Purpose and Need statement and forward for analysis these management measures:

Tanner crab are a prohibited species bycatch in the Gulf of Alaska (GOA) groundfish fisheries. Directed fisheries for Tanner crab in the GOA are fully allocated under the current limited entry system. No specific conservation measures exist in the GOA to address significant, adverse interactions with Tanner crab by trawl and fixed gear sectors targeting groundfish. Tanner crab stocks have been rebuilding since peak fisheries occurred in the late 1970s. Specific protection measures should be advanced to facilitate stock rebuilding.

Alt 1: Status Quo – No action

Alternative 2: Close areas to all groundfish (trawl, pot, and longline) fisheries.

Option 1: Year round
- Suboption 1: trawl gear only
- Suboption 2: pot gear only
- Suboption 3: longline gear only
- Suboption 4: Vessels using approved, modified gear would be exempt from closures (e.g., trawl sweep modifications or pot escape mechanisms).

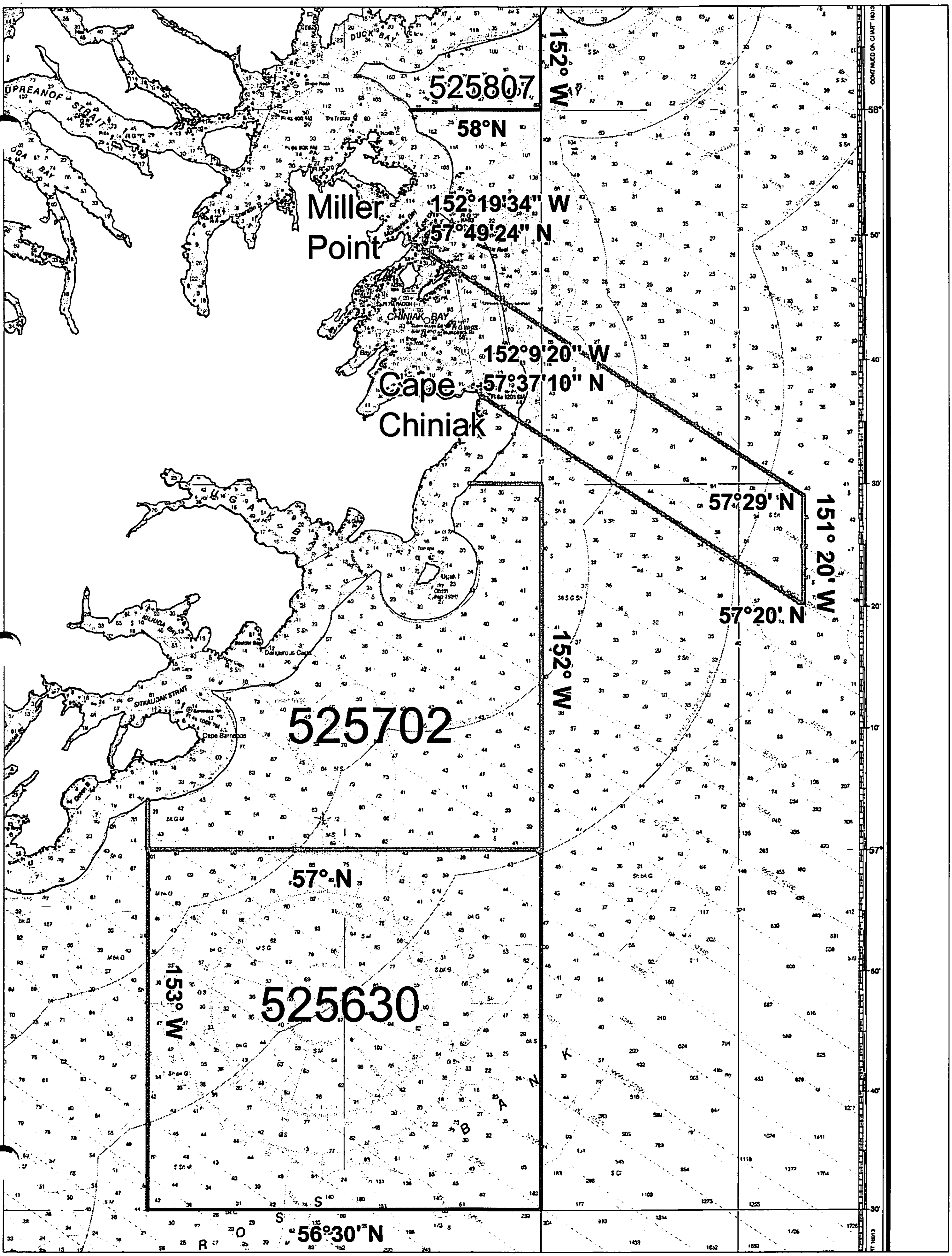
Option 2: Seasonally (January 1 – July 31)
- Suboption 1: trawl gear only
- Suboption 2: pot gear only
- Suboption 3: longline gear only
- Suboption 4: Vessels using approved, modified gear would be exempt from closures (e.g., trawl sweep modifications or pot escape mechanisms).

Alternative 3: In order to fish in these areas, require 100% observer coverage on all groundfish (trawl, pot, and longline) vessels

ADF&G Northeast Section
- Statistical Area 525807
- Chiniak Gully
  (Four corners at 152°19'34" W x 57°49'24" N by 57°29' N x 151°20'W by 57°20' N x 151°20'W by 57° x 152°9"20' W)

ADF&G Eastside Section
- Statistical Area 525702

ADF&G Southeast Section
- Statistical Area 525630


525807
58°N
152° W
Miller Point
152°19'34" W
57°49'24" N
152°9'20" W
57°37'10" N
Cape Chiniak
57°29' N
151° 20' W
57°20' N
525702
152° W
57° N
525630
153° W
56°30' N
DUCK BAY
CHINIAK BAY
SITKALIDAK STRAIT

handout Bob Krueger
D2 (b)

Alaska Whitefish Trawlers Association

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North Pacific Fisheries Management Council
Anchorage, AK
October 2009 council meeting

Agenda item D-2 b
Review discussion paper on GOA Tanner and Chinook bycatch

Proposed intensive bycatch monitoring program
East Side of Kodiak Island (Sand Box)

Final agreement to increase information on crab bycatch in Gulf of Alaska pot gear and non-pelagic trawl gear fisheries occurring around Ugak and Sitkalidak Island

Context: Representatives of trawl and cod pot fisheries have been discussing tanner crab bycatch in the non-pelagic trawl and pot gear fisheries. Participants in these discussions were Julie Bonney (Alaska Groundfish Data Bank), Theresa Peterson (Alaska Marine Conservation Council), John Gauvin (H&G Workgroup), Jeff Stephan (United Fishermen's Marketing Association, Inc), Oliver Holm (fisherman-pot sector), Jerry Bongen (fisherman-pot sector), Jeff Scott, (fisherman-trawl sector), Curt Waters (fisherman-trawl sector), Alexus Kwachka (fisherman- pot sector), and Walter Sargent (fisherman- pot sector).

The focus of the discussions has been data gaps surrounding the extent of incidental catch of tanner crab (*Chionoecetes bairdi*) in the Kodiak area. According to the NPFMC's draft report on crab bycatch in the Gulf, the trawl flatfish and cod fisheries and the pot cod fishery account for most of the bairdi tanner crab bycatch in Gulf fisheries. Extrapolations from the limited observer data result in high variability from year to year and serve to reduce stakeholders' confidence in the degree to which the data reflect actual bycatch amounts and rates. After some discussion on the status of the tanner resource in the Kodiak district of the Gulf of Alaska and the crab bycatch issue in general, the group agreed that the objective should be to increase the observer coverage in two areas of specific concern to each fishery sector represented at the meeting. The increased coverage would be designed to provide a more accurate picture of the extent of non-pelagic trawl and pot cod tanner crab bycatch in an area where stakeholders have various concerns regarding the available data and possible effects on the tanner resource.

The area of primary concern to the pot gear fishery is known as the "sandbox", at the 60-80 fathom contour outside the Type 2 closure off Ugak. This area is an important fishing ground for the Kodiak tanner fishery and is fished extensively by flatfish and cod trawl vessels. The most recent ADF&G crab survey shows some abundance of adult male bairdi in this area. Likewise, the trawl representatives attending the discussion are concerned about incidental catch of tanner crab in the pot cod fishery which is conducted extensively inside the Type 2 trawl closure area adjacent to Ugak where the same ADF&G survey shows high relative abundance of adult female bairdi resource.

Attendees agreed that a requirement to carry a fishery observer for pot cod and non-pelagic trawl fishing is needed to improve tanner crab bycatch data in the above mentioned locations (Figure 1). Existing observer coverage requirement for cod and flatfish trawl fisheries that operate in the above area is 30% for the shoreside trawl and 100% for the at-sea trawl (H&G sector). For the pot fishery, 30% coverage is required for vessels over 60 ft and no coverage is required for vessels less than 60 ft. Many pot cod vessels are less than 60 feet in length and therefore not required to carry observers.

Steps to improve data to assess the extent of tanner crab bycatch in the areas of concern: All parties to this agreement concur that the goal should be to improve accuracy of bycatch data so that both sectors and fishery managers can better evaluate bairdi bycatch. To accomplish this, parties to this agreement will jointly request that the North Pacific Council and the Alaska Board of Fisheries enact a requirement for 100% observer coverage for all vessels fishing for cod with pots or fishing with non-pelagic trawls within the areas delineated in the attached figure (the triangle drawn around "sandbox" as delineated in the attached figure plus the area inside the Type 2 area delineated by the orange lines in the attached figure). Once in place, vessels fishing with non-pelagic trawls and pot cod fishermen will, for a period of two years during both the State and Federal A season fisheries (January 1 to June 10), be required to carry a NMFS-trained observer to fish within the two areas shown in the attached figure. For a limited number of trips ADF&G shellfish biologists may be on board vessels to supplement data collection or, if appropriate, replace NMFS-trained observers.

The cost of 100% observer coverage for both fisheries represents a large increase in operating costs to fish the designated areas. Outside funding that will cover a large portion of the increased cost must be secured before the monitoring project can move forward. The group agrees to work jointly with appropriate staff from ADF&G, NMFS Alaska Region and Alaska Fisheries Science Center to collaborate on a proposal to provide funding to pay for the additional observer coverage needed during the two year project. This would potentially include funding from the North Pacific Research Board (NPRB) or other institutions.

Before work on funding mechanisms is done, both sectors need to demonstrate that there is sufficient support to move forward with getting better information on bairdi bycatch in the areas of interest. To this end, pot and trawl sectors will identify vessel fishermen who fish in the areas where observers will be required for this two year project. Both sectors agree to collect signatures of these stakeholders. Once approximately 75% of the fishery participants have agreed to the project, the group will then work jointly to develop work proposals to seek funding to pay for and administer the additional observer coverage during the two year period during which additional observer catch data will be collected. Once sufficient funding is found for the increased observer coverage, fishery managers will be asked to enact a requirement for 100% observer coverage inside the areas specified for the project for the two year period.

Both the pot and trawl sector agree that the only way that this project will move forward is when both sectors agree to participate.

Julie Bonney Alaska Groundfish Data Bank	Theresa Peterson Alaska Marine Conservation Council

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Julie Bonney
Alaska Groundfish Data Bank

Dorothy Childers for Theresa Peterson
Theresa Peterson
Alaska Marine Conservation Council

John Gauvin
H&G Workgroup

Jeff Stephan
United Fishermen's Marketing Assn, Inc.

Oliver Holm
Fisherman – Pot Sector

Jeff Scott
Fisherman – Trawl Sector

Curt Waters
Fisherman – Trawl Sector

Walter Sargent
Fisherman – Pot Sector

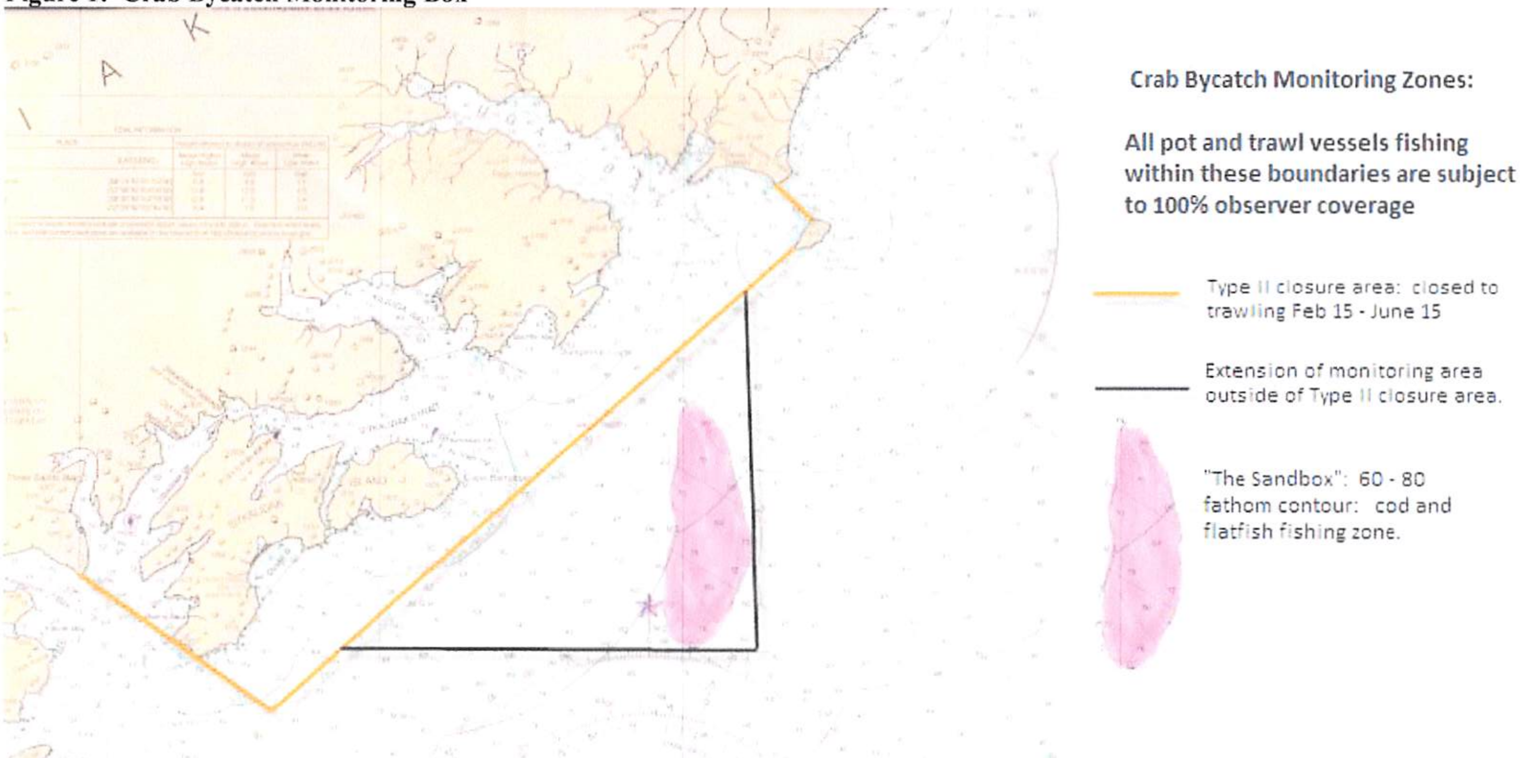
Jerry Bongen
Fisherman – Pot Sector

Alexus Kwachka
Fisherman – Pot Sector

Fishery Participant Signatures

Name	Signature	Vessel	Sector
Mike McElhenie	Mike McElhenie	Alaska Beauty	Trawler
Sam McCarthy	[illegible]	F/V Cape	Trawler
Peter McCarthy	Peter McC[illegible]	F/V Stella	Trawl
Jeff Scott	[illegible]	F/V [illegible]	Trawl
Rob [illegible]	[illegible]	[illegible]	Trawl
Chris O'Callaghan	Chris O'Callaghan	Laura	Trawler
[illegible]	[illegible]	Pacific Star	Trawler
Curt Waters	[illegible]	Mar Del Norte	Trawler
[illegible]	[illegible]	Michelle Renee	Trawler
Ryan Chandler	[illegible]	Topaz	Trawler
[illegible]	[illegible]	Mar Pacific	Trawler
Ryan Piller	[illegible]	Alaska Beauty	Trawler
Rick Dawson	Rick Dawson	Mar Pacific	Trawler
[illegible]	[illegible]	Mar Pacifico	Trawler
Zach Stigall	[illegible]	Mar Pacifico	Trawler
Jay Stinson	[illegible]	Alaskan	Trawler/LL
Mike Helligso	[illegible]	Collier Brothers	Trawler/Pot
Bart Ashley	Bart Ashley	Gold Rush	Trawler
Kent Helligso	[illegible]	[illegible] Star	Trawler/LL [illegible]
Jason Chandler	[illegible]	Topaz	Trawler
Chadwick Johnson	[illegible]	Walter N	Trawler
Mirek Lewan	[illegible]	Mirek Tranq	Trawler
Richard Starr	[illegible]	Alaskan Defiant	Trawler LL
Keith Reynolds	[illegible]	F/V Dawn	Trawler

Figure 1: Crab Bycatch Monitoring Box



alexus kwatcha
handout D2b

Tanner Crab Bycatch & Interaction with Trawl Fishery
Kodiak Island 2009

Crab entangled in trawl mesh.