AGENDA C-3(b)
APRIL 2009

MEMORANDUM

TO: Council, SSC and AP Members

FROM: Chris Oliver for
Executive Director

DATE: March 24, 2009

SUBJECT: GOA Chinook salmon and Tanner crab bycatch

ESTIMATED TIME 6 HOURS ALL C-3 ITEMS

ACTION REQUIRED

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

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.

A revised discussion paper was mailed to you on March 16. The discussion paper is attached as Item C-3(b)(1), but without the color maps. This provides 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 relatively 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). 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 misleading, 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 2009 version, we re-queried the database for the expanded years 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, including a problem statement and alternatives. The AP last reviewed this discussion paper in December 2008, and their minutes are attached as Item C-3(b)(2). The SSC last reviewed an iteration of this discussion paper in April 2008, and their excerpted minutes are attached as Item C-3(b)(3).

AGENDA C-3(b)(1)
APRIL 2009

Chinook Salmon and *Chinoecetes Bairdi* Crab Bycatch in Gulf of Alaska Groundfish Fisheries

March 2009

Staff Discussion Paper

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1 Introduction

Since the implementation of the groundfish fishery management plans for Alaska, the North Pacific Fishery Management Council (Council) has adopted measures intended to control the bycatch of species taken incidentally in groundfish fisheries. Certain species are designated as 'prohibited' in the groundfish fishery management plans, as they are the target of other domestic fisheries. Catch of these species and species groups must be avoided while fishing for groundfish, and when incidentally caught, they must be immediately returned to sea with a minimum of injury[1]. These species include Pacific halibut, Pacific herring, Pacific salmon, steelhead trout, king crab, and tanner crab.

To further reduce the bycatch of these prohibited species, various bycatch control measures have been instituted in the Alaska groundfish fisheries (a history is provided in NMFS 2004, Appendix F.5). In the Gulf of Alaska (GOA) groundfish fisheries, halibut bycatch limits (which close the groundfish target fisheries after the limits are reached) and bottom trawl seasonal and permanent closure areas to protect red king crab have been established. To date, no bycatch control measures have been implemented for salmon or other crab species taken incidentally in GOA groundfish fisheries.

The Council has at various times in the past several years requested staff prepare and update discussion papers examining the scope of salmon and crab bycatch in the GOA groundfish fisheries, and proposing management options that might be considered to regulate such bycatch. Most recently, in June 2008, the Council limited the scope of the discussion paper to focus on two species and two areas with potentially high bycatch levels: Chinook salmon (*Oncorhynchus tshawytscha*) and *Chinoecetes bairdi* Tanner crab, in the central and western GOA. This discussion paper provides a general overview of the available information on bycatch levels (Section 2 for Chinook, and Section 6 for *C. bairdi* crab), and species abundance and directed fisheries (Sections 5 and 7 for Chinook and crab, respectively). Preliminary alternatives have been proposed for bycatch management measures in previous iterations of this discussion paper, and they are included here (Section 8.1), along with strawman closure areas that may be considered for managing bycatch (Section 8.3).

2 Data sources used in this discussion paper

Catch and bycatch data were obtained from the NMFS catch accounting database, and analyzed to represent the amount, species composition, timing, and location of salmon and crab caught incidentally in GOA groundfish fisheries. The process that is used to estimate bycatch for GOA groundfish fisheries is described in Section 2.1. Because most vessels in participating in the GOA groundfish fisheries are not required to have 100% observer coverage, an estimation procedure is used to extrapolate bycatch and discard rates on observed vessels to the fleet as a whole. The data resulting from this process is used in Sections 4.1 and 4.2 for Chinook salmon, and Sections 6.2, 6.3, and 6.5 for *C. bairdi*. Further discussion on the proportion of GOA groundfish fisheries that are observed is addressed in Section 2.2.

Spatial analysis of bycatch in this discussion paper used only the data directly from observed vessels, and is described in Section 2.3. The spatial analysis is used to describe the location of bycatch (Sections 4.3 and 6.4), as well as to develop preliminary strawman closures under the management options (Section 8.3). Abundance estimates for crab were provided by Alaska Department of Fish and Game (ADFG) staff from the ADFG survey, and are included in Section 7.

[1] Except when their retention is authorized by other applicable law, such as the Prohibited Species Donation Program.

2.1 Estimation procedures for bycatch and discards in the Alaska groundfish fisheries

The Alaska Region manages groundfish and prohibited species catch (PSC) under Fishery Management Plans for Groundfish of the Bering Sea/Aleutian Islands and for the Gulf of Alaska. The Alaska Region estimates bycatch (here defined as PSC) and discards (non-retained catch) based on data from the North Pacific Groundfish Observer Program, Weekly Production Reports (WPR), and Alaska Department of Fish and Game fish tickets. The observer data is used to create bycatch and discard rates, and landings data (observer data, fish tickets or WPRs) is multiplied against the rates to provide bycatch and discard estimates. In the Alaska Region, the source for landings data is observer data for 100% observed vessels, WPR data for catcher/processors with 30% observer coverage, and fish tickets for all shoreside deliveries. The estimation procedures for bycatch and discards rely on two key components of the catch accounting system of which they are a part. First, the estimation procedures are designed to provide a quick turn-around of the data so that inseason management has useable rates as quickly as possible after receiving the landing reports and the observer data. The system makes maximum use of small amounts of observer data quickly (at coarser aggregation levels) which are updated and refined as more data becomes available. Secondly, although complex, the system is designed so that changes to the management structure could be mirrored in the catch accounting structure to allow inseason management to stay current with fisheries regulations and specifications.

PSC and discard estimates are based on observer data, and are calculated using separate procedures. The estimation procedures are run daily and the estimates for the current year are recalculated and refreshed daily to incorporate new data or any edits to existing data. It is assumed that unobserved vessels have incidental catch rates, and the bycatch and discard rates are applied to unobserved hauls as well[2].

Prohibited species bycatch estimation

Management of PSC species is based solely on an estimation procedure described below rather than reported catch. Vessels are required to return all PSC to the sea with minimal injury.

All observer data is used in the calculation of PSC bycatch rates. All possible rates at five levels of aggregation are calculated daily. As landings data is updated or received, bycatch estimates are created by finding the best possible matching rate and multiplying the landed catch by the best rate. PSC is managed, and rates are calculated, in numbers of animals for crab and salmon, and in weights for halibut and herring.

Rates for each PSC species are calculated at the following levels of aggregation:

- Precedence 50 CV. Vessel specific catcher vessel (CV) rate aggregated by:
  - Vessel ID, year, trip target date, and fisheries management plan (FMP) area (BSAI or GOA);
- Precedence 50 CP. Vessel specific catcher processor (CP) rate aggregated by:
  - Vessel ID, year, trip target date, gear, federal reporting area, special subarea;
- Precedence 40. Sector specific 3-week average aggregated by:
  - Year, trip target code[3], week end date, processing sector (CV, CP, or Mothership), gear, federal reporting area, special subarea;

[2] PSC and discard estimates are also calculated for catch in the State Pacific cod fishery that sets its guideline harvest level based on the Federal Pacific cod acceptable biological catch.
[3] Targets include: A - Atka Mackerel, B - Bottom trawl Pollock, C - Pacific cod, D - Deepwater flatfish (GOA only), E - Alaska plaice, F - Other flatfish, H – Shallow water flatfish (GOA only), I - halibut (directed), K - rockfish, L - flathead sole, O - Other groundfish, P - Pelagic pollock, rocksole (BSAI only), S - sablefish, T - Greenland turbot, W - arrowtooth flounder, X - Rex sole (GOA only), and Y - Yellowfin sole (BSAI only).

- Precedence 30. Across-sector 3-week average aggregated by:
  - Year, trip target code, week end date, gear, federal reporting area, special subarea;
- Precedence 20. FMP area rate aggregated by:
  - Year, trip target code, gear, FMP area.

Rates are calculated by summing the total number or weight of observed PSC and dividing by the total groundfish weight (retained and discarded catch of groundfish) of sampled observer hauls at the above levels of aggregation. Note that hauls or sets with no PSC are included in the denominator. At the end of 2005, 26,413 individual PSC rates were calculated for the 7 PSC species, and 134,604 estimates were calculated from these rates. The three-week averages in Precedence levels 30 and 40 above are 3-week moving averages that include catch from the previous and following weeks. At least 3 observed hauls or sets must be included in the average before it is used in the matching process.

As an example of the process, consider the case where the best rate available was Precedence 30. Each night the suite of all possible rates are calculated to include the most current data. When the reported catch from an unobserved catcher vessel from the GOA fishing in the Pacific cod target with hook and line gear in reporting area 630 is received, for example as a fish ticket from a shoreside plant, the program searches for a matching PSC rate. Since the vessel was unobserved, no vessel specific rates will be found (Precedence 50). If no observed trips were made by a similarly situated catcher vessel during the three-week period including the prior and the following weeks, no rate at Precedence 40 would be created for the match. The program would then look for a matching rate at the next precedence level (30) which would include observed bycatch by any observed vessel using hook and line gear in the Pacific cod target in reporting area 630, including catcher/processors or catcher vessels delivering to motherships. Upon finding a match, the catch would be multiplied by the Precedence 30 rate, providing an estimate of PSC.

The information in this section was provided by Martin Loefflad, Fisheries Monitoring and Analysis Division, Alaska Fisheries Science Center. Detailed information on 2008 observer sampling protocols can be found at: http://www.afsc.noaa.gov/Quarterly/jfm2008/jfm08feat.pdf.

In order to continue to improve the system for managing groundfish and prohibited species catch, the Alaska Fisheries Science Center has contracted with a consultant to review the current data and data systems used for inseason management and catch accounting in the Alaska Region. The purpose of the contract is to identify the type of data that is available, and its limitations, and to look at the statistical assumptions associated with all estimation procedures. It is intended that the evaluation will result in recommendations for practical system design changes to incorporate statistical uncertainty into estimates of catch and bycatch.

2.2 Proportion of GOA groundfish catch that is observed

The North Pacific Groundfish Observer Program collects catch and bycatch data used for management and inseason monitoring of groundfish fisheries. Since 1990, all vessels larger than 60 ft (length overall) participating in the groundfish fisheries have been required to have observers onboard at least part of the time. The amount of observer coverage is based on vessel length. No vessels less than 60 ft are required to have observers onboard. Trawl and hook and line vessels that are 60 ft to 125 ft must have an observer onboard for 30% of fishing days, by quarter. Similar gear vessels that are larger than 125 ft must have an observer onboard 100% of the time, and shore-based processing facilities must have an observer present for 100% of the time. All pot vessels greater than 60 ft LOA must have observer coverage while 30% of their pots are pulled for the calendar year.

There is a greater prevalence of smaller vessels participating in the GOA groundfish fisheries, and over the past 10 years, participation by smaller vessels in the GOA groundfish fisheries has generally increased, particularly catcher vessels less than 60 ft length overall (NPFMC 2003). Because observer coverage requirements are generally based on vessel length, the proportion of total catch that is observed in GOA groundfish fisheries is much lower than, for example, in the Bering Sea fisheries. The majority of the GOA fleet is subject to 30% observer coverage. Table 1 illustrates the total groundfish catch in the GOA, the total amount of groundfish that is caught while an observer is onboard the vessel, and the resulting percentage. In the western GOA, the proportion of catch that is caught while an observer is onboard ranges from 25-36% over the years 2004-2007; in the central GOA the range is from 32% to 37%. In comparison, the average percentage of observed catch in the Bering Sea is approximately 86%, and in the Aleutian Islands is approximately 95%. The precision of bycatch estimates depends upon the number of vessels observed and the fraction of hauls sampled (Karp and McElderry 1999). Because of the relatively lower levels of observer coverage in the GOA, estimates of salmon and crab bycatch are less precise in the GOA than in Bering Sea groundfish fisheries.

Table 1 Total catch, observed catch, and percent observed catch by area and year

Area	Year	Total (mt)	Observed (mt)	Percent
Western GOA	2004	50,853	14,414	28%
	2005	53,142	13,195	25%
	2006	51,944	17,253	33%
	2007	46,968	16,882	36%
Central GOA	2004	108,707	37,744	35%
	2005	120,030	41,586	35%
	2006	131,271	42,349	32%
	2007	118,871	44,113	37%
Eastern GOA	2004	7,610	2,911	38%
	2005	8,709	3,072	35%
	2006	8,772	3,293	38%
	2007	4,274	3,225	75%
Bering Sea	2004	1,695,228	1,450,413	86%
	2005	1,702,671	1,467,153	86%
	2006	1,696,337	1,470,680	87%
	2007	1,569,110	1,352,914	86%
Aleutian Islands	2004	98,169	93,188	95%
	2005	94,209	89,516	95%
	2006	95,288	91,461	96%
	2007	107,090	101,060	94%

Note: This table does not include jig gear, but otherwise includes all targets.
Source: http://www.fakr.noaa.gov/sustainablefisheries/inseason/percent_observed.pdf

Detailed information on actual observed coverage levels in the GOA groundfish fisheries has been presented to the Council meeting as part of their reports from the Observer Advisory Committee, most recently at the April 2008 Council meeting. NMFS compiled a series of tables that provides a breakout of the percentage of harvest observed for each year 2004–2007, inclusive, in order to evaluate the effective rate of coverage in particular target fisheries. The data are broken out by observer coverage category (30%, 100%), gear type, area, and component of the catch by the <60' fleet that is unobserved.[4] The information for the central GOA and the western GOA is presented in Table 2 and Table 3, respectively.

[4] Note that the total catch data referenced is from the NMFS catch accounting system, and the observer data is from the NMFS observer database. The observer data includes all sampled and unsampled hauls that occurred while an observer was onboard. High variability in percent observed catch among years has been correlated to several factors, such as the varying season lengths, number of participating vessels, different catch rates per year, weather, and market prices.

Information in the tables pertinent to the discussion of fisheries in the GOA is summarized below. For the GOA Pacific cod pot fisheries, more than half the catch from 2004–2007 came from the <60 ft fleet, which is unobserved. The remaining catch primarily came from the >60 ft to <125 ft fleet where percent coverage ranged from 17-28% over the four years. For the Pacific cod trawl fisheries delivering shoreside, coverage in the >60 ft to <125 ft category ranged from 24%–30% in this time frame. The State waters Pacific cod fishery is unobserved, however bycatch rates from comparable vessels/areas are applied to the State waters Pacific cod catch. Bycatch attributable to the State waters Pacific cod fishery is included in this discussion paper, but is presented in a separate section.

For the pollock pelagic trawl fishery, data is mostly confidential for the unobserved <60 ft fleet each year, except in the western GOA in 2006 and 2007 where catch represented 54-71% of the total. The remaining catch came from the >60 ft to <125 ft fleet where coverage ranged from 31%–37% over the four years, with the exception of 51% coverage in the western GOA in 2005. For non-pelagic trawl arrowtooth flounder and shallow water flatfish targets delivered shoreside, the majority of the catch was in the >60 ft to <125 ft category and percentage covered ranged from 13%–34% over the three-year period. Catch of flatfish in the catcher processor fleet was largely in the >60 ft to <125 ft category, with the exception of arrowtooth flounder in the central GOA, and percentage covered varied widely.

At various times, it has been suggested that vessels might volunteer to take observers onboard even when it is not required under observer coverage requirements, in order to increase the proportion of catch that is observed in the GOA, particularly in certain fisheries or areas of interest, and hopefully to increase the accuracy of catch accounting extrapolations based on observer data. Currently, there is an outstanding regulatory issue that prevents observer providers from working with the fishing industry outside of providing observers as mandated under the regulations, because observer providers must not have a financial interest other than the provision of observers.

In 2008, there was one instance of a 58 ft catcher vessel fishing in the western GOA Pacific cod fishery taking an observer on board. The vessel's incentive was to demonstrate that the western GOA has lower halibut bycatch rates than the central GOA, and as there were no vessels larger than 60 ft fishing in the western GOA, all catch from that area was assigned central GOA halibut bycatch rates. The problem with using observer data obtained in this voluntary manner is that it introduces a potential for bias, as the industry would control the time, area, etc. of the observer data.

Table 2 **Central Gulf of Alaska total catch (mt), observed catch, and percent observed catch by area, harvest sector, gear type, trip target fishery, and vessel length**

Sector	Gear	Trip target	Length	2004			2005			2006			2007		
				Total	Observed	Percent	Total	Observed	Percent	Total	Observed	Percent	Total	Observed	Percent
CP	NPT	Pacific cod	>=60 and <125	–	–	0%	565	411	73%	–	–	0%	0	166	0%
			>=125	–	–	100%	0	0	0%	0	0	0%	0	0	0%
		Rockfish	>=60 and <125	–	–	17%	0	0	0%	–	–	0%	0	4	0%
			>=125	6,654	6,655	100%	7,973	7,353	92%	7,716	7,716	100%	4,656	4,656	100%
		Flathead sole	>=60 and <125	–	–	104%	–	–	77%	–	–	70%	–	–	104%
		Arrowtooth	>=60 and <125	0	0	0%	2,735	2,150	79%	3,878	1,500	39%	518	0	0%
			>=125	–	–	100%	–	–	100%	3,785	3,785	100%	4,498	4,498	100%
		Rex sole	>=60 and <125	2,674	0	0%	2,776	1,133	41%	6,883	1,691	25%	–	–	36%
			>=125	–	–	100%	–	–	100%	0	0	0%	0	0	0%
	POT	Pacific cod	>=60 and <125	0	0	0%	0	0	0%	0	0	0%	–	–	0%
S	NPT	Pacific cod	<60	–	–	0%	–	–	0%	–	–	0%	–	–	0%
			>=60 and <125	12,443	3,716	30%	7,376	2,185	30%	4,861	1,152	24%	8,377	2,216	26%
		Arrowtooth	<60	0	0	0%	0	0	0%	0	0	0%	–	–	0%
			>=60 and <125	7,517	1,476	20%	8,519	2,212	26%	12,543	2,993	24%	12,818	2,574	20%
		Shallow water flatfish	<60	0	0	0%	11	0	0%	0	0	0%	547	0	0%
			>=60 and <125	3,339	1,127	34%	6,835	1,300	19%	10,432	1,393	13%	13,382	3,441	26%
		Rockfish	<60	120	0	0%	0	0	0%	0	0	0%	134	0	0%
			>=60 and <125	12,292	3,864	31%	9,477	2,989	32%	7,197	1,913	27%	5,758	3,522	61%
	POT	Pacific cod	<60	2,426	0	0%	3,233	0	0%	3,778	0	0%	4,296	0	0%
			>=60 and <125	2,475	687	28%	4,920	1,298	26%	4,369	981	22%	4,090	969	24%
			>=125	0	0	0%	0	0	0%	–	–	0%	0	0	0%
	PTR	Rockfish	>=60 and <125	66	217	327%	535	636	119%	1,999	1,211	61%	2,990	4,029	135%
		Pollock, bottom and midwater	<60	–	–	0%	1,677	0	0%	–	–	0%	–	–	0%
			>=60 and <125	36,431	13,520	37%	47,273	14,845	31%	44,371	14,187	32%	33,530	11,150	33%

Notes for Table 2 and Table 3 follow Table 3.

Source: http://www.fakr.noaa.gov/sustainablefisheries/inseason/percent_observed.pdf

Table 3 Western Gulf of Alaska total catch (mt), observed catch, and percent observed catch by area, harvest sector, gear type, trip target fishery, and vessel length

Source: http://www.fakr.noaa.gov/sustainablefisheries/inseason/percent_observed.pdf

Sector	Gear	Trip Target	Length	2004			2005			2006			2007		
				Total	Observed	Percent	Total	Observed	Percent	Total	Observed	Percent	Total	Observed	Percent
CP/M	HAL	Pacific cod	<60	0	0	0%	0	0	1%	0	0	0%	–	–	0%
			>=60 and <125	2,394	509	21%	–	–	7%	2,199	1,587	72%	2,895	1,989	69%
			>=125	925	925	100%	292	292	100%	956	956	100%	442	444	100%
		Sablefish	>=60 and <125	572	211	37%	618	254	41%	540	288	53%	758	447	59%
			>=125	359	359	100%	415	411	99%	344	341	99%	191	172	90%
	NPT	Pacific cod	>=60 and <125	635	0	0%	–	–	625%	–	–	0%	–	–	39%
			>=125	–	–	100%	0	0	0%	0	0	0%	0	0	0%
		SW Flatfish	>=60 and <125	–	–	0%	–	–	21%	–	–	57%	–	–	0%
		Rockfish	>=60 and <125	–	–	117%	–	–	0%	–	–	189%	0	0	0%
			>=125	5,291	5,298	100%	3,459	3,351	97%	6,625	6,623	100%	8,274	8,272	100%
		Flathead sole	>=60 and <125	1,047	114	11%	1,803	24	1%	–	–	35%	1,040	352	34%
			>=125	–	–	100%	–	–	100%	0	0	0%	0	0	0%
		Arrowtooth	>=60 and <125	–	–	1989%	–	–	2134%	–	–	71%	–	–	94%
			>=125	901	901	100%	1,220	1,220	100%	953	953	100%	1,771	1,771	100%
		Rex sole	>=60 and <125	–	–	5%	–	–	12%	–	–	21%	–	–	56%
			>=125	–	–	100%	0	0	0%	0	0	0%	–	–	100%
	POT	Pacific cod	<60	0	0	0%	0	0	0%	0	0	0%	–	–	0%
			>=60 and <125	–	–	0%	–	–	34%	–	–	0%	–	–	18%
S	HAL	Pacific cod	<60	–	–	0%	242	0	0%	78	0	0%	327	0	0%
			>=60 and <125	4	0	0%	–	–	0%	0	0	0%	–	–	0%
		Sablefish	<60	837	0	0%	728	0	0%	1,043	0	0%	982	0	0%
			>=60 and <125	529	41	8%	380	122	32%	461	141	31%	471	56	12%
			>=125	0	0	0%	–	–	0%	0	0	0%	0	0	0%
	NPT	Pacific cod	<60	1,464	0	0%	3,554	0	0%	5,114	0	0%	–	–	0%
			>=60 and <125	183	0	0%	783	392	50%	–	–	25%	–	–	77%
	POT	Pacific cod	<60	4,823	0	0%	1,962	0	0%	1,913	0	0%	2,441	0	0%
			>=60 and <125	5,016	1,138	23%	4,428	965	22%	3,882	683	18%	2,205	378	17%
			>=125	–	–	64%	–	–	0%	–	–	0%	–	–	0%
	PTR	Pollock, bottom and midwater	<60	–	–	0%	–	–	0%	13,391	0	0%	13,029	0	0%
			>=60 and <125	7,611	2,938	39%	10,988	5,613	51%	11,604	4,858	42%	5,258	1,662	32%

Notes for Table 2 and Table 3:

These tables do not include data from shoreside processors using paper weekly production reports because the data is at the processor level. The vessel length associated with the catcher vessels delivering to the shoreside processor is not available. This includes 5,717 mt of total groundfish catch in the GOA, consisting of 19 processors in 2004, 11 processors in 2005, and 8 processors in 2006 in the GOA.

1. Values where total and observed columns are blank (-) indicate confidential data. Confidential data have been defined as <3 vessels and processors for that given year, area, sector, gear type, target fishery, and vessel length.
2. Total catch data are from the catch accounting system, and the observer data are from the observer database in March 2008.
3. Harvest sector: S=shoreside; CP/M=catcher processor or mothership
4. Gear type: HAL=hook-and-line; JIG=jig (not included in this table); NPT=non-pelagic trawl, POT=pot; PTR=pelagic trawl
5. Vessel length: <60=vessels less than 60 ft length overall (LOA); >=60 and <125=vessels greater than or equal to 60 ft and less than 125 ft LOA; >=125=vessels greater than or equal to 125 ft LOA
6. Year= target fishery year
7. Weight is rounded to the nearest mt.
8. Percent= (mt of observed catch/mt of total groundfish catch in catch accounting system)*100
9. Not included in the GOA are trip target fisheries per gear type: HAL= pollock, deepwater flatfish, rockfish, other species, arrowtooth (2,406 mt shoreside, 404 mt CP/M); NPT= pollock, deepwater flatfish, shallow water flatfish, rockfish, flathead sole, other species, sablefish (21,367 mt shoreside, 1,633 mt CP/M); POT= pollock, other species (18 mt shoreside); PTR= Pacific cod, shallow water flatfish, flathead sole, other species, arrowtooth, sablefish (2,220 mt shoreside, 566 mt CP/M)
10. For CPs and motherships groundfish catch estimates, the catch accounting system uses weekly production reports for vessels>=60 and <125 and observer data for vessels >=125 except for pot gear uses weekly production reports for vessels >=60.
11. In some cases, the observed data are higher than the total catch for a given area, sector, gear type, target fishery, vessel length. There are several reasons that this occurs:
    a. In 2004-2006, four CPs >=125 ft. had haul data considered to be invalid by the Observer Program. These data were replaced with weekly production reports in the catch accounting system, but are still used as the observed total.
    b. For catcher/processors and motherships >=60 and <125, there can be a mismatch between the trip target that is assigned from the observed data and the trip target that is assigned based on weekly production report data. This occurs when a vessel targets more than one target species during a week.
    c. For the shoreside sector, the total catch is based on fish tickets, which could be different from the observer data.
    d. The two databases include separate sources of information. The catch accounting system partially uses weekly production reports, landing reports, and observer data. Production reports are focused on different goals from the observer data (production vs. total catch), uses a different method to determine catch and targets, and in the cases of 30% observer coverage include dis-coordinated time frames of estimates, especially at the target level (i.e. observer data may not cover the entire week that a production report is based on).
12. A high level of variability in the percent observed catch for a given target fishery may be explained by the level of coverage that vessels had prior to entering a different FMP area. Observer coverage is by quarter and by fishery category, not by FMP area. A 30% vessel may have enough observer coverage in one FMP area to meet the requirements for their fishing in another FMP area. A high level of variability in percent observed catch also may be attributed to a variable number of vessels that participate in certain GOA fisheries each year.
13. This is NMFS' approach to the OAC data request, as of March 26, 2008.

2.3 Spatial analysis of bycatch patterns

In order to map the location of Chinook salmon and *C. bairdi* crab bycatch in GOA fisheries, the analyst used data from observed vessels only. Only observed hauls are associated with geographical coordinates. The observer program database extrapolates species composition of individual basket samples from each haul to the haul level, and the spatial analysis uses the haul-level extrapolated bycatch numbers of Chinook and *C. bairdi*, as well as the official ton weight of the haul, to calculate bycatch rates.

It has been noted that prohibited species bycatch in the GOA and BSAI pollock fisheries is sampled at the plant, rather than onboard the vessel. All hauls are mixed together in the vessel's hold, and at the plant, the composition of all hauls together is evaluated, and the proportion of bycatch in all hauls together is determined. In the observer database, this proportionate value of bycatch composition is then assigned back to each of the individual hauls, with their associated geographical coordinates. Consequently, this skews the mapping of the bycatch data, by averaging the bycatch among several hauls at several locations, when in fact it might be the case that all the bycatch was caught during one haul in one location, and other locations had little or no associated bycatch. This is a caveat to the mapping of the data which may be important if the data are used identify regulatory closures areas, and the impact would need to be investigated at that point.

The distribution of bycatch for 2001-2008 is mapped using a data query from the observer database, queried by Jeannie Heltzel, NPFMC, in March 2009. This is an update of a previous iteration of this discussion paper, and the strawman closures that are identified in this paper are based on the distribution of bycatch from 2003-2007, queried from the observer database in October 2008 by Ms Heltzel. Specific locations of salmon and crab bycatch were input into a GIS to produce charts of catch locations. Information on crab survey abundance estimates were obtained from published Alaska Department of Fish and Game (ADFG) reports, as well as data provided by ADFG staff.

3 Review of Existing Closures

There are already seasonal and permanent area closures that have been implemented for the GOA groundfish fisheries, many of which were instituted to reduce bycatch or interactions with Steller sea lions. It is important to consider the development of new spatial controls to reduce bycatch within the context of existing time and area closures. The various State and Federal closures affecting the GOA groundfish fisheries are described below, along with their intended purpose. The year the closure was implemented is noted in parentheses. Figure 15 (page A at the end of the document) maps the existing closures in the entire GOA management area; Figure 16 and Figure 17 (page B) pinpoint the western and central regulatory areas, respectively, which are the focus of this discussion paper.

Kodiak red king crab closures: Type 1 and Type II (1993). Trawl closure areas, designed to protect Kodiak red king crab because of the poor condition of the king crab resource off Kodiak and because trawl bycatch and mortality rates are highest during the spring months when king crab migrate inshore for reproduction. The molting period off Kodiak begins around February 15 and ends by June 15. Type I areas have very high king crab concentrations and, to promote rebuilding of the crab stocks, are closed all year to all trawling except with pelagic gear. Type II areas have lower crab concentrations and are only closed to non-pelagic gear from February 15 through June 15. In a given year, there may also be Type III areas, which are closed only during specified 'recruitment events', and are otherwise opened year-round.

Steller Sea Lion (SSL) 3-nautical mile (nm) no transit zone (2003). Groundfish fishing closures related to SSL conservation establish 3-nm no-transit zones surrounding rookeries to protect endangered Steller sea lions.

SSL no-trawl zones for pollock (2003). Groundfish fishing closures related to SSL conservation establish 10-nm fishing closures surrounding rookeries to protect endangered Steller sea lions.

Scallop closures (1995). Year-round closure to scallop dredging to reduce high bycatch of other species (i.e., crabs) and avoid and protect biologically critical areas such as nursery areas for groundfish and shellfish.

Prince William Sound rookeries no fishing zone (2003). Groundfish fishing closures related to SSL conservation include two rookeries in the PWS area, Seal Rocks (60° 09.78' N. lat., 146° 50.30' W. long.) and Wooded Island (Fish Island) (59° 52.90' N. lat., 147° 20.65' W. long.). Directed commercial fishing for groundfish is closed to all vessels within 3 nautical miles of each of these rookeries.

Cook Inlet bottom trawl closure (2001). Prohibits non-pelagic trawling in Cook Inlet to control crab bycatch mortality and protect crab habitat in an areas with depressed king and Tanner crab stocks.

State Water no bottom trawling (2000). State managed area provides year-round protection from all bottom trawl gear. Closes all state waters (0–3 nm) to commercial bottom trawling to protect nearshore habitats and species.

Southeast Alaska no trawl closure (1998). Year-round trawl closure E. of 140° initiated as part the license limitation program.

4 Chinook Salmon Bycatch

Pacific salmon, including Chinook, chum (*O. keta*), coho *(O. kisutch*), sockeye (*O. nerka*), and pink (*O. gorbuscha*) are taken incidentally in the groundfish fisheries within the Gulf of Alaska. Salmon bycatch is currently grouped as Chinook salmon or 'other' salmon, which consists of the other four species combined. Bycatch of Chinook salmon in the last five years (average of 25,312 salmon, 2003–2007) is higher than the time series average (average of 21,606 salmon, 1990–2007, Table 4). For the purpose of this discussion paper, it is assumed that salmon caught as bycatch has a 100% mortality rate in the groundfish fisheries.

The following sections provide updated information on Chinook salmon bycatch in the GOA groundfish fisheries. A historical report on salmon bycatch in groundfish fisheries off Alaska as it pertains to the GOA is provided in Witherell et al. (2002).

Table 4 **Bycatch of Pacific salmon in Gulf of Alaska groundfish trawl fisheries, by species, 1990-2008**

Year	Chinook	'Other' salmon[a]	Chum	Coho	Sockeye	Pink
1990	16,913		2,541	1,482	85	64
1991	38,894		13,713	1,129	51	57
1992	20,462		17,727	86	33	0
1993	24,465		55,268	306	15	799
1994	13,973		40,033	46	103	331
1995	14,647		64,067	668	41	16
1996	15,761		3,969	194	2	11
1997	15,119		3,349	41	7	23
1998	16,941	13,539				
1999	30,600	7,529				
2000	26,705	10,996				
2001	14,946	5,995				
2002	12,921	3,218				
2003	15,358	10,362				
2004	21,447	5,816				
2005	31,207	6,694				
2006	18,816	4,273				
2007	39,733	3,487				
Average 1990–2007	**21,606**	15,454[a]				
Average 2003–2007	**25,312**	4,818				
2008 (through 10/25/08)	16,493	2,088				

[a] Combines chum, coho, sockeye, and pink salmon.

[b] Average combines chum, coho, sockeye, and pink salmon bycatch for 1990-1997.

Source: NMFS catch reports (http://www.fakr.noaa.gov/sustainablefisheries/catchstats.htm) for 1990-2002 (all species) and 2003-2008 (non-Chinook species); NMFS catch accounting PSC data for 2003-2007 (Chinook), October 2008.

4.1 Bycatch by area, gear type, and target fishery

In the GOA, Chinook salmon bycatch primarily occurs in the western and central regulatory areas, and corresponds to the locations of the trawl fisheries. Table 5 illustrates bycatch for 2003-2007, and 2008-to-date, across regulatory and reporting areas. In all years except 2008 to date, salmon bycatch in the eastern regulatory area is less than 2% of total Chinook bycatch. Since 1998, the eastern GOA (east of 140°W longitude) has been closed to all trawling, with the implementation of Amendment 58 to the GOA groundfish FMP. Chinook bycatch in the western regulatory area as a proportion of total GOA Chinook bycatch varies between a tenth and a third, by year, but averages to approximately 20%.

Table 5 **Chinook salmon bycatch by reporting area, 2003-2008, in Gulf of Alaska groundfish fisheries**

Regulatory Area		2003	2004	2005	2006	2007	2008 (through 10/25/08)	Average 2003-2007
Western	610	2,859	6,162	7,567	4,880	3,671	2,268	5,028
Central	620	3,876	5,320	6,976	5,678	28,941	7,405	10,158
	630	8,437	9,957	16,180	8,168	7,084	6,115	9,965
Eastern	640	186	36	483	89	71	705	173
	650	0	4	0	0	2	0	1
Grand Total		15,358	21,478	31,207	18,816	39,768	16,493	25,325

Source: NMFS catch accounting PSC data, October 2008.

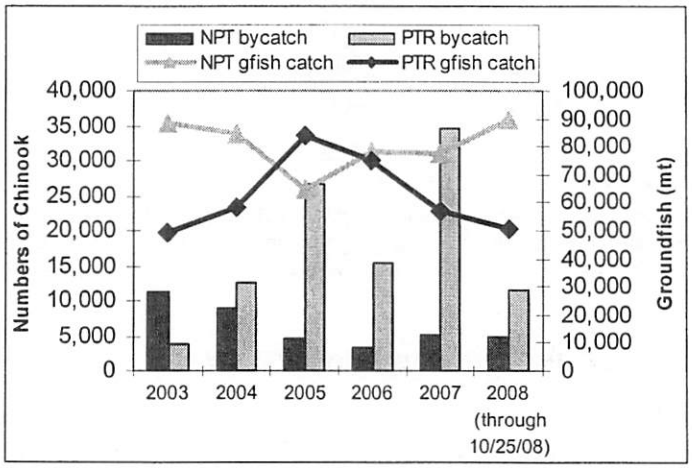
Table 6 identifies Chinook bycatch for 2003-2008, by gear type. Pelagic and non-pelagic trawling are almost entirely responsible for Chinook salmon bycatch. In 2005-2007, pelagic trawl gear accounted for over 80% of Chinook bycatch. The relationship between groundfish catch and pelagic and non-pelagic trawl Chinook bycatch was consistent from 2003-2005 (Figure 1), however since then bycatch rates in the pelagic trawl fishery have been highly variable and have not paralleled groundfish catch.

Table 6 Chinook salmon bycatch by gear type, in Gulf of Alaska groundfish fisheries, 2003-2008

Gear type	2003	2004	2005	2006	2007	2008 (through 10/25/08)	Average 2003-2007
Hook and line	0	31	0	0	35	0	13
Non-pelagic trawl	11,388	9,006	4,593	3,434	5,071	4,975	6,698
Pelagic trawl	3,970	12,440	26,614	15,382	34,663	11,518	18,614
Pot	0	0	0	0	0	0	0
Grand Total	15,358	21,478	31,207	18,816	39,768	16,493	25,325

Source: NMFS catch accounting PSC data, October 2008.

Figure 1 Chinook bycatch in GOA Groundfish Trawl Fisheries



Source: Chinook bycatch from NMFS catch accounting PSC data, October 2008; groundfish catch from NMFS catch accounting data, October 2008. Represents total GOA groundfish catch excluding State waters catch.

Chinook bycatch with non-pelagic trawl gear is distributed among several target fisheries, while pelagic trawl bycatch occurs predominantly in the pollock target fishery (Table 7). In 2005–2007, the flatfish non-pelagic trawl target fisheries accounted for approximately 6-10% of Chinook bycatch in the GOA, although for 2008 through October 25th, that percentage has increased to 17%. In 2003 and 2004, the flatfish target fishery accounted for 45% and 31% of Chinook bycatch, respectively. Averaged over 2003-2007, bycatch in the pollock pelagic trawl target fishery represents 73.2% of total GOA Chinook bycatch, or 18,533 fish annually. Chinook bycatch in the rockfish target fishery has increased since the implementation of the rockfish pilot program in 2007. Table 8 illustrates the distribution of bycatch in the pollock pelagic fishery among reporting areas. While bycatch in the western GOA is consistently lower than it is in the central regulatory area, the proportional bycatch by area within all years 2003-2008 is highly variable. 2007 was the year of highest bycatch in the Chignik area (620), with 28,034 Chinook, while in the Kodiak area (630), 2005 was the highest bycatch year with 13,370 Chinook.

Table 7 Chinook salmon bycatch by target fishery, in Gulf of Alaska groundfish fisheries, 2003-2008

Gear type	Target fishery	2003	2004	2005	2006	2007	2008 (through 10/25/08)	Average 2003-2007
Pelagic trawl	Pollock	3,939	12,440	26,551	15,376	34,357	10,757	18,533
	Rockfish	2	*	63	0	304	761	92
Non-pelagic trawl	Arrowtooth Flounder	3,348	359	1,798	408	1,504	2,608	1,484
	Flathead Sole	598	5,289 [5]	16	56	0	0	1,192
	Pacific Cod	3,167	908	41	882	634	640	1,126
	Pollock	423	571	1,296	380	50	70	544
	Rex Sole	2,819	498	982	1,444	714	0	1,291
	Rockfish	917	885	397	263	1,733	1,465	839
	Shallow Water Flatfish	116	498	63	0	434	192	222

Source: NMFS catch accounting PSC data, October 2008.

Table 8 Chinook salmon bycatch in the pelagic pollock trawl fishery, by reporting area, 2003-2008

Reporting area		2003	2004	2005	2006	2007	2008 (through 10/25/08)	Average 2003-2007
Western GOA	610	738	2,013	5,951	4,529	3,364	2,035	3,105
Central GOA	620	1,121	4,886	6,747	4,843	28,034	6,892	8,754
	630	2,013	5,513	13,370	5,915	2,925	1,448	5,197

Source: NMFS catch accounting PSC data, October 2008.

4.2 Timing of Chinook bycatch

The timing of salmon bycatch follows a predictable pattern in most years. Chinook salmon are caught in high quantities regularly from the start of the trawl fisheries on January 20 through early April, and again during September/October in the pollock B season fishery (Table 9). Figure 2 illustrates the difference in seasonal bycatch patterns between the pelagic and non-pelagic trawl fisheries with respect to Chinook bycatch. For the pelagic fishery, Chinook bycatch pulses in correlation with the seasons of the pollock target fishery. For the non-pelagic trawl fisheries, Chinook bycatch is caught consistently throughout the year, although in higher quantities in the spring months. Because of the varied target fisheries in which the non-pelagic trawl vessels participate, Chinook bycatch does not correlate well to groundfish catch by that sector as a whole. The spike in non-pelagic trawl groundfish catch in July is due to participation in the rockfish fisheries, which incur very low Chinook bycatch.

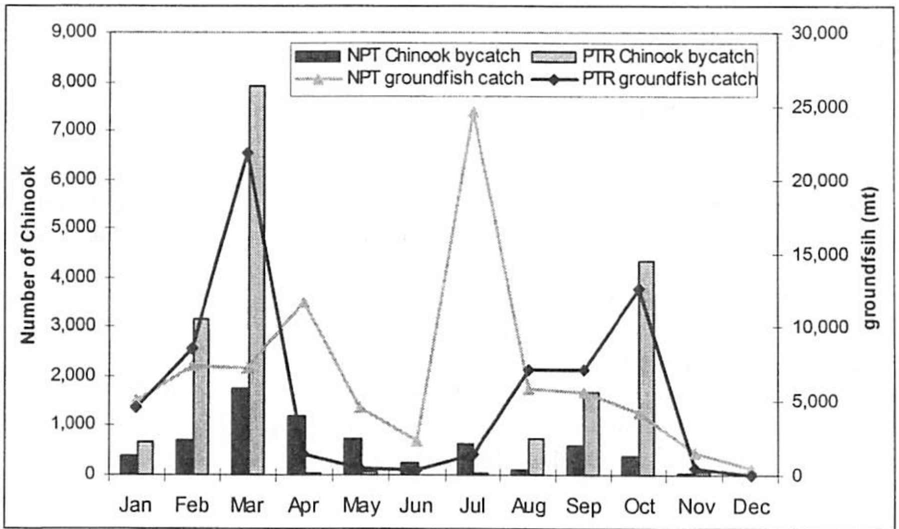
[5] Since this discussion paper was last presented to the Council, NMFS reloaded catcher vessel data from 2003-2008 into the Catch Accounting system in order to identify catcher vessels delivering to motherships. This resulted in the recalculation of some PSC estimates. As a result, Chinook bycatch in the 2004 flathead sole fishery increased from 1,446 to 5,289 Chinook. PSC associated with other target fisheries was not substantially affected. NMFS is currently reviewing these PSC estimates and may revise them at a future date. The data are current as of October 2008.

Table 9 **Chinook salmon bycatch by month, 2003-2008, in Gulf of Alaska groundfish fisheries**

Month	2003	2004	2005	2006	2007	2008 (through 10/25/08)
January	1,988	285	924	1,952	169	314
February	1,524	3,765	10,400	1,816	1,664	710
March	1,005	7,019	7,269	4,799	28,226	6,931
April	3,286	1,042	382	1,143	203	3,117
May	2,372	34	60	10	1,402	1,225
June	0	38	7	28	1,089	363
July	929	1,034	460	235	654	702
August	1,203	1,484	385	811	253	129
September	470	2,759	1,829	4,098	2,179	370
October	2,580	4,018	9,490	3,786	3,859	2,632
November	*	0	*	138	19	
December		*	*		50	

* = data is confidential.
Source: NMFS catch accounting PSC data, October 2008.

Figure 2 **Average Chinook bycatch and groundfish catch by vessels using pelagic and non-pelagic trawl gear, by month, 2003-3007**



Source: Chinook bycatch from NMFS catch accounting PSC data, October 2008; groundfish catch from NMFS catch accounting data, October 2008. Represents total GOA groundfish catch excluding State waters catch.

4.3 Location of Chinook bycatch

The data presented in the sections above has all been based on the NMFS catch accounting prohibited species catch data, which takes bycatch reports from observed fishing trips and applies these bycatch rates to all groundfish catch within each target, gear type, and reporting area. In order to examine the spatial distribution of bycatch at a finer scale than that of the reporting area, it is only possible to use the bycatch data collected on observed trips, as only observed hauls are associated with geographical coordinates. Section 2.1 describes the proportion of fishing trips which are observed in the GOA. Consequently, it should be remembered, while interpreting the series of maps cited in this section, that the data represents only a small proportion of the GOA fishing effort. Additionally, all of the maps use observer data that has been extrapolated to the haul level[6].

In the previous iteration of this discussion paper, dated December 2008, the distribution of bycatch was mapped for 2003-2007. Figure 20 and Figure 23, on pages E and G at the end of this document, map the total number of Chinook observed during the years 2001-2008, in fisheries using pelagic and non-pelagic trawl gear, respectively. In order to see how the most recent bycatch patterns compare to the eight-year time series, Figure 21 and Figure 24, on pages E and G, show bycatch distribution for 2008 only. Figure 22 and Figure 24 (pages F and G) illustrate the total bycatch rate, number of Chinook per metric ton of total catch, for the period 2001 to 2008, for the same gear types. Other closures already in effect for non-pelagic trawl and pot fisheries are illustrated on the maps.

4.4 Factors affecting bycatch: hatchery releases of Chinook salmon

The United States and Canada account for the highest numbers of hatchery releases of juvenile Chinook salmon, although a limited number are released from Russia. The North Pacific Anadromous Fish Commission compiles reports that summarize these hatchery releases (Table 10). Hatchery releases in each region have decreased in recent years.

The United States has the highest number of annual releases (81% of total in 2006), followed by Canada (18%). Of the US releases, the highest numbers are coming from the State of Washington (61% in 2006), followed by California (16% in 2006), and then Oregon (11% in 2007). Hatcheries in Alaska are located in southcentral and southeast Alaska. Since 2004, the number of hatcheries has ranged from 33 (2004–2005) to 31 (2006), with the majority of hatcheries (18–22) located in southeast Alaska, while 11 hatcheries are in Cook Inlet and 2 in Kodiak (Eggers, 2005a; 2006; Josephson, 2007).

The highest numbers of Canadian releases of Chinook in 2006 occurred in the West Coast Straits of Georgia (20 million fish) followed by Vancouver Island area (12.4 million fish) the Lower Fraser River (3.3 million fish) (Cook and Irvine, 2007).

No correlation is discernable between the bycatch of salmon in the GOA and the release from any of these hatchery sites.

[6] Observers do not sample the entire haul from a fishing tow, but rather collect one or several basket samples. The number of Chinook collected within the basket sample is extrapolated by the Observer Program to represent the number of Chinook caught in the entire haul. Extrapolating to the haul level allows the data to be better compared across hauls, even though individual sample sizes may differ.

Table 10 Hatchery releases of juvenile Chinook salmon, by country, compared to GOA groundfish bycatch, in millions of fish

Year	Russia	Canada	USA	Total	Total GOA groundfish Chinook bycatch
1999	0.6	54.4	208.1	**263.1**	.031
2000	0.5	53.0	209.5	**263.0**	.027
2001	0.5	45.5	212.1	**258.1**	.015
2002	0.3	52.8	222.1	**275.2**	.013
2003	0.7	50.2	210.6	**261.5**	.015
2004	1.17	49.8	173.6	**224.6**	.021
2005	0.84	43.5	184.0	**228.3**	.031
2006	0.78	41.3	181.2	**223.3**	.019
2007					.040

Source: North Pacific Anadromous Fisheries Commission reports: Russia (Anon. 2007; TINRO-centre 2006, 2005); Canada (Cook and Irvine 2007); USA (Josephson 2007; Eggers 2006, 2005a; Bartlett 2005, 2006, 2007).

4.5 Impacts of bycatch: river of origin of GOA Chinook

The direct effects of GOA groundfish bycatch of Chinook salmon on the sustainability of salmon populations is difficult to interpret without specific information on the river of origin of each bycaught salmon. No bycatch sampling studies have been conducted in the GOA trawl fisheries to look at the origin of salmon bycatch, although some studies have been undertaken in the Bering Sea pollock trawl fishery. Limited information is available from other studies into the river of origin of salmon species.

The High Seas Salmon Research Program of the University of Washington routinely tags and monitors Pacific salmon species. It should be noted that Coded Wire Tag (CWT) information may not accurately represent the true distribution of hatchery-released salmon. Much of the CWT tagging occurs within the British Columbia hatcheries and thus, most of the tags that are recovered also come from those same hatcheries. CWT tagging does occur in some Alaskan hatcheries, specifically in Cook Inlet, Prince William Sound, other Kenai region hatcheries, as well as in hatcheries in Southeast Alaska (Johnson, 2004).

Chinook salmon tags have been recovered in the area around Kodiak through recovery projects in 1994, 1997, and 1999. The majority of tags recovered from non-Alaska Chinook salmon were from British Columbia, and the study concluded that there was only a low incidental harvest of Cook Inlet Chinook salmon in the Kodiak area (Dinnocenzo and Caldentey 2008).

Other CWT studies have tagged Washington and Oregon salmon, and many of these tagged salmon have been recovered in the GOA (Myers et al. 2004). In 2006, 63 tags were recovered in the eastern Bering Sea and GOA (Celewycz et al. 2006). Of these, 8 CWT Chinook salmon were recovered from the Gulf of Alaska trawl fishery in 2006 and 2007, 8 CWT Chinook salmon were recovered from the Bering Sea-Aleutian Islands trawl fishery in 2006 and 2007, 44 CWT Chinook salmon were recovered from the Pacific hake trawl fishery in the North Pacific Ocean off WA/OR/CA in 2006, and 3 CWT steelhead were recovered from Japanese gillnet research in the central North Pacific Ocean.

Overall, tagging results in the GOA showed the presence of Columbia River Basin Chinook and Oregon Chinook salmon tag recoveries (from 1982–2003). Some CWT recovered by research vessels in this time period also showed the recoveries of coho salmon from the Cook Inlet region and southeast Alaska coho salmon tag recoveries along the southeastern and central GOA (Myers et al 2004).

Additional research on stock discrimination for Chinook salmon is being conducted by evaluating DNA variation, specifically single nucleotide polymorphisms (SNPs). A baseline has been developed that identifies the DNA composition of many BSAI and GOA salmon stocks. Until GOA trawl bycatch samples can be collected and analyzed, however, there is no information to determine what proportion of GOA Chinook bycatch is attributable to rivers of origin in the GOA or elsewhere. The Alaska Fishery Science Center is developing a research plan for sampling Chinook bycatch, but the focus is currently on bycatch in the Bering Sea pollock fishery, and GOA trawl bycatch has not yet been prioritized.

5 Chinook salmon stocks and directed fisheries

The State of Alaska manages commercial, subsistence and sport fishing of salmon in Alaskan rivers and marine waters and assesses the health and viability of individual salmon stocks accordingly. The catches of Chinook salmon in Southeast Alaska are regulated by quotas set under the Pacific Salmon Treaty. In other regions of Alaska, Chinook salmon fisheries are also closely managed to ensure stocks of Chinook salmon are not overharvested. No gillnet fishing for salmon is permitted in Federal waters (3-200 miles), nor commercial fishing for salmon in offshore waters west of Cape Suckling.

Directed commercial Chinook salmon fisheries occur in the Southeast Alaska troll fishery in the GOA, and in the Yukon River, Norton Sound District, Nushagak District, and Copper River. In all other areas, Chinook are taken incidentally, and mainly in the early portions of the sockeye salmon fisheries. Catches in the Southeast Alaska troll fishery have been declining in recent years due to U.S./Canada treaty restrictions and declining abundance of Chinook salmon in British Columbia and the Pacific Northwest. Chinook salmon catches have been moderate to high in most regions over the last 20 years (Eggers 2004).

Forecasts of salmon runs (catch plus escapement) for major salmon fisheries, and projections of statewide commercial harvest are published annually by ADFG. For purposes of evaluating the relative amount of GOA groundfish bycatch as compared to the commercial catch of salmon by area, Table 11 shows the commercial catch of Chinook species by management area between 2003 and 2007. The catches are shown here only as a proxy for an indication of run strength for Chinook stocks across the GOA. Available information on individual stocks and run strengths varies greatly by river and management area. A brief overview of Chinook stocks by area is included in Section 5.1 below. Commercial catches are subject to market constraints and, thus, are not the best estimate of the relative stock size. However, limited information regarding the health of the resource can be obtained by reviewing the commercial catch.

Table 11 Chinook salmon GOA commercial catch, by area, compared to GOA groundfish bycatch, 2003-2007, in 1000s of fish

Year	Southeast	Prince William Sound	Cook Inlet	Kodiak	Chignik	Alaska Peninsula/ Aleutian Islands[a]	Total	Total GOA groundfish Chinook bycatch
2003	431	49	20	19	3	7	**529**	15
2004	497	39	29	29	3	18	**615**	21
2005	462	36	29	14	3	14	**558**	31
2006	379	32	19	20	2	13	**465**	19
2007	359	41	18	17	2	13	**450**	40

[a] Area includes part of the Bering Sea Aleutian Islands

Source: ADFG (http://www.cf.adfg.state.ak.us/geninfo/finfish/salmon/catchval/blusheet/07exvesl.php), NMFS catch accounting PSC data, October 2008.

For Chinook stocks, the 2004 catch in the southeast area represented the highest Chinook harvest on record (since statehood) and almost twice the 10-year average (Eggers 2005b). In Prince William Sound, the 2007 harvest was below the projected harvest and the 7th largest since 1985. Cook Inlet harvests were low compared to long term averages as well. For Kodiak, the 2004 harvest was much higher than the previous 10-year average (Eggers 2006), with lower catches in 2007 compared to the long term average.. For Chignik, the 2004 harvest of Chinook was approximately equal to the previous two years' harvests (under the cooperative management plan) and roughly half of the 10- and 20-year averages. South Alaska Peninsula Chinook harvest in 2007 was less than the 10-year average.

5.1 GOA Chinook salmon stocks

This section provides a brief overview of GOA Chinook salmon stocks. More detailed information on escapement and river systems is available and can be added to this section in future.

Southeast Alaska Stocks

Chinook salmon are known to occur in 34 rivers in the Southeast region of Alaska, or draining into the region from British Colombia or Yukon Territory, Canada (known as transboundary rivers). Harvest in Southeast Alaska occurs under the Pacific Salmon Treaty. 11 watersheds have been designated to track spawning escapement, and counts of these 11 stocks are used as indicators of relative salmon abundance as part of a coast-wide Chinook model. The Taku, Stikine, and Chilkat rivers together make up over 75% of the summed escapement goals in the region. Escapement on the Taku River remains low relative to the 1990-1999 average, but escapement to the Stikine River has increased greatly since 1999 (Pahlke 2007).

The Chinook salmon quota for Southeast Alaska, all gears, in 2006, was 329,400. In addition, a harvest sharing agreement with Canada under the treaty allows harvest in the Stikine River; the US allocation in 2006 was 13,350 fish. There was no directed fishery for Chinook salmon on the Taku River in 2006 due to low forecast returns (Nelson et al 2008).

Prince William Sound

The Prince William Sound management area encompasses all coastal waters and inland drainages entering the north central Gulf of Alaska between Cape Suckling and Cape Fairfield. An Sustainable Escapement Goal for Copper River Chinook is established at 24,000 fish, and inriver escapement to the upper Copper River is established for all salmon species combined. In 2005, about half of the Copper River Chinook salmon run was harvested commercially, a third went to spawning escapement, and the reminder was harvested by upriver sport users or personal and subsistence users (Hollowell et al. 2007).

Cook Inlet

The Cook Inlet management area is divided into 2 areas, the Upper Cook Inlet (northern and central districts) and the Lower Cook Inlet. Inseason management of Cook Inlet commercial salmon fisheries is based upon salmon run abundance and timing indicators. Catch data, catch per effort data, test fish data, catch composition data, and escapement information from a variety of sources is used to assess stock strength on an inseason basis. For Chinook salmon, surveys are made to index escapement abundance (Clark et al 2006).

There are three biological escapement goals (Kenai River early and late runs, Deshka River) and 18 sustainable escapement goals in effect for Chinook salmon spawning in Upper Cook Inlet. After experiencing a significant downturn in the early to mid-1990s, Northern District Chinook salmon stocks continue to trend sharply upward and most escapement goals are being met or exceeded. For the years 2000-2004, for the 15 Upper Cook Inlet populations with the most complete escapement observations, 97% of observed escapement exceeded the lower end of the escapement goal range (Clark et al 2006). Late-run Kenai River Chinook salmon runs are estimated by sonar, and have been relatively stable.

The recent 5-year average commercial harvest was used to forecast the harvest of Chinook salmon in 2008 for the Upper Cook Inlet. The commercial harvest estimate for Chinook salmon is 23,000 fish.

There are 3 sustainable escapement goals in effect for Chinook in the Lower Cook Inlet. Chinook salmon is not normally a commercially important species in the Lower Cook Inlet. The 2007 harvest totaled just under 500 fish, of which virtually all came from the Halibut Cove Subdistrict (Nelson et al 2008). Very little escapement information is available for this area.

Kodiak, Chignik, South Alaska Peninsula

There are three streams that support viable Chinook salmon in the Kodiak management area: Ayakulik River, Karluk River, and Dog Salmon Creek. Commercial harvest occurs during targeted sockeye salmon fisheries. Escapement objectives have been estimated for the Ayakulik and Karluk river systems, and escapement for all three rivers is estimated using fish counting weirs. In 2007, the escapement on the Ayakulik of 6,535 Chinook was within the escapement goal range, but below the previous ten-year average of 14,274 salmon (Dinnocenzo and Caldentey 2008). For the Karluk, 2007 escapement of 1,765 Chinook was below the escapement goal range of 3,600 to 7,300, although in previous years escapements have been within the goal range since 1998. Escapements have averaged 370 fish for Dog Salmon Creek since 1998 (Dinnocenzo and Caldentey 2008).

For the Chignik River, the 2004 Chinook escapement of 7,800 fish was the largest on record and greatly exceeded the escapement goal of 1,300-2,700 fish (Eggers 2006). There are no Chinook spawning streams in the South Alaska Peninsula district.

6 *C. Bairdi* Tanner Crab Bycatch

Several species of crabs may be taken incidentally in GOA groundfish fisheries, however this discussion paper focuses only on *C. bairdi* Tanner crab. The following sections provide updated information on bycatch in the GOA groundfish fisheries.

6.1 Mortality Rates

There are several sources that have calculated mortality rates for crab in various gear types and target fisheries, and many of them differ. The various studies are summarized in Table 12. At their May 2009 meeting, the Council's Crab Plan Team will be discussing the issue of appropriate mortality rates in both directed crab fisheries and other fisheries where crab is caught incidentally, and may be able to provide further guidance after that time. In the meantime, the data presented in the sections below do not account for handling mortality.

Table 12 Various calculations of mortality rates for harvested crab

Study		Directed crab fisheries			Groundfish fisheries			Scallop fishery
		King crab	*C. opilio* Tanner crab	*C.bairdi* Tanner crab				
		Pot	Pot	Pot	Pot	Trawl	Longline	Dredge
Council re-evaluation of overfishing levels	NPFMC et al 2007	20%	50%	20%				
Council's annual Crab SAFE report	NPFMC 2007	8%	24%	20%	20%	80%	20%	40%
Council's groundfish amendment	NPFMC 1995				8%	80%	37%	40%
NRC study	NRC 1990					12-82%		
1998 snow crab study	Warrenchuk and Shirley 2002			22.2%[a]				

[a] Estimate considered to be conservative because the estimated effects of wind and cold exposure as well as handling injuries were considered separately and not synergistically.

6.2 Bycatch in Federal groundfish fisheries, by area, gear type, and target fishery

In the GOA, *C. bairdi* bycatch primarily occurs in the western and central regulatory areas, and corresponds to the locations of the trawl and pot fisheries. Table 13 illustrates bycatch for 2003-2007, and 2008-to-date, across regulatory and reporting areas. Crab bycatch in the eastern regulatory area is negligable. Crab bycatch in the western regulatory area as a proportion of total GOA *C. bairdi* bycatch varies between 3% and 26% of the total, by year, and averages to approximately 10% over 2003-2007.

Table 13 ***C. bairdi*** **bycatch by reporting area, 2003-2008, in GOA Federal[7] groundfish fisheries**

Reporting area		2003	2004	2005	2006	2007	2008 (through 10/25/08)	Average 2003-2007
Western	610	7,458	22,479	45,808	10,431	32,458	28,010	23,727
Central	620	24,033	5,893	9,578	67,316	57,452	43,746	32,854
	630	117,365	63,131	116,112	254,472	219,945	150,244	154,205
Eastern	640	1	0	33	28	17	64	16
	650	1	27	0	22	84	0	27
Grand Total		148,856	91,530	171,532	332,268	309,956	222,064	210,829

Source: NMFS catch accounting PSC data, October 2008. Excludes PSC attributed to the State Pacific cod fishery.

Table 14 identifies *C. bairdi* bycatch for 2003-2008, by gear type. Non-pelagic trawling and pot gear are almost entirely responsible for *C. bairdi* bycatch. In 2003, 2004, and 2006, non-pelagic trawl gear accounted for over 90% of *C. bairdi* bycatch, however since 2007, pot bycatch of *C. bairdi* crab has increased significantly. It should be remembered, however, that the relative observer coverage in these fisheries is notably limited, particularly in the Pacific cod pot fishery. Additionally, the relative impact of bycatch on the mortality of crab likely differs by gear type, although studies differ as to the degree. Section 6.1 provides information about the mortality rates of crab by gear type.

Table 14 ***C. bairdi*** **bycatch by gear type, in GOA Federal groundfish fisheries, 2003-2008**

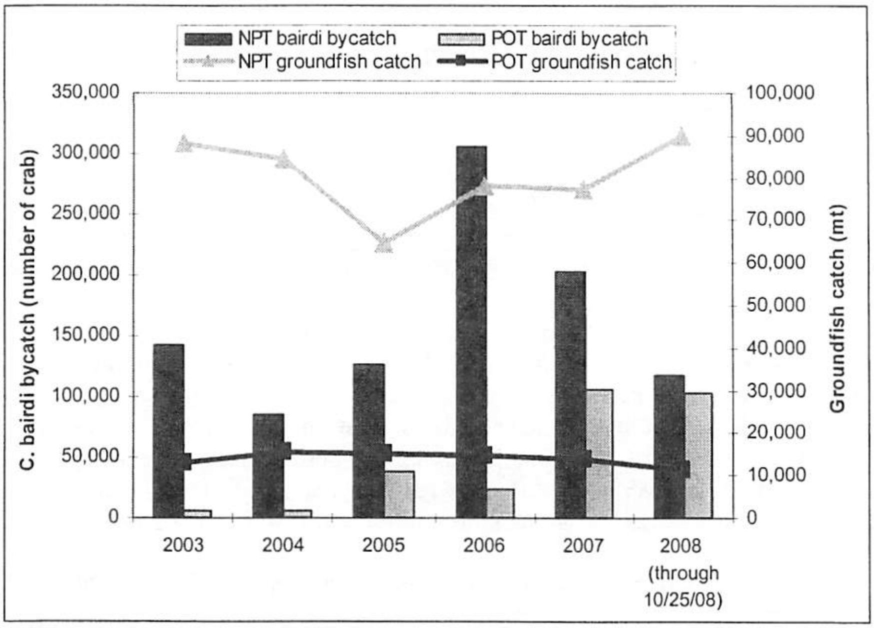
Gear type	2003	2004	2005	2006	2007	2008 (through 10/25/08)	Average 2003-2007
Hook and line	21	28	1,770	596	272	1,638	538
Non-pelagic trawl	142,206	84,885	126,285	306,592	202,547	117,103	172,503
Pot	6,520	5,950	43,341	24,672	105,583	103,255	37,213
Pelagic trawl	110	667	136	407	1,554	67	575
Grand Total	148,856	91,530	171,532	332,268	309,956	222,064	210,829

Source: NMFS catch accounting PSC data, October 2008. Excludes PSC attributed to the State Pacific cod fishery.

Catch of groundfish by pot gear has remained relatively consistent throughout the last five years (Figure 3). In contrast, non-pelagic trawl bycatch has decreased somewhat since the high of approximately 300,000 crab in 2006, while groundfish catch has increased. Table 15 provides a time series of *C. bairdi* bycatch in groundfish trawl fisheries since 1993. Bycatch of *C. bairdi* Tanner crabs in the last 5 years (167,145 crabs per year average, 2003–2007) is higher than the average for the time series from 1993–2003 (108,540 crabs).

[7] Prohibited species catch (PSC), including catch of *C. bairdi*, is extrapolated to all catch in the GOA groundfish fleet using specific catch estimation procedures based on observed bycatch rates (see further explanation in Section 2.1). The observed bycatch rate is also applied to Pacific cod catch in the State managed fisheries that base their guideline harvest level on the Federal Pacific cod acceptable biological catch level (ABC). In order to provide the Council with an estimation of only the PSC taken in Federal fisheries, crab bycatch in the State waters pot fisheries was identified based on the date and location of catch. A discussion of the State waters Pacific cod fishery bycatch is presented separately in Section 6.5.

Figure 3 Annual bycatch of C. bairdi Tanner crab and groundfish catch, by Federal trawl and pot fishery sectors, 2003-2008



Source: *C. bairdi* crab bycatch from NMFS catch accounting PSC data, October 2008; excludes PSC attributed to the State Pacific cod fishery. Groundfish catch from NMFS catch accounting data, October 2008. Represents total GOA groundfish catch excluding State waters catch.

Table 15 *C. bairdi* crab bycatch in GOA groundfish trawl fisheries, 1993-2007

Year	*C. bairdi* Tanner		Year	*C. bairdi* Tanner
1993	55,304		2000	48,716
1994	34,056		2001	125,882
1995	47,645		2002	89,433
1996	120,796		2003	142,488
1997	134,782		2004	62,277
1998	105,817		2005	126,905
1999	29,947		2006	306,767
			2007	197,286
Average 1993-2007	**108,540**			
Average 2003-2007	**167,145**			

Data has been screened for confidentiality.

Source: M. Furuness, J. Keaton, NOAA Fisheries, 1993-2002; NMFS catch accounting PSC data for 2003-2007, October 2008.

The highest numbers of Tanner crab taken as bycatch occur primarily in the non-pelagic trawl fisheries (specifically the flatfish target fisheries, and sometimes Pacific cod and pollock targets) and in the pot fishery for Pacific cod (Table 16). Trawl flatfish fisheries represented approximately 90% of *C. bairdi* bycatch in 2003-2004, but has decreased in proportion since then to only 44% in 2008 to date. The pollock non-pelagic trawl fishery accounted for 35% of *C bairdi* bycatch in 2006, but only 6% in 2007, and negligible amounts in other years. Bycatch attributable to the trawl Pacific cod fishery has increased in 2007 and 2008, representing approximately 5% and 8% respectively, in those years. The Pacific cod pot fishery accounted for 25%, 34%, and 47% of GOA bycatch in 2005, 2007, and 2008, respectively, but only 4-7% in other years.

Table 16 Bycatch of *C. bairdi* Tanner crabs in Gulf of Alaska Federal groundfish fisheries, by gear type and target fishery, 2003-2008.

Gear type	Target Fishery	2003	2004	2005	2006	2007	2008 (through 10/25/08)	Average 2003-2007
Non-pelagic trawl	Arrowtooth Flounder	29,159	33,512	68,936	88,425	43,416	27,485	52,690
	Flathead Sole	17,534	30,410	43,956	25,884	254	6,776	23,608
	Pacific Cod	2,227	1,161	1,314	742	15,231	18,364	4,135
	Pollock	1	555	0	83,599	19,346	244	20,700
	Rex Sole	33,932	9,030	4,461	73,528	45,274	49,207	33,245
	Rockfish	178	1,517	1,445	959	152	62	850
	Shallow Water Flatfish	59,153	8,700	5,984	33,455	78,706	14,776	37,200
Pot	Pacific Cod	6,520	5,950	43,341	24,672	105,583	103,255	37,213

* = data is confidential.

Source: NMFS catch accounting PSC database, October 2008. Excludes PSC attributed to State Pacific cod fishery.

6.3 Timing of bycatch in Federal groundfish fisheries

Bycatch amounts of *C. bairdi* Tanner crab taken in groundfish fisheries fluctuate temporally in direct response to groundfish catches (Table 17). Trawl Pacific cod and flatfish are managed on a quarterly basis, and the trawl fishery beginning on January 20th each year. The pot Pacific cod fishery has two seasons, and any catch in the Pacific cod target fishery from March to August has been attributed to the State managed Pacific cod fishery (see Section 6.5; Figure 4). In the trawl fisheries, average bycatch of Tanner crabs from 2003 - 2007 (in numbers of crabs) increased significantly in mid-March and April due to bycatch in the combined flatfish fisheries, and high bycatch was largely associated with the flatfish fisheries (Figure 4). If the spring months are indeed a time of high bycatch for Tanner crab, the Type II Red king crab closure in place in southeastern Kodiak (Section 3), which is in effect from February 15 to June 15, is likely to be effective at reducing Tanner crab bycatch in that area.

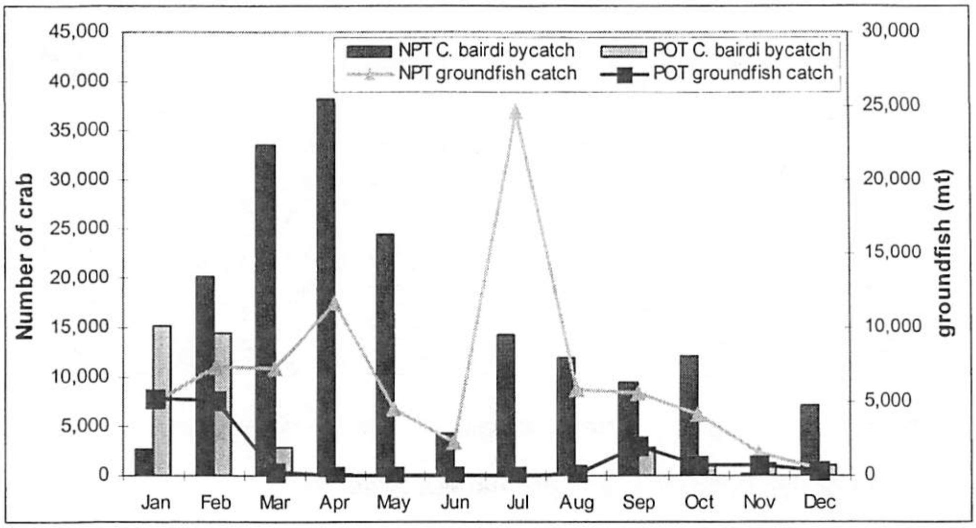
Table 17 *C. bairdi* crab bycatch by month, 2003-2008, in GOA Federal groundfish fisheries

Month	2003	2004	2005	2006	2007	2008	Average 2003-2007
January	4,315	1,999	31,788	9,903	43,411	59,974	18,283
February	9,930	7,519	19,878	66,206	69,675	64,346	34,642
March	19,281	34,643	39,790	71,340	12,482	8,969	35,507
April	22,715	24,492	47,696	64,496	32,177	31,165	38,315
May	35,929	1,615	11,553	21,640	51,343	2,491	24,416
June	10,298	1,893	1,093	7,707	8	54	4,200
July	6,097	16,698	8,518	22,765	17,499	35,653	14,316
August	9,346	354	481	36,878	12,736	18,546	11,959
September	6,300	1,491	5,497	19,495	29,198	200	12,396
October	24,645	725	1,839	10,569	28,990	666	13,354
November	*	78	2,841	494	1,895		1,061
December		24	559	776	10,542		2,975

* = data is confidential.

Source: NMFS catch accounting PSC data, October 2008. Excludes PSC attributed to State Pacific cod fishery.

Figure 4 **Average bycatch of C. bairdi Tanner crab and total groundfish catch by month, for non-pelagic trawl and pot sectors, in Federal fisheries, 2003-2007**



Source: *C. bairdi* crab bycatch from NMFS catch accounting PSC data, October 2008; excludes PSC attributed to the State Pacific cod fishery. Groundfish catch from NMFS catch accounting data, October 2008. Represents total GOA groundfish catch excluding State waters catch.

6.4 Location of *C. bairdi* bycatch

The data presented in the sections above has all been based on the NMFS catch accounting prohibited species catch data, which takes bycatch reports from observed fishing trips and extrapolates them to arrive at GOA-wide totals for recorded Chinook bycatch. In order to examine the spatial distribution of bycatch at a finer scale than that of the reporting area, it is only possible to use the bycatch data collected on observed trips, as only observed hauls are associated with geographical coordinates. Section 2 describes the proportion of fishing trips which are observed in the GOA. Consequently, it should be remembered, while interpreting the maps, that the data represents only a small proportion of the GOA fishing effort. Additionally, all of the maps use observer data that has been extrapolated to the haul level[8].

In the previous iteration of this discussion paper, dated December 2008, the distribution of bycatch was mapped for 2003-2007. Figure 25 and Figure 28 (on pages H and J, at the end of this document) map the total number of *C. bairdi* observed during the years 2001-2008, in Federal fisheries using non-pelagic trawl and pot gear, respectively. In order to see how the most recent bycatch patterns compare to the eight-year time series, Figure 26 and Figure 29, on pages H and J, show bycatch distribution for 2008 only. Figure 27 and Figure 30, on pages I and K, illustrate the total bycatch rate, number of Chinook per metric ton of total catch, for the period 2001 to 2008, for the same gear types. Other closures already in effect for non-pelagic trawl and pot fisheries are illustrated on the maps.

6.5 Bycatch of *C. bairdi* in the State waters Pacific cod pot fishery

The State-managed Pacific cod fishery in western and central GOA began in 1997, and is only open to pot and jig gear. The fishery is managed in five districts: South Alaska Peninsula, Chignik, Kodiak, Cook Inlet, and Prince William Sound. The State bases its guideline harvest level on the Federal acceptable

[8] Observers do not sample the entire haul from a fishing tow, but rather collect one or several basket samples. The number of Chinook collected within the basket sample is extrapolated by the Observer Program to represent the number of Chinook caught in the entire haul. Extrapolating to the haul level allows the data to be better compared across hauls, even though individual sample sizes may differ.

biological catch for Pacific cod, and the Council and NMFS reduce the Federal total allowable catch for Pacific cod to accommodate the State fishery. In most cases, the fisheries open one week after the close of the Federal Pacific cod A season, and occur in late February – April.

In the discussion of bycatch numbers for *C. bairdi* above, catch amounts attributable to the State Pacific cod fishery have not been included in the data. Because the State Pacific cod fishery guideline harvest level is based on the Federal acceptable biological catch for Pacific cod, NMFS inseason management tracks the catch of Pacific cod in the State water fishery, and also makes prohibited species catch extrapolations based on that groundfish catch. In order to provide the Council with a separate estimation of *C. bairdi* crab taken in the Federal and State fisheries, crab bycatch in the State Pacific cod pot fishery was identified based on the date and location of catch. These data are presented separately in this section.

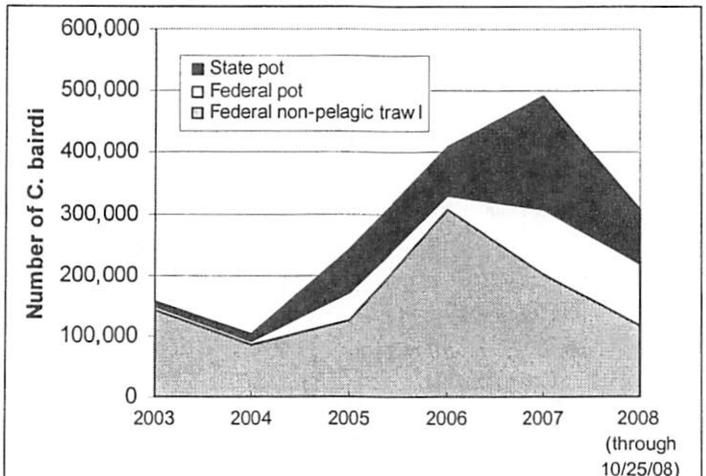
Table 18 identifies the *C. bairdi* bycatch attributable to the State managed Pacific cod pot fishery, which varied from approximately 6,600 crab in 2003, to 184,566 crab in 2007[9]. The contribution of the State managed fishery to overall *C. bairdi* bycatch in the GOA ranged from a low of 4%, in 2003, to a high of 37%, in 2007. Since 2005, the State Pacific cod fishery has contributed a minimum of 20% to the overall *C. bairdi* bycatch in the GOA (Figure 5). It is worth nothing that the bycatch estimates from the State managed fishery are based on minimal observer coverage, and these estimates should be interpreted with caution.

Table 18 ***C. bairdi*** **bycatch in Federal and State groundfish fisheries, 2003-2008**

	2003	2004	2005	2006	2007	2008 (through 10/25/08)
Federal fisheries (hook and line, pot, and trawl)	148,856	91,530	171,532	332,268	309,956	222,064
State Pacific cod fishery (pot gear)	6,515	11,081	72,733	78,729	184,566	85,495
Grand Total	**155,372**	**102,610**	**244,265**	**410,997**	**494,522**	**307,559**
State as % of total	4.2%	10.8%	29.8%	19.2%	37.3%	27.8%

Source: NMFS catch accounting PSC database, October 2008.

Figure 5 **Federal and State** ***C. bairdi*** **bycatch in GOA groundfish fisheries**



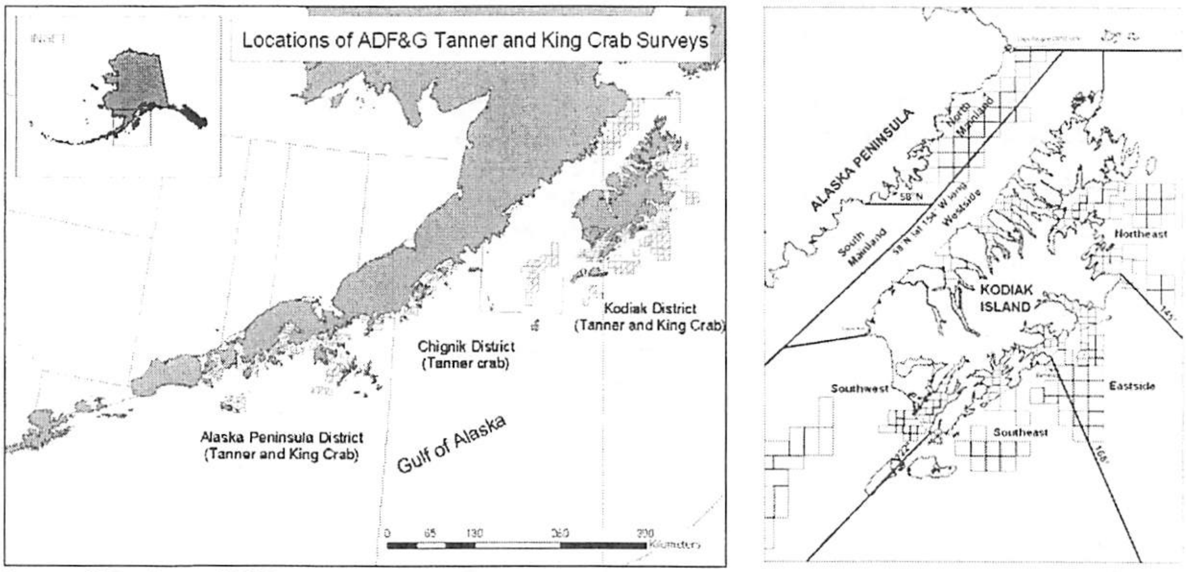
Source: NMFS catch accounting PSC data, October 2008.

[9] In previous versions of this discussion paper, the *C. bairdi* crab bycatch attributable to the State versus Federal pot fishery was not presented separately.

7 *C. bairdi* Tanner crab stocks and directed fisheries

Crab fisheries in the GOA are managed by the State of Alaska. Abundance estimates are produced by region (where possible). For most regions, actual abundance estimates are limited and commercial fishing has been closed. An annual trawl survey is conducted by ADFG. The survey methodology is designed to concentrate sampling in areas of historical king and Tanner crab abundance (Figure 6).

Figure 6 ADF&G trawl survey stations for Tanner and king crab abundance, and fishery management districts around Kodiak Islands



Source: K Spalinger, ADFG

Commercial fishing for *C. bairdi* in 2007 occurred in areas of the Eastside and Northeast sections of the Kodiak District and the Western section of South Alaska Peninsula District. Catch information for 2003 to 2008 is provided in Table 19. Guideline harvest levels (GHLs), by region, are the following for 2009: Kodiak (Eastside and Northeast sections combined) 400,000 pounds and South Peninsula 275,000 pounds (ADFG 2008). In 2007, the GHL for the two Kodiak districts was 800,000 pounds, and for the South Peninsula was 200,000 pounds (ADFG 2007).

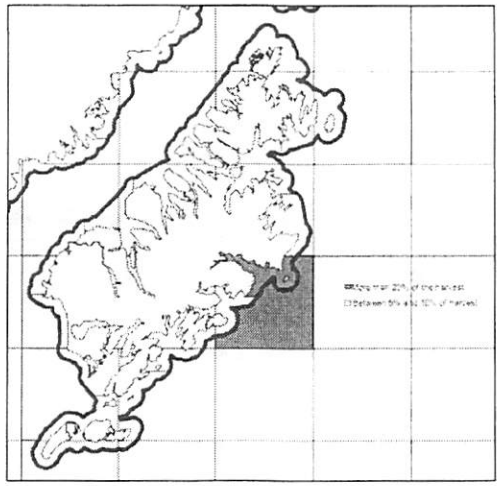
Table 19 Commercial fishery harvest from Kodiak, Chignik, and South Peninsula districts, compared to groundfish fisheries bycatch

	Tanner crab commercial fishery						*C. bairdi* Tanner crab bycatch in the groundfish fisheries (number of crab, includes juvenile, male and female)
	Kodiak		Chignik		South Peninsula		
	millions of pounds	average number of crab	millions of pounds	average number of crab	millions of pounds	average number of crab	
2003	0.51	215,594	no fishery		no fishery		148,856
2004	0.795	253,971	no fishery		no fishery		91,530
2005	1.75	738,535	0.4	179,372	0.3	135,747	171,532
2006	2.1	887,534	0.2	80,000	0.29	128,889	332,268
2007	0.8	338,266	no fishery		0.2	87,719	309,956
2008	0.5	211,864	no fishery		0.25	108,696	222,064 (through 10/25/08)

Source: http://www.cf.adfg.state.ak.us/geninfo/shellfsh/shellfish_harvest.php for commercial harvest, average crab weight from K. Spalinger; NMFS catch accounting PSC database, October 2008 for groundfish bycatch.

ADFG staff mapped the location of the majority of Tanner crab harvest, on average, between 2005-2008 (Figure 7). It was noted that relative importance of harvest may vary on a year to year basis.

Figure 7 Location of high percentages of the Tanner crab harvest, based on 2005-2008 average.



Note: Only one statistical area, Kiliuda, was not included that was important in one year.
Source: K. Spalinger and N. Sagalkin, ADFG

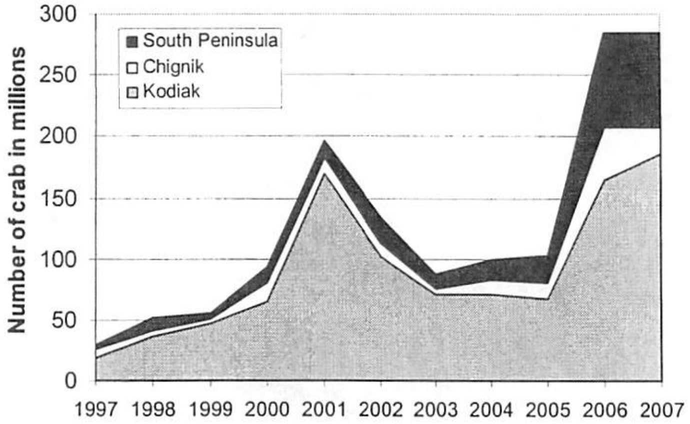
Population estimates for 1997-2007, based on the ADFG surveys, are provided in Table 20 and Figure 8. Population estimates are illustrated individually for the Kodiak, South Peninsula, and Chignik Districts in Figure 9 through Figure 11. The patterns in groundfish bycatch of Tanner crab are roughly comparable with the trends in abundance (see Figure 5 on page 25). For the South Peninsula this estimate represents an increase from the previous survey. Recent survey results indicate an increase in females from 2006–2007 (Spalinger 2007). Maps of the juvenile and mature male and female Tanner crab density, from the 2007 ADFG survey, are included as Figure 18 and Figure 19, on pages C and D, at the end of this document.

Table 20 Population estimates for Kodiak, Chignik, and South Peninsula districts, from the ADFG bottom trawl survey, compared to groundfish fisheries bycatch (# of crab)

	Tanner crab population estimates				*C. bairdi* Tanner crab bycatch in the GOA groundfish fisheries
	Kodiak	Chignik	South Peninsula	Total GOA	
1997	19,549,768	6,187,241	3,423,890	29,160,899	
1998	37,301,601	3,638,101	11,494,791	52,434,493	
1999	47,308,846	3,679,516	4,821,093	55,809,455	
2000	65,757,053	15,016,398	13,236,554	94,010,005	
2001	169,728,000	12,661,036	14,285,065	196,674,101	
2002	102,080,109	10,770,374	20,741,451	133,591,934	
2003	70,568,053	5,736,390	11,267,753	87,572,196	148,856
2004	71,001,649	12,071,083	16,140,938	99,213,670	91,530
2005	67,676,189	13,425,618	22,258,555	103,360,362	171,532
2006	165,042,947	42,001,597	77,288,253	284,332,797	332,268
2007	186,255,950	21,372,141	76,775,256	284,403,347	309,956

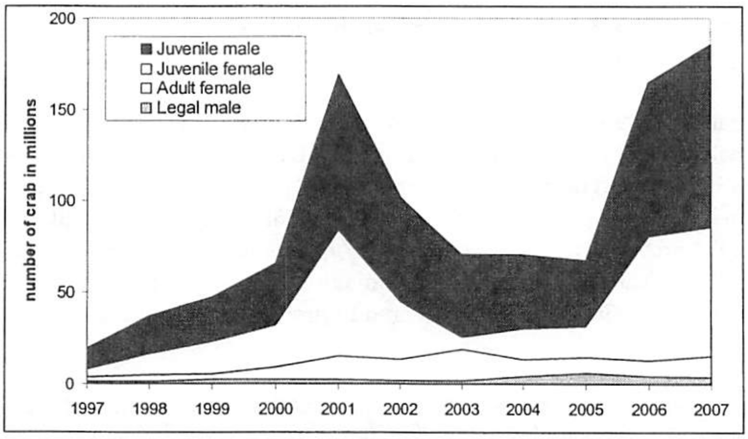
Source: Spalinger 2008 for ADFG survey; NMFS catch accounting PSC database, Oct 2008 for groundfish bycatch.

Figure 8 **Population estimates for Kodiak, Chignik, and South Peninsula districts, from the ADFG bottom trawl survey**



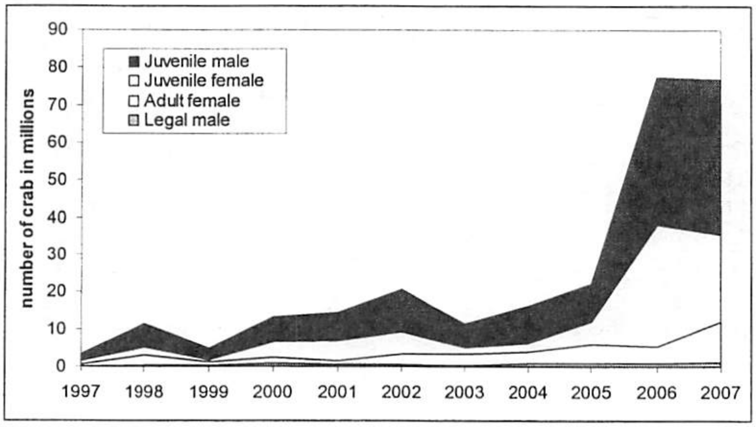
Source: Spalinger 2008.

Figure 9 **Tanner crab population estimates in the Kodiak district, based on ADFG trawl surveys 1997-2007**



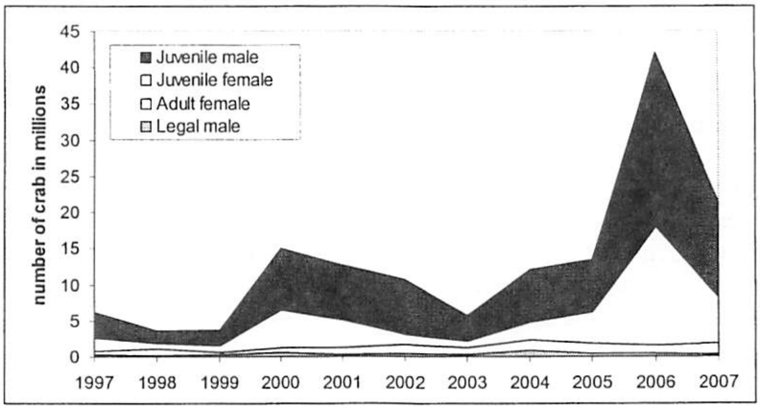
Source: Spalinger 2008.

Figure 10 **Tanner crab population estimates in the South Peninsula district, based on ADFG trawl surveys 1997-2007**



Source: Spalinger 2008.

Figure 11 Tanner crab population estimates in the Chignik district, based on ADFG trawl surveys 1997-2007



Source: Spalinger 2008.

Population estimates for Cook Inlet management region list male *C. bairdi* Tanner crab abundances in the Southern region as 3.1 million males, however it was noted that the estimate of legal sized males is at a historic low. Female abundance in this region was estimated at 2.1 million crabs in 2001, primarily due to a very high number of estimated juveniles. The southern region has been closed to commercial fishing due to low crab abundances since 1995 (Bechtol et al. 2002).

The Kamishak and Barren Islands District of the Cook Inlet management region has also been closed to commercial fishing (since 1991) due to concerns of low crab abundance. In these regions the male abundance is estimated at 6.1 million crabs, with a near historic low in mature males, while female abundance is estimated at 5.1 million crabs with a record low percentage of mature females. There are limited data to assess the Outer, Eastern, and Central Districts of the Cook Inlet management region, and both regions have been closed to commercial fishing (since 1998 for Central and 1993 for Eastern/Outer).

For the Southeast region, a population survey was begun in 1997/1998 to evaluate regional distribution of *C. bairdi* Tanner crab stocks and the relative abundance estimates. However, at present, no estimates of overall *C. bairdi* Tanner crab abundance in the region are available.

8 Management options to reduce bycatch

In order for the Council to move forward with management options to reduce bycatch, it is important to determine what is the Council's desired objective, as this influences what management options will appropriately address the problem. The Council has already narrowed the scope of this discussion paper down to two species of interest: Chinook salmon and *C. bairdi* Tanner crab. Bycatch of these two species in the GOA groundfish fisheries is high relative to other salmon or crab species. The Council's purpose in trying to reduce bycatch is likely to be one of the following factors, or a combination of them: a. groundfish bycatch of these species represents a conservation concern; b. groundfish bycatch of these species is impacting directed fisheries for these species; or c. mortality caused by groundfish bycatch of these species is at a socially unacceptable level (note, this is ties into one of the Council's management objectives for the groundfish fisheries).

In all cases, the Council is evaluating whether the groundfish fisheries' bycatch levels cross a threshold at which corrective action is warranted. For various reasons, information is not available to determine, with specificity, to what degree the amount of bycatch taken in groundfish fisheries is likely to affect the sustainability of salmon and crab populations. Sections 5 and 7 provide limited information on the Chinook and *C. bairdi* populations, with which to put in context the bycatch numbers presented in the discussion paper. Based on this information, the Council will decide further action should be considered, and management options to reduce bycatch should be instituted.

The type of management options available to the Council include seasonal and permanent area restrictions to a particular gear type or target fishery; temporal area restrictions, that may be triggered by attainment of a bycatch limit; or creation of industry-level bycatch management entities that can effect real-time communication to avoid 'hotspot' areas of high bycatch. All of these management options have benefits and disadvantages, which cannot be fully analyzed in this discussion paper, but which will be addressed in detail should the Council choose to initiate an analysis. The sections below provide a brief outline of the management options that could be included in an analysis, as well as some preliminary strawman closures to illustrate some of the options.

8.1 Draft alternatives

The following suite of draft alternatives for reducing salmon and crab bycatch in the GOA groundfish fisheries were first proposed by the Council in December 2003, and have been iteratively refined since that time. In June 2008, the Council eliminated alternatives for salmon and crab species other than Chinook salmon and *C. bairdi* Tanner crab, and requested staff to begin to develop strawman closures to pair with the draft alternatives. The following are the draft alternatives:

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 high bycatch rates.
Alternative 4: Voluntary bycatch cooperative for hotspot management.

C. bairdi Tanner Crab

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 high bycatch rates of Tanner crab by gear type.
Alternative 4: Voluntary bycatch cooperative for hotspot management.

In June 2005, the Council also provided, in their motion, the following comments on developing trigger limits, and general recommendations for an analysis.

Trigger limits:

1- Average numbers are not an appropriate approach to establishing trigger limits. The analysis should instead focus upon the use of biomass-based approaches for establishing appropriate trigger levels.
2- Trigger limits under consideration should be separated by gear type (i.e. separate limits for pot gear versus trawl gear)
3- Rather than considering an improperly defined duration of a triggered closure, the Council recommends moving in the direction of dynamic revolving closures (hot spots) which reflect the distribution and mobility of the crab population.

General recommendations for the analysis:

1- Differential discard mortality rates by gear type should be addressed in the analysis using the most up-to-date and applicable information.
2- Additional information must be included with respect to the overall precision of bycatch estimates given the low levels of observer coverage in many of the fisheries under consideration.
3- The addition of another alternative (from staff discussion paper) for an exemption from time and area closures if an observer is on board, seems pre-mature at this time.
4- Emphasis should be focused on alternatives 3 and 4 rather than focusing attention on trigger limits under alternative 2.
    a. With respect to alternative 3, additional information may be necessary (in addition to ADFG survey information and bycatch information from the NOAA groundfish observer program) in order to appropriately identify sensitive regions for year-round or seasonal closures. Some of this additional information may include catch data from the directed Tanner crab fisheries in these areas.
    b. Alternative 4 should include the concept of required participation in a contractual agreement for a hot spot management system
5- A rate-based approach format should be added as much as possible in all graphs and figures for the analysis.
6- Consideration should be given to the overall significance of the total amount of Tanner bycatch numbers as compared with the best available information on the population abundance in order to evaluate the actual population-level impact of the bycatch from the directed groundfish fisheries.

8.2 Estimating trigger limits

Trigger limits, as proposed under Alternatives 2, would close designated areas to all or specified gear types or target fisheries once a bycatch limit has been reached. PSC limits and associated closures have been used for salmon and crab bycatch in the Bering Sea groundfish fisheries (Witherell and Pautzke 1997). For instance, the pelagic trawl pollock fishery accounts for a high percentage of GOA Chinook bycatch. The Council might set a bycatch limit for Chinook salmon, and once it has been attained (either by the fleet as a whole, or exclusively by the pollock fishery), a designated area might be closed to pollock fishing for the remainder of the year or season. Likewise for Tanner crab, the Council might establish a linkage between the bycatch limit and the non-pelagic trawl flatfish fishery, and once the bycatch limit has been reached, an area closure could apply to the flatfish fishery.

In the past, the Council has provided direction to staff with respect to establishing trigger limits. Staff were encouraged to look at abundance-based methodologies for developing potential trigger limits. These could either be based on an estimate of, or float as a percentage of, the overall biomass of Chinook or *C. bairdi* species. This abundance-based approach has been used in the BSAI groundfish fisheries for crab species. A stair-step procedure of increasing PSC limits corresponding to higher population levels is in place for red king crab; an abundance-based zonal approach is used for *C. bairdi* Tanner crab; and the snow crab PSC limit is based on the percentage of annual biomass estimates. Biomass-based limits require a good understanding of the relative stock status for that species. Sections 5 and 7 provide an overview of stock status for Chinook salmon and *C. bairdi* Tanner crab in the GOA, but a detailed understanding of the health and vulnerability of crab stocks will be integral to determining the appropriate mechanism for establishing trigger limits, if the Council chooses to include a trigger limit management option in a future analysis.

The proposed alternatives using trigger closures would work similar to other existing PSC management measures. Currently in the GOA, PSC limits are only set for halibut in the flatfish fisheries, so that if the PSC limit for the target fishery (or group of target fisheries) is reached within a given season, the fishery (or fisheries) is closed for the remainder of the season. Establishing trigger bycatch limits for Chinook salmon or *C. bairdi*, as proposed under Alternatives 2, would result in a similar procedure. Inseason management would monitor the accrual of bycatch toward the PSC limit. As most of the GOA groundfish fisheries are subject to less than 100% observer coverage, bycatch rates from observed vessels would be applied to catch on unobserved vessels using the catch accounting database estimation procedure, described in Section 2.1.

In order to establish PSC limits for Chinook or *C. bairdi*, the Council would first establish what type of bycatch would accrue to the trigger limit (e.g., all bycatch by any gear type, or specific bycatch by gear type, target fishery, and/or regulatory area). Next, the Council would establish what the consequence of arriving at the limit would be (e.g., an area closure for the remainder of the year or season), and to whom the consequence would apply (e.g., a particular gear type and/or target fishery).

It has been suggested that establishing trigger PSC limits for managing Chinook salmon and *C. bairdi* crab bycatch in the GOA is problematic. The low proportion of observed catch in the GOA means that the reporting of total bycatch numbers involves considerable extrapolation. Inherent in the catch estimation procedure is the fact that a catch of one salmon or crab in a small groundfish haul (resulting in a high bycatch rate) can sometimes be extrapolated to very large amounts of catch, resulting in exceedingly high bycatch totals for the GOA as a whole. The Alaska Fisheries Science Center is looking into the possibility of including estimates of statistical confidence into the bycatch estimation procedure, but for the moment, the current procedure is the best available. It is also the procedure that is currently used to manage the PSC limit for halibut in the GOA.

8.3 Determining appropriate area closures and preliminary strawman closures

Year-round and seasonal closures, such as those proposed under Alternatives 3, have also been used in both the GOA and BSAI fisheries to control the bycatch of prohibited species. Currently, in the GOA, trawl closure areas have been implemented around Kodiak Island to protect red king crab. Area closures can also be associated with PSC trigger limits, as under Alternative 2, so that a particular area is closed once the PSC limit is reached.

For salmon, the highest bycatch is seasonal, and is tied to the timing of the pollock fishery. Seasonal closures of hot spot locations could merit examination, rather than year-round closures. Seasonal salmon closures have been used to control salmon bycatch in the BSAI groundfish fisheries, although in recent years these closures have been problematic, and measures to address salmon bycatch, including revised area closures and PSC limits that would close the pollock fishery when triggered, are currently under review (NMFS 2008). Given that the Council is currently revising bycatch reduction measures for salmon in the BSAI, any measures evaluated in the GOA should consider and build upon lessons learned in the BSAI.

There are various methodologies available for identifying appropriate areas to close in order to reduce bycatch of salmon and crab. One such is to look at areas of high abundance of the species in question, and restrict fishing in those areas. This methodology could be used for crab, but as discussed above, is less effective for Chinook salmon. To some extent, closures that protect *C. bairdi* crab are already in effect for non-pelagic trawl vessels, such as the Type I and II red king crab closures as well as State water closure, which encompass some areas of high Tanner crab abundance (see Section 7). However, Tanner crab abundance is variable from year to year, as are bycatch patterns, which complicates the identification of key abundance areas.

Another methodology that was used by the Council to create habitat closures in the Aleutian Islands and the northern Bering Sea is the footprint approach. For example, in the Aleutian Islands, closures were intended to protect coral (and fish habitat), and little is known about the abundance of coral in those areas. Closures in this instance were identified to contain fishing within historic limits. The footprint approach is not necessarily helpful when protecting highly mobile species such as salmon, however.

The default methodology for this preliminary analysis is to use bycatch locations as a proxy for abundance, and identify closure areas based on the locations of hauls with observed bycatch. High incidence of bycatch and high bycatch rates, summed over the years 2003-2007, were used to identify the strawman closures described below. There are many problems with this approach, some of which have already been described above. The observer data is the best available data for designing closures based on where the fishery encounters bycatch. However, the observed fishing trips represent only a relatively small proportion of total fishing trips in the western and central GOA. Also, for vessels that are not 100% observed, the areas where a vessel chooses to fish while it has an observer onboard may be purposefully different than the areas where it fishes without an observer. This might occur if a vessel chooses not to make longer trips with an observer onboard, because it might require paying the observer for a longer duration than is necessary to meet the observer requirement. If this is the case, basing a spatial analysis of where bycatch is occurring on the observer data may not always produce an accurate representation of actual bycatch distribution. Another issue with using the observer data for identifying regulatory closures was discussed in Section 2.3, on page 8, with respect to sampling bycatch at the plant in the pollock fishery, and the fact that it effectively averages the bycatch caught on a trip across all the hauls that occurred during that trip.

Additionally, areas with high numbers of bycatch also tend to be the areas where most of the catch is occurring. By prohibiting vessels from fishing in areas of high catch per unit effort, bycatch closures would force vessels to fish longer in other, less productive areas, which may result in higher bycatch rates in the long run. This issue can be addressed by looking at areas with high bycatch rates (e.g. crab/mt groundfish) instead of looking at absolute bycatch numbers. However, bycatch rates are also a problematic methodology, because some of the highest bycatch rates arise from having one salmon or crab caught in a small tow of groundfish, which may not necessarily be representative of a high abundance area that would benefit from a closure.

Bycatch patterns (as with abundance patterns for Tanner crab) are also highly variable from year to year. The correlation between the location of fishery catch and salmon and crab bycatch has not been fully investigated, but preliminary analysis seems to indicate that the variability is as much a function of salmon and crab life history changes or abundance as it is changes in the fleet's fishing patterns. This complicates the identification of appropriate closure areas to protect Chinook salmon and *C. bairdi* crab, as a closure that might be appropriate to protect the species in one year may be ineffective in another one. This appears to have been the case with the salmon closure areas for Chinook and chum salmon in the BSAI, which are currently under review by the Council. Since the initial evaluation of strawman closures was made, in the version of this discussion paper dated December 2008, staff have mapped and included additional years of observed bycatch history: 2001, 2002, and 2008. Consequently, it is the strawman closures that are described below, based on 2003-2007 bycatch, are often mapped against the 2001-2008 time series, or against 2008 alone. This comparison will allow the Council to see the annual variability in bycatch patterns, and some of the problems with establishing closure areas as a mechanism to reduce Chinook and Tanner crab bycatch in the GOA groundfish fisheries.

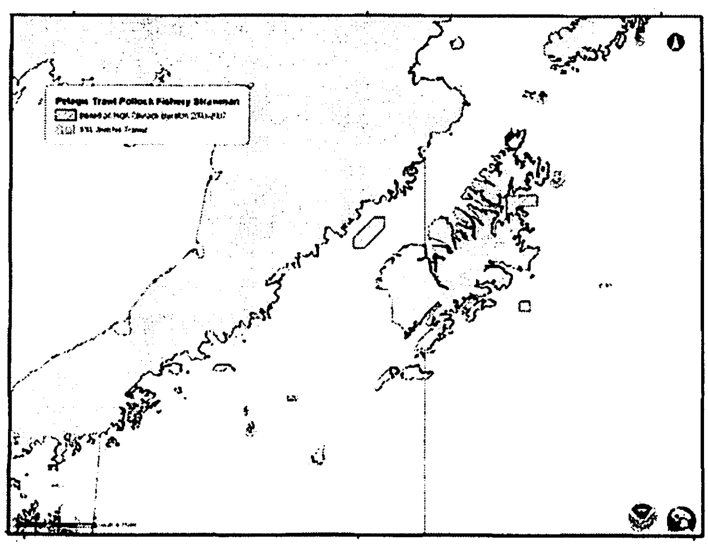
Strawman closures for Chinook salmon

For Chinook salmon, staff tried to look at separate strawman closures for vessels using pelagic and non-pelagic trawl gear. While the majority of salmon overall is taken in the pollock pelagic trawl fishery, the non-pelagic trawl fisheries combined contribute an average of 25% to the total GOA Chinook bycatch. Based on the observer data, however, it was very difficult to identify hotspot bycatch areas that could serve as strawman closure areas for the non-pelagic trawl fleet. For this reason, strawman closures for non-pelagic trawl gear are not included in this discussion paper, although it is possible that further detailed analysis of the observer data may be able to suggest a different methodology for identifying closures for this gear type in the future.

For pelagic trawl, strawman closures were identified based on high incidence of Chinook salmon in the pelagic pollock trawl fishery during 2003-2007 (Figure 12). The closures were identified by selecting areas with the highest category of observed bycatch during those years, extrapolated to the haul level, and also include any areas of the second highest category that surround it. An attempt was made to include areas of at least two blocks of high or highest catch. The closure areas are overlaid on maps of the observed number of Chinook salmon from 2001-2008 (Figure 31, on page L at the end of the document), and for 2008 only (Figure 32), which provides information on the spatial variability of the catch on an annual basis. Additionally, the strawman closures are compared to the bycatch rate of salmon, from 2001-2008, for the pelagic trawl fishery (Figure 33). This methodology results in three closure areas, all of which occur in the central GOA.

As discussed in Section 2.3 and above, prohibited species in the pollock fishery are sampled at the plant, and the location of the bycatch is averaged among all hauls in a given trip. Should the Council proceed with an analysis of closure areas for pelagic trawl gear, a more detailed spatial analysis would need to be conducted to investigate the impact of this averaging on the delineation of appropriate closure areas.

Figure 12 Chinook salmon strawman closures for pelagic trawl gear, based on high incidence of bycatch summed for 2003-2007



Strawman closures for *C. bairdi* Tanner crab

For *C. bairdi* crab, staff looked at separate strawman closure areas for vessels using non-pelagic trawl gear and for those using pot gear, using 2003-2007 bycatch data. The strawman closures do not overlap at all. All closure areas for non-pelagic trawl gear fall in the central GOA, as areas of bycatch in the western GOA did not meet the criteria used to develop the strawman areas. Pot strawman closures do extend into the western GOA. In order to provide different perspectives on the closures, given the problems with developing closures as noted above, staff looked at several ways of identifying strawman closures.

The first set of strawman closures (Figure 13 and Figure 14) are based on areas of high incidence of bycatch. The closures were identified by selecting areas with the highest category of observed bycatch in 2003-2007, extrapolated to the haul level, and also include any areas of the second highest category that surround it. An attempt was made to include areas of at least two blocks of high or highest catch. There are three individual strawman closures identified for non-pelagic trawl gear, and seven areas identified for pot gear, five in the central GOA and two in the western GOA. The non-pelagic trawl and pot closures identified through this method occur in completely different areas, and there is no overlap between them. Figure 13 illustrates the non-pelagic trawl and pot strawman closures for the central GOA on the same map.

The closure areas for non-pelagic trawl gear are overlaid on a map of high incidence of bycatch in the years 2001-2008 (Figure 34, on page N at the end of the document), and a map showing only 2008 (Figure 35), to illustrate the spatial variability on an annual basis. The map also denotes existing closures that pertain to vessels fishing with non-pelagic trawl gear. For pot gear, Figure 38 (page P) compares the pot strawman closures to high incidence of bycatch in 2001-2008, and Figure 39 does the same for the year 2008. Figure 40 compares the strawman closures based on high incidence of bycatch to the pot gear bycatch rate for 2001-2008. The strawman areas that are identified in the figures are also areas where the much of the catch is taken. Implementing closures in these areas will be disruptive to the fishery, and displacement of effort will occur, which may result in lower catch per unit effort and other bycatch effects.

Figure 13 *C. bairdi* crab strawman closures in the central GOA, for non-pelagic trawl and pot gear, based on high incidence of bycatch summed over 2003-2007

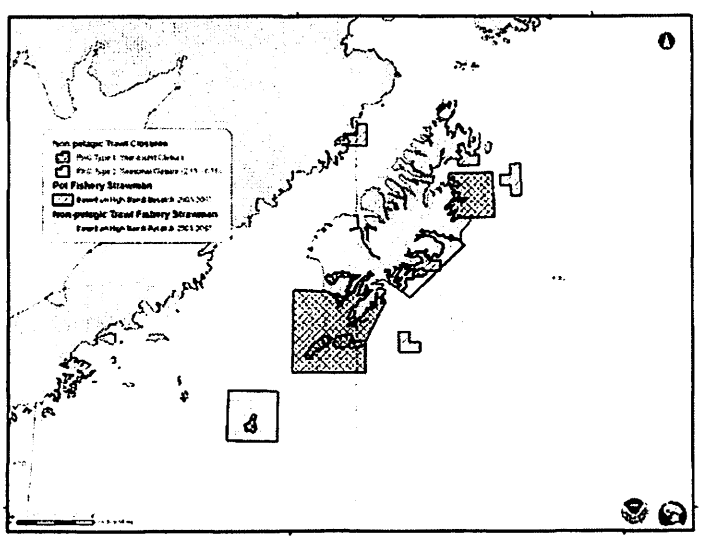
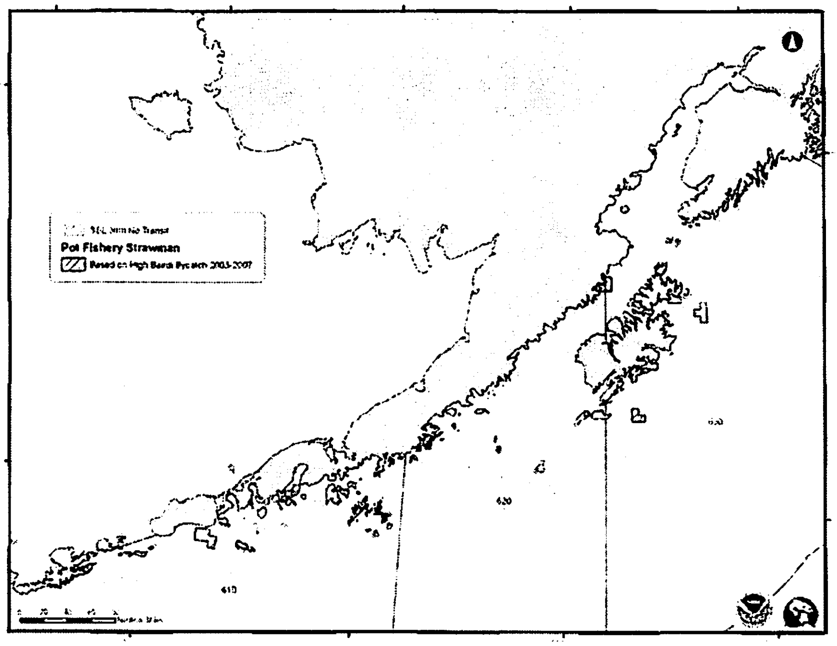


Figure 14 C. *bairdi* crab strawman closures for pot gear in the western and central GOA, based on high incidence of bycatch summed over 2003-2007



Staff also looked at areas where bycatch has repetitively been observed, without looking at the amount of bycatch that was reported for those areas. Areas that have repetitive bycatch may also be candidates for closure areas, and looking at bycatch in this way eliminates the extrapolation that occurs under the set of high incidence strawman closures. However, it is also likely that these areas are also the most heavily fished. The areas identified using this approach are similar to the areas identified using the high incidence of bycatch approach, and staff did not reproduce them in this paper. Similarly, staff evaluated strawman closure areas based on the top 10% of records of high bycatch, which were also little different from those identified by looking at high incidence overall.

For non-pelagic trawl gear, staff also provided another set of strawman closures identifying areas based on the bycatch rate (Figure 36, on page O). This approach results in fewer total closures areas than by looking at high incidence, and the closure areas do not overlap (see Figure 37 for a comparison). This approach was not used to develop strawman closure areas using bycatch rate for pot gear. The methodology used by staff involves identifying blocks with the highest bycatch rate as those for the strawman closure, and for pot gear, there were no particular areas with high bycatch rates in 2003-2007.

Catch statistics for strawman closures

Table 21 provides a synthesis of the strawman closures identified above. The data , summed for 2001 to 2008, is from the observer database which was used to map the distribution of Chinook and *C. bairdi* bycatch in the western and central GOA. The table provides the overall bycatch rate of Chinook salmon or *C. bairdi* crab per total catch in the western and central GOA, by gear type, for 2001-2008, and compares it to the bycatch rates in the areas encompassed under the sets of strawman closure areas. Additionally, the total number of tows or sets occurring in each set of closure areas is compared to the total number of hauls that contain the bycatch species in question, which gives an idea for the degree to which bycatch is pervasive in the strawman closures. The final columns identify how much of the total observed catch and total observed bycatch come from the strawman closure areas.

Table 21 Total observed catch and Chinook or bairdi bycatch in strawman closures, by gear type, compared to catch and bycatch of that gear type in the western and central (W/C) GOA, summed over 2001-2008

Area, gear type, and bycatch species	**Total Chinook or bairdi bycatch**[2] (number)	**Total fishery catch**[2] (mt)	**Bycatch rate** (bycatch/ total catch)	**Total number of tows/sets in strawman areas**	**Total tows/ sets with bycatch in strawman areas**	**% of total W/C GOA bycatch occurring in strawman areas**	**% of total W/C GOA catch occurring in strawman areas**
Chinook – pelagic trawl gear							
Pelagic trawl in western and central GOA	24,299	119,638	0.20				
Pelagic trawl strawman closures based on high incidence of Chinook[1]	9,524	32,567	0.29	965	702	39.2%	27.2%
C. bairdi – non-pelagic trawl gear							
Non-pelagic trawl in western and central GOA	249,277	219,768	1.13				
Non-pelagic trawl strawman closures based on high incidence of bairdi[1]	150,029	22,850	6.57	1,832	690	60.2%	10.4%
Non-pelagic trawl strawman closures based on high bycatch rates of bairdi[1]	13,426	355	37.82	60	34	5.4%	0.16%
C. bairdi – pot gear							
Pot gear in western and central GOA	41,569	10,550	3.94				
Pot gear strawman closures based on high incidence of bairdi[1]	14,937	849	17.59	215	124	36.9%	8.1%

Source: NMFS observer database, March 2009.
[1] The methodology used to identify the strawman closures is described earlier in Section 8.3, and the closures themselves are illustrated in Figure 12, Figure 13, Figure 14, and Figure 37 (on page O at the end of the document).
[2] These numbers are based on observer data that has been extrapolated to the haul level. Observers do not sample the entire haul from a fishing tow, but rather collect one or several basket samples. The number of a particular bycatch species collected within the basket sample is extrapolated by the Observer Program to represent the number of that bycatch species caught in the entire haul.

For the pelagic trawl gear strawman closures for Chinook, the bycatch rate increases from an average of 0.20 GOA-wide to 0.29 in the strawman closure areas as a group. 73% of all observed tows in the strawman closure areas contained Chinook bycatch. The strawman closure areas encompass areas where almost 40% of the observed Chinook bycatch was reportedly caught[10], but they also represent areas where 27% of the total catch in the pelagic trawl fishery was harvested. Consequently, if these areas were made into regulatory closures, a quarter of the effort in the fishery would be dispersed into other areas. Should the Council choose to pursue an analysis with this as an alternative, the analysis would have to look at the likely areas where the fishery could recoup that effort, and what the bycatch rates would be likely to be in those areas.

For the non-pelagic trawl fishery, there are two proposed sets of strawman closure areas, based on areas of high bycatch incidence, and areas of high bycatch rates. It is apparent from Table 21 that the strawman closures based on high incidence of bycatch encompass much more fishing effort than those that are based on high bycatch rate. As discussed earlier in the section, a high bycatch rate may often be assigned to an area because there has been low groundfish fishing effort in the area, and so the catch of a relatively small amount of bycatch may result in an apparent high bycatch rate. Should the Council initiate an analysis that looked at the development of closure areas based on bycatch rates, the analysts would need to carefully examine the individual records for each area, in order to determine to what degree the closure of the area would be likely to assist the Council's overall goal to reduce bycatch. For the non-pelagic strawman closure areas based on high incidence, only a third of the tows encompassed in the strawman areas contained bairdi bycatch. The strawman closure areas account for approximately 60% of observed bairdi bycatch, and approximately 10% of observed catch.

The bycatch rate for pot gear within the pot strawman closure areas increases to 17.59, from the western/central GOA-wide pot gear bycatch rate of 3.94. Approximately 37% of the observed bairdi bycatch is caught in the strawman closure areas, compared to approximately 8% of the observed total catch. Pot and non-pelagic trawl gear are assumed to have different bycatch mortality rates for crab species, but because the calculated mortality rates differ widely according to the source (see Section 6.1), the calculation from overall bycatch to bycatch mortality is not made in this discussion paper.

8.4 Voluntary bycatch cooperatives

Alternative 4 for both crab and salmon species would establish a bycatch pool or cooperative for hotspot area management. This alternative is designed after the current BSAI bycatch cooperatives, in use by industry to control salmon bycatch in the pollock fishery. Currently in the BSAI, a program of voluntary area closures is in place with selective access to those areas for fleets which demonstrate success in controlling bycatch (Haflinger 2003, NMFS 2008). Voluntary area closures can change on a weekly basis, and depend upon the supply and monitoring of information by fishermen. The sharing of bycatch rates among vessels in the fleet has allowed these bycatch hotspots to be mapped and identified on a real-time basis, so that individual vessels can avoid these areas (Smoker 1996, Haflinger 2003, NMFS 2008). This system relies upon information voluntarily reported to Sea State by the fleet per their cooperative agreements.

One problem with implementing a voluntary cooperative program in the GOA is the fact that the GOA fisheries tend to be of short duration. In the Bering Sea, hotspot areas can be closed on a weekly basis, however this approach would not work in the GOA fisheries. Additionally, the program is more easily implemented in the Bering Sea pollock fishery because the fishery is rationalized, and the agreement is between cooperatives with dedicated pollock allocations. An extensive discussion of the BSAI intercooperative agreement is included in the Draft Environmental Impact Statement for Bering Sea Chinook Salmon Bycatch (NMFS 2008).

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[10] See Section 2.3 for discussion of the sampling mechanism for the GOA pollock fishery, and impacts on the averaging of bycatch across multiple haul locations.

9 Action by the Council

The decision before the Council is whether to initiate an analysis to examine one or more of the management options proposed in this discussion paper, or others that the Council may wish to include in an analysis. Strawman closures have been developed by staff in order to provide a starting point for discussion of management options that include spatial or temporal fishery closures.

If the Council chooses to initiate an analysis, the Council should articulate a problem statement for this action, and a set of alternatives to analyze. It would be helpful for staff to receive guidance on how to continue refinement of the strawman alternatives if they are to remain part of the package.

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11 Preparers

March 2009 update	Diana Evans, NPFMC John Olson, NMFS Alaska Region Jeannie Heltzel, NPFMC
Original discussion paper	Diana Stram, NPFMC Cathy Coon, formerly NPFMC

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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 C-3(b)
Supplemental
APRIL 2009

Alaska Marine Conservation Council

March 23, 2009

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

RE: Agenda Item C3(b) - Gulf of Alaska Tanner crab discussion paper

Dear Chairman Olson,

My name is Leigh Gorman Thomet. I reside in Kodiak Alaska. With my family, we make our living in the salmon, halibut, sable fish fisheries. I've also engaged in the herring fishery in Sitka, Cook Inlet, Kodiak and Togiak. I am writing with regard to the Tanner crab bycatch issue.

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 reasons are as follows:

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. That is down 100,000 pounds from 2008, and also 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 the requests of the trawl fleet, which 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, however, has asked for measures to moderate trawl impact on Tanner crab. Management measures are essential for benefitting everyone and the community as a whole.

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2. <u>The Tanner crab discussion papers show there are significant gaps in observer data.</u>

There is significant variability in the numbers that are inaccurate to encounters with Tanner crab. While this is the only available bycatch data, it is not particularly useful in establishing bycatch caps. Perhaps even more importantly, low observer coverage stymies the monitoring of bycatch caps, hence, the majority of vessels are observed only 30% of the time or not at all.

In 2008, the Alaska Marine Conservation Council(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 these groups as the cost of observer coverage, (that is required by regulation), appeared to be high and funding was not available. In order to implement such a plan, there needs to be commitment from ADFG and/or NMFS Observer Program. Consequently, they were not forthcoming, due to the short timeframe that was available to put a significant program into effect. We sincerely hope management agencies, the fishing 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 in need of 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. However, there are distinct areas of biological concern in federal waters that remain unaddressed. Recently, as a conservation measure to reduce pressure on rebuilding crab stocks, ADFG prohibited fishing by the Tanner crab pot fishery in inner bays. Developing measures that are specific and appropriate for both pot AND trawl sectors targeting groundfish are of equal importance.

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

In 2005, the Council adopted measures to protect Essential Fish Habitat (EFH) based on the conclusion that bottom trawl gear, de facto, has the highest impact on seafloor habitat. Supporting those results is a study that was conducted by the NMFS Auke Bay Lab (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.) The study measured habitat complexity and species abundance inside Type I trawl closures around Kodiak Island as compared to adjacent areas open to trawling. The study also found 33% more juvenile Tanner crab and an increased abundance of sea whips inside the no trawl zone. Sea whips account for the majority of biotic structural habitat on the sea floor.

Alaska Marine Conservation Council

In closing, please consider the collective responses of the approximately 100 Kodiak Fishermen's request for developing alternatives for analysis. I also 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
Leigh Gorman Thomet
AMCC Board Member

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Alaska Marine Conservation Council

RECEIVED
MAR 2 2009
N.P.F.M.C.

March 13, 2009

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

RE: Agenda Item C3(b) - 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.

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

   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.

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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 as a conservation measure to reduce fishing pressure on rebuilding 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 Essential Fish Habitat (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.)

   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

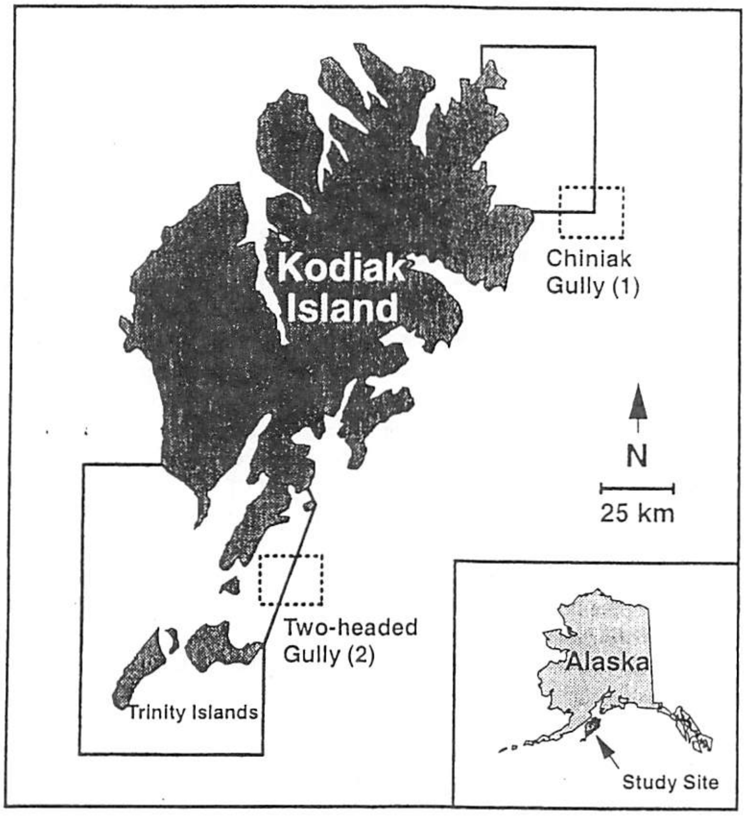

Figure 1. Map of Kodiak Island, Alaska, showing the two study sites (dashed lines) and closed areas (solid lines) where nonpelagic trawling is prohibited year-round. Site 1 is located at the Chiniak Gully. Site 2 is located at the Two-Headed Gully.

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 m² at Site 1 [1999], 10.6 m² 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	
	Functional	1998		1999		1998	
Taxon	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						

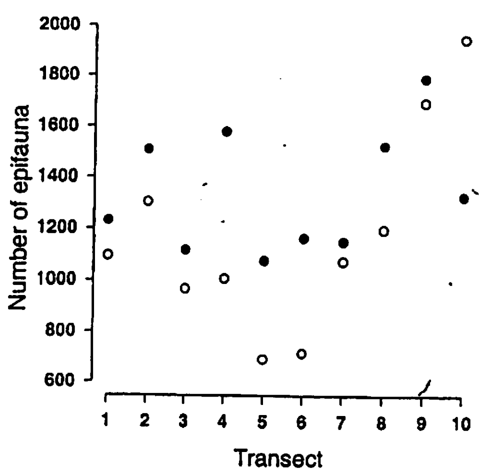

Figure 2. Abundance of megafauna per transect in the areas open (open circles) and closed (closed circles) to bottom trawling at Site 2.

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 m²) was nearly 70 times the density outside the groves (0.33 individuals per 100 m²). 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

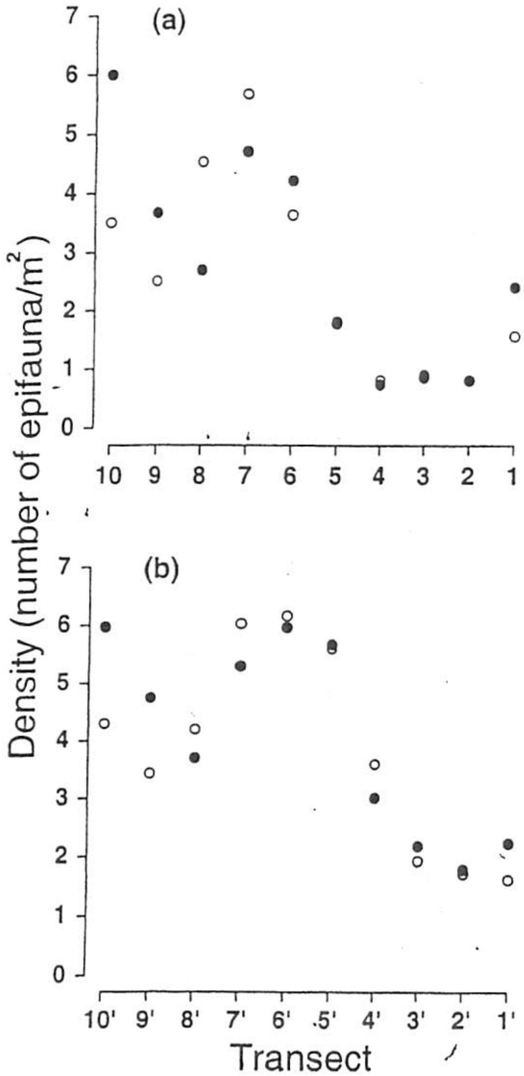

Figure 3. Densities of megafauna per transect in the open (open circles) and closed (closed circles) areas at Site 1 in (a) 1998 and (b) 1999.

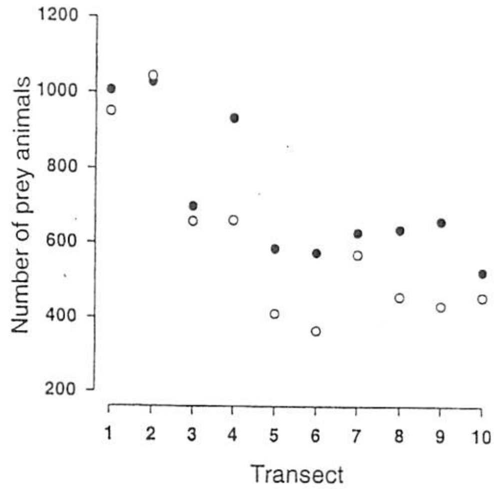

Figure 4. Numbers of prey animals per transect in the open (open circles) and closed (closed circles) areas at Site 2.

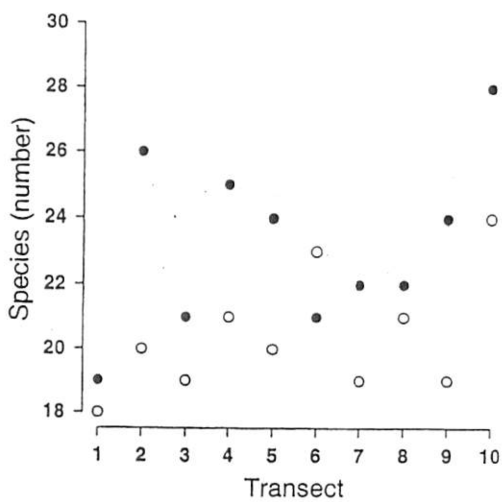

Figure 5. Numbers of species per transect in the open (open circles) and closed (closed circles) areas at Site 2.

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

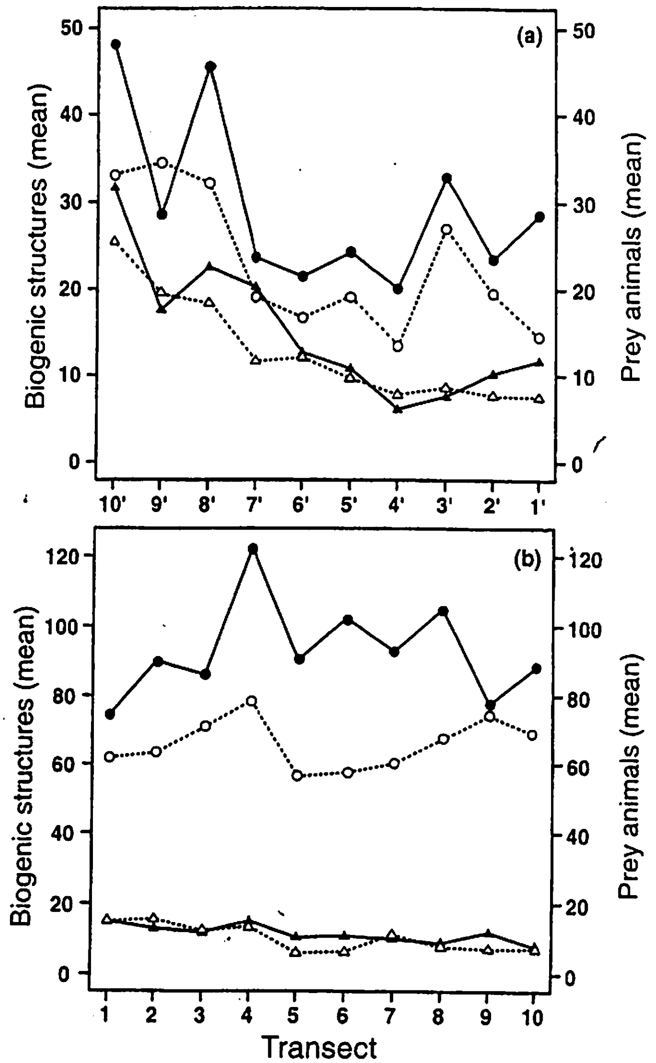

Figure 6. Mean abundance of biogenic structures (circles) in the open (dotted line) and closed (solid line) areas at (a) Site 1 (1999) and (b) Site 2. Mean abundance of prey animals (triangles) in the open (dotted line) and closed (solid line) areas at (a) Site 1 (1999) and (b) Site 2. Structures and 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

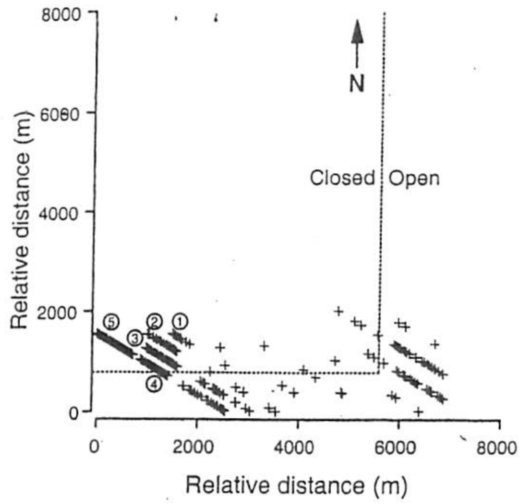

Figure 7. Locations of large (height > 80 cm) *Halipteris willemoesi* (+) on transects within the study area at Site 1 in 1998 and 1999. Five groves of large sea whips, numbered 1–5, were delineated at this site.

Table 4. Densities (number of animals/m²) 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*

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 believe 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/m² and 6/m², 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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AGENDA C-3(b)
Supplemental
APRIL 2009

North Pacific Council Members,
Meeting Anchorage Hilton April 1- thru April 7, 2009

Chairman: Eric Olson and Members of the Board

For the record my name is Kenny Wilson. I am a life long resident of Dillingham and life long fishermen here in Bristol Bay. I hold a Bristol Bay Salmon Drift Permit and participated in the herring fishery in the 70's as a purse seiner in the 80's purse seiner herring spotter for 8 years and also participating in the Togiak gillnet herring fishery. And will be participating in the Security Cove gillnet herring fishery this year.

I would like to address my concerns here in Bristol Bay and the Togiak area's where we have seen " Draggers " fishing for yellow fin sole. This is happening during our Local BBEDC " Halibut fishery and during our Togiak Herring fishery and runs into our King Salmon fishery. .

- My concerning is bycatch of Halibut and Chinook of trawlers disturbing tangling and destroying some of our local fishermen's halibut long lines when set. This has happen this past 2008 spring in the Box where the Draggers are allowed to fish.

- The halibut harvest have drop from 200,000 pounds to (30,000 for 2008) total for all BBEDC halibut fishermen .This past 2008 halibut fisherman had pay for halibut expenses with their Salmon fishery income.

- This halibut fishery was a great fishery in the past. Since the salmon prices have drop fishermen we were able to buy food and oil for the winter just from halibut fishing. This halibut fishery is a big and important fishery to us it maybe small for the big trawlers but a big help for us.

- One of my biggest concern is the Damage this trawl fishery has done to the ecosystem. I have been doing research on the internet and the Scientist mentioned "fishing style stirs a swath of destruction on shallow sea floors." Bottom trawling causes extensive damage that can be seen from space. This is what a Hawaiian scientists stated. They are finding out in deep waters like around Hawaii trawling is not a problem. This shallow water fishery does more damage to the sea floor than any other fishery.

- Do we take that chance here in Bristol Bay. The satellite images of mud trails are available on the Web site www.skytruth.org inside the gallery and labeled as "trawling impacts".

- We know that this trawling is killing everything in the path as they sweep up and down the Bristol Bay peninsula small box where 14 trawling boats is allowed. The Bristol Bay Trawl Area between the Walrus Islands and Cape Constantine is very important gateway to many types of feed and Salmon and halibut migrating north Western Alaska and into Bristol Bay trawl area.

- Scientific findings about trawling impacts have led to increasing restrictions on this trawling method. In 2005, the General Fisheries Commissions for the Mediterranean banned trawling in the Mediterranean Sea below depths of 1,000 meters. And the United States closed vast deep areas off Alaska to bottom trawling. In 2006, the United Nations General Assembly began deliberations on a trawling moratorium on the high seas, This covered 45% of the Earths surface, The South Pacific nations effectively put and end to trawling in an area amounting to 14% of the Earth's surface.

- We have one chance and it is here at this meeting this week to do good for our future in Western Alaska. Do we turn our backs and look the other way and say go ahead and keep fishing out here in Bristol Bay. Just because we have big industrial companies that have big bucks to back them that doesn't mean that fishery has to go on and destroy the bottom sea floor. Once this yellow fin fishery is wiped out are they going to return. In the past we seen a lot of yellow fin up in the western part of Togiak where the herring fishery takes place. Now this past spring there wasn't that much. The bottom would move we knew there were a lot we would catch a bucket and cook them and have fresh yellow fin for supper or lunch. I am concerned once you take away this yellow fin are the halibut and other species that feed on these fish going to survive. The big question are we taking away to much feed for the Walrus and other birds. One of our halibut boats found birds dead by the hundreds between Walrus Island and Security Cove and reported them to the Fish and Wild Life.

- The Chinook Salmon are entering into Nushagak at the time this Yellow fin sole fishery is taking place also. Our escapement goal has been reach only to the low number. We need to act now instead of reacting after the fact. This to me is good management on your part. We only had 2100 Kings were caught during our commercial opening here in the Nushagak King fishery last year 2008.

- I spoke at the October meeting and testified and said stated I had encounters with one of the trawlers near shore. I was just checking to see if they were fishing outside the legal line. One boat was inside heading north inside the line chasing yellow fin out to the Tremont trawler which was heading south with his trawl out. The Enterprise was chasing yellow fin outside the line.

- In the herring fishery it is illegal to chase herring or guide herring into a waiting seine. This was done by Beaver Nelson back in the 80's with a helicopter in Sitka years ago and since that happened it was outlawed. To me the Trawler Enterprise was doing the same thing for the Trawler Tremont. This is an old trick every fisherman knows.

- This is the time "**Now or Never**" to save the walrus feeding grounds, and let the halibut and King Salmon go into their spawning grounds so our communities can survive.

- I urge you to believe the Scientist and believe our locals we know what we catch all you have to do is look at our halibut deliveries. The great halibut fishery that once gave us 200,000 pounds a year is now lost to 30,000 pounds a spring.

- I heard boats coming back into Dillingham with nothing on board not only one trip but 2 trips. And people us saying I am done theirs nothing out their anymore.
- The stories that I am hearing if nothing is done to stop these trawlers at this meeting. They all plan on not participating in the halibut fishery at all this spring.

- I know every CDQ fishermen these are my friends I grew up with them in Bristol Bay.

It is now or never are we at the bottom, lets at least try and build it back up, then we can tell our children "yes" I went to the 2009 North Pacific Council Bycatch meeting concerning Halibut and Chinook and they listened to me. They took action to saved our communities and turn their backs on big money "trawls".

I urge you to "Vote No and stop Trawling in Bristol Bay. This will be one of the greatest things you have accomplished as a board member. I assure you, many people from Bristol Bay will thank you kindly and never forget what you did as a council member. It is your duty to "Protect" "Stocks of Concern"

Thank you Council members

Kenny Wilson

Kenny Wilson
Dillingham

March 17, 2009

RECEIVED
MAR 17 2009
N.P.F.M.C.

Chris Oliver, Executive Director
North Pacific Fisheries Management Council
605 W. 4th Avenue, Suite 306
Anchorage, AK 99501-2252
Telephone (907) 271-2809 Fax (907) 271-2817

Re: Written comment to the NPFCM meeting March 30 - April 7, 2009

Dear Mr. Oliver.

I am the Chairman of the Nushagak Advisory Committee in Dillingham. We met on February 5, 2009. Our AC exists and functions under the auspices of the Alaska Department of Fish and Game Board Support division.

One of our agenda items was the near shore Bristol Bay Trawl Area (NBBTA) that occurs every year just off the Nushagak Peninsula. Measures to clean-up conflicting language in 5 AAC 39.164. (b) and 5 AAC 39.165 have been addressed by the BOF. Council deliberation could have a detrimental effect on the continuance of our near-shore herring, salmon, and halibut fisheries.

Concerns brought forth by commercial fishermen, subsistence users, the Qayassiq Walrus Commission, the Bristol Bay Native Association, members of the public, and our AC committee members were unified in opposition to the continuance of the NBBTA fishery.

Salmon by-catch that occurs in the Bering Sea during the Pollock and Cod fisheries affects the economy of Bristol Bay. Reports of estimations that up to 60% of those salmon are of Western Alaska origin and with an estimation of 28% of Nushagak emphasizes the need for harvest caps and penalties to encourage cleaner fishing practices. With the by-catch of juvenile King Salmon and other salmon species during the trawl fishery, we believe that is a primary contributing factor to the decline of our commercial fishing opportunities. The past two years of our King Salmon fishing during early June were failures and provided no commercial opportunity. The forecasted runs did not return as forecasted. Prior years commercial harvests were lackluster.

We appeal to you to take conservatory action to reduce or eliminate King Salmon by-catch. Our subsistence users, sport fish industry, and commercial fishermen have been negatively impacted with reduced harvest.

The NSBBTA is of utmost concern to our area fishermen. For years our local halibut fishermen have complained of low halibut harvests compared to pre-trawling effort. By-catch of halibut and salmon is our primary complaint. Fishermen complain that they are also losing long line gear to trawl activity whenever they fish near shore. This fishery has become economically unviable with low productivity with more and more fishermen not participating because of low catches.

We are also concerned that the fishing activity has affected the walrus haul-out on Round Island due to disturbance and the effects of trawl activity on the ocean floor. We believe that the fishery affects the clam resource that the walrus rely on during the summer and are forced to move elsewhere. Walrus are very sensitive to disturbances. With the concentrated fishing effort near Round Island we believe that they are driving walrus out of the area. During the last year's Qayassiq Walrus Commission Hunt on Round Island, there were no walrus for them to harvest. Prior years reports were such that hunters were reporting declining numbers during the fall hunt.

Our herring fishermen complain that they believe that the trawlers are targeting herring, as after spawning, they migrate east near shore along the Nushagak Peninsula. The trawl fishery occurs during the peak of the Togiak Herring Fishery continuing until mid-June. With the presence of herring arriving to spawn even after the consummation of the herring fishery and observance of the intense trawl activity near shore during the out-migration of herring only leads us to believe that massive amounts of herring are being caught.

Our preference is for total closure of the NBTTA fishery. If that is not possible, considerations for a larger no fishing buffer around Round Island and moving the fishery out to 12 miles or farther offshore could be acceptable. Enacting conservation measures is essential to ensuring the viability of our halibut, herring, and salmon fisheries and ensuring that walrus will continue their seasonal haul-out on Round Island.

We thank you for your considerations.

Hans Nicholson

Hans Nicholson

Chairman, Nushagak Advisory Committee
ADF&G
PO Box 230
Dillingham, Alaska 99576

TO: Chairman Eric Olson
North Pacific Fishery Management Council

Subject meeting: March 30th thru April 7, 2009

For the Record my name is David Pedersen I live in Dillingham, Alaska.

History
I have commercial fished from 1978- current. I fish halibut , Salmon , herring, Black cod ,and Salmon in areas from Norton Sound to Prince William Sound including, Nuuivak Island, Bristol Bay, Kukokwin Bay Alutians, Peninsula & Kodiak. Started halibut fishing in the Mid-80's at Nunivak Island & Kuskokwim Bay. Fishing was good. I sold my catch in the Bethel and Dillingham and acquired by Ice in September in Snow Drifts@ Cape Newenham since ice wasn't available in either towns. I would also have to give some customers a glass ball to intice buying. Even sold Bycatch Cod and N&N Market in 1986 (See attachment news article.

Small Boat

Bristol Bay area had been closed to halibut fishing for years. It was opened to held local residents enter an alternative fishery to supplement their income & restricted up to 32' boats. We were also resticted in how far we could fish off shore because of weather (being able to find protection) and fuel capacity to appprox 50 miles off shore, depending on vessel fuel capacity & design. The NSBBTA is Large interegal portion of the area we can placidly fish. The area also supports transit of fish into Togiak Bay, Halibut & Salmon transit this area to access the respective bays.

Detrimental Effects

In the 80's when you passed a trawler you would see Kelp & other ocean floor vegetation floating on the surface followed by herds of birds feeding. Now all you see is a cloud of dirt with no to few birds when you pass. This destruction of the Ocean floor has to have a detrimental effect on all species including halibut , walrus, salmon, birds and other species that feed on what should be a lush habitat living on the Ocean floor.

In the 80's you could catch 5000 lbs halibut in a couple days w/lots of bycatch of Cod. 2008 I made 5-5 day trips and caught less than 5000 lbs total w/no catch of Cod, are we already to late?

Lively Hood

The West coast of Alaska has minimal opportunities for income producing vacations. This trawl fishery is not only restricting subsistence, But also the lost opportunities of local fishermen entering into alternative fishery.

Conclusion

I support restricting in NSBBTA fishery to 50 miles offshore to help local residents develop near shore fisheries. It's not that they can't catch yellow fin in other area's.

People's Column

Fishing seizures protested

As a lifelong Bristol Bay fisherman, I have viewed with consternation and alarm some recent events.

Lately Public Safety, the enforcement branch of Fisheries, has been, as a practice, seizing nets and fish of suspected fishing violators.

This spring, information has it that they have prepared seizure teams with the intention of seizing as many as 50 power boats.

The effect of this is to penalize citizens without ever having proven that they are guilty. (Pause here and reflect that a deputy, perhaps not a familiar one, can bring a large penalty on persons who he only suspects of a violation.)

Now, the constitution says in the 14th ammendment: "No State shall make or enforce any law which shall abridge the privileges or immunities of the citizens of the United States. Nor shall any State deprive any person of life, liberty, or property, without due process."

Well, the suspect's fish, his nets and his boat are his property and I believe you will agree that a deputy's arrest is not due process.

So, as fishermenm, we find attempts being made to make us second-class citizens by denying us our constitutional rights.

Further, we see the executive branch of the state government attempting to be judge and jury — very upsetting; especially as I, along with most fishermen, have requested that the fishery be protected. Now it appears that those with the charge of enforcing the law are willing to violate our constitution for expediency. Their job is difficult, but this reminds me of how the Communists have operated — we must make horrible examples ... teams are cheaper? I think you get the drift.

The state has spent a lot of money in Bristol Bay at the expense of enforcement on the Peninsula and elsewhere, some which hearsay says are preying on the same run in illegal fashion with no interference, but attention is riveted on Bristol Bay markers. It seems to have no balance, does it?

The real concern I have is that the wrong kind of enforcement is oppression. No one should be willing to give up their constitutional rights so that the enforcement branch may have things simpler. That fixes nothing.

Lowell W. Stambaugh
Dillingham/Astoria

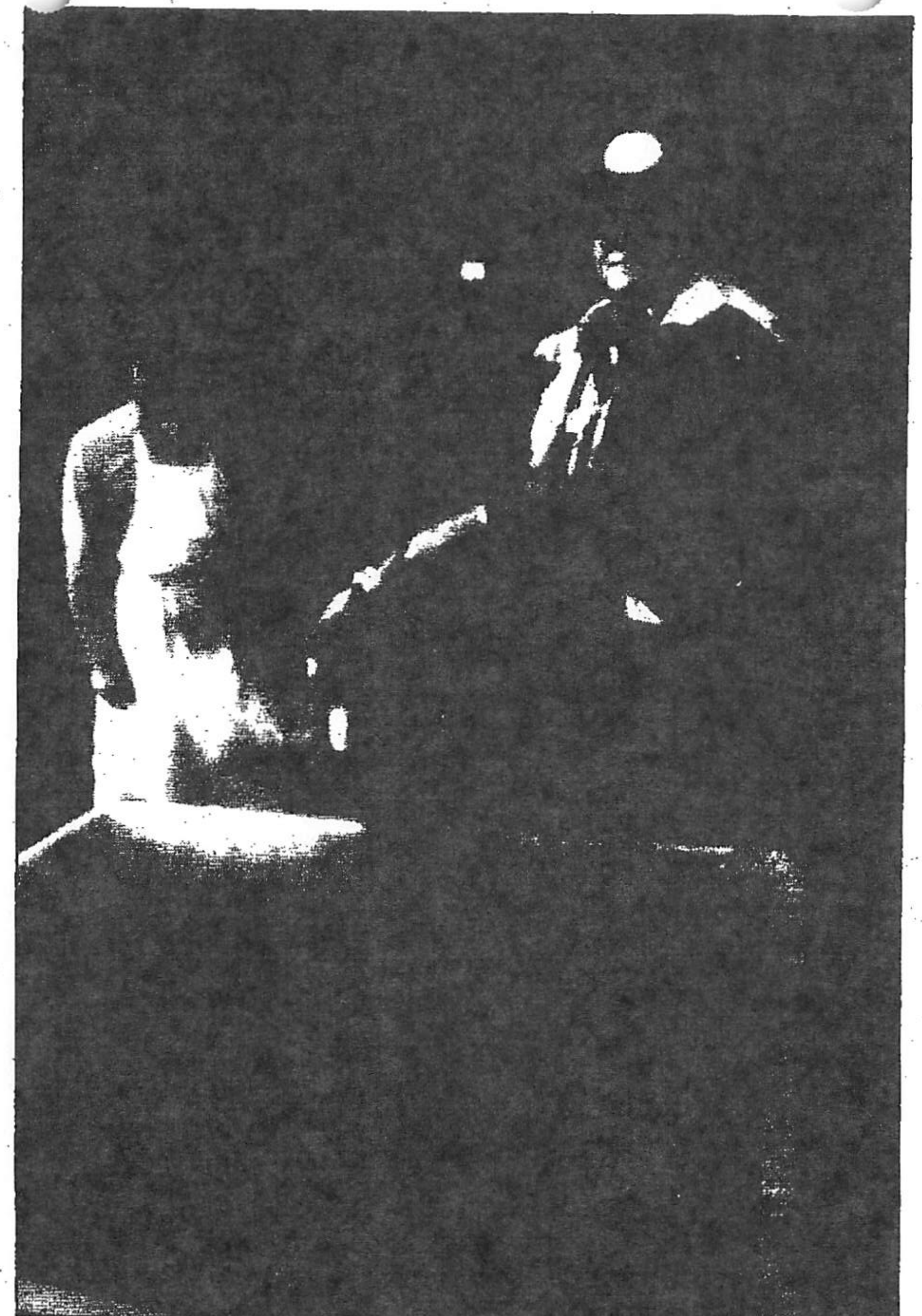
Nels quits

Dear Editor:

You have probably heard that I have withdrawn from the race for Lt. Governor. I have talked the decision over with several of my political advisors and they agree with my assessment that my chances of winning are limited to remote without an adequate supply of money.

I estimated that I would need at least $195,000 back in November to win the race. I have not been able to raise anywhere near that amount. I have also been spending my own money which I promised my family I would not do.

This is a hard decision to make, but a realistic appraisal of my chances tell me that funds are needed to travel, buy



What cod this be?

Why Pacific cod of course. The tasty Bering Sea groundfish were caught by *F/V Fat Emma* skipper Dave Pedersen longlining for halibut near Nelson

Nels G. Johnson
P.O. Box 197
Dillingham, Alaska 99576

Fax Cover Sheet
No: 13 pages

TO: North Pacific Fishery Management Council
Eric A. Olson, Chairman
Chris Oliver, Executive Director
605 W. 4th Avenue, Suite 306
Anchorage, Alaska 99501-2252

FROM: Nels G. Johnson

RE: Written comments and scientific data

DATE: March 25, 2009

Eric and Chris,

Enclosed is a copy of my written comments along with scientific data to support my comments.

Thank you.

North Pacific Fishery Management Council

Testimony from: Nels G. Johnson

My name is Nels G. Johnson, a member of Curyung Tribal. I have been commercial fishing for salmon and herring and am a halibut long-line fisherman and have been fishing since 1980. I have observed walrus, whales, sea lions, seals, herring, salmon, which are basically our subsistence food sources.

I am in support of the Qayassiq Walrus Commission and its resolution. I also support the Bristol Bay Marine Mammal Council and their resolution. Also I am in support of the tribes within Bristol Bay who have submitted supporting resolutions to strengthen the issues and concerns expressed by both the Qayassiq Walrus Commission and the Bristol Bay Marine Mammal Council.

I am also concerned about disturbances to walrus and grey whale feeding habitat caused by the trawl fishery in the Nearshore Bristol Bay Trawl Area. The endangered Stellar Sea Lion population's habitat is also being threatened and the noise from the trawl vessels is impacting all the feeding habitat areas of the above mentioned marine mammal species, which the trawl fishing fleet is literally destroying the ocean bottom.

Our main concern is the returning chinook salmon species, which have been seen by local herring fishermen swimming around the same area where the trawl fishing is taking place on their way to their spawning areas. Another local concern is the interception of halibut, which the local long-line fleet depend upon, and due to this the majority of local halibut fishermen are hanging up their hooks, because they can not compete with the amount of by-catch halibut being caught by the bottom trawl fleet.

"Bottom trawling is the most destructive of any actions that humans conduct in the ocean," said zoologist Les Watling of the University of Hawaii. The impacts caused by bottom trawling is clearly visible from outer space. Another observation was made by Elliott Norse of the Marine Conservation Biology Institute along with Les, who quotes, "Ten years ago in working together we both calculated that each year, worldwide, bottom trawlers drag an area equivalent to twice the lower 48 states."

In conclusion, I am not in support of the proposal submitted by representatives from Best Use Cooperative who was trying to convince us to support the bottom trawlers with less fishing time and smaller fishing area.

NOAA Fisheries
Office of Protected Resources

Steller Sea Lion *(Eumetopias jubatus)*

Status | Taxonomy | Species Description | Habitat | Distribution | Population Trends | Threats | Conservation Efforts | Regulatory Overview | Key Documents | More Info

Steller Sea Lion
(Eumetopias jubatus)
Photo: NOAA's National Marine Mammal Laboratory

Status
ESA Endangered - Western Distinct Population Segment
ESA Threatened - Eastern Distinct Population Segment
MMPA Depleted - throughout its range

Taxonomy
Kingdom: Animalia
Phylum: Chordata
Class: Mammalia
Order: Carnivora
Family: Otariidae
Genus: *Eumetopias*
Species: *jubatus*

Species Description
The Steller sea lion, also known as the northern sea lion, is the largest member of the Otariid (eared seal) family. Steller sea lions exhibit sexual dimorphism, in which adult males are noticeably larger than females and further distinguished by a thick mane of coarse hair. Adult males may be up to 10-11 ft (3-3.4 m) in length and can weigh up to 2,500 lbs (1,120 kg). Females are smaller than males, at 7.5-9.5 ft (2.5-3.0 m) in length and weigh up to 770 lbs (350 kg). The coats of adult males and females are light blonde to reddish brown and slightly darker on the chest and abdomen. The light coloration is still visible when the body is wet, which is different from many pinniped species. Like other pinnipeds, their coat of fur "molts" every year. Both sexes also have long whitish whiskers, or vibrissae, on their muzzle. The flippers and other hairless parts of the skin are black. The fore-flippers are broader and longer than the hind-flippers and are the primary means of locomotion in water. On land, sea lions, unlike "true" seals, can turn their hind flippers forward for walking.

Steller sea lions "forage" near shore and pelagic waters. They are capable of traveling long distances in a season and can dive to approximately 1300 ft (400 m) in depth. They also use terrestrial habitat as haul-out sites for periods of rest, molting, and as rookeries for mating and pupping during the breeding season. At sea, they are seen alone or in small groups, but may gather in large "rafts" at the surface near rookeries and haul outs. This species is capable of powerful vocalizations that are accompanied by a vertical head bobbing motion by males. Steller sea lions are opportunistic predators, foraging and feeding primarily at night on a wide variety of fishes (e.g., capelin, cod, herring, mackerel, pollock, rockfish, salmon, sand lance, etc.), bivalves, cephalopods (e.g., squid and octopus) and gastropods. Their diet may vary seasonally

Did You Know?

- Steller sea lions' impressive low-frequency vocalizations sound more like a "roar" when compared to California sea lions, which sound more like a "bark."
- The scientific name, *Eumetopias jubatus*, comes from the Greek words "eu" and "metopion" for "typical/well" and "broad forehead," and the Latin word jubatus for "having a mane."
- Steller sea lions are named for the German surgeon and naturalist George Wilhelm Steller. In 1742, he observed and described these large pinnipeds.
- Steller sea lions are the fourth largest pinniped in the world, behind the northern elephant seal, southern elephant seal, and walrus.

depending on the abundance and distribution of prey. They may disperse and range far distances to find prey, but are not known to migrate.


Steller Sea Lion
(Eumetopias jubatus)
Photo: NOAA's National Marine Mammal Laboratory

Steller sea lions are colonial breeders. Adult males, also known as bulls, establish and defend territories on rookeries to mate with females. Bulls become sexually mature between 3 and 8 years of age, but typically are not large enough to hold territory successfully until 9 or 10 years old. Mature males may go without eating for 1-2 months while they are aggressively defending their territory. Females typically reproduce for the first time at 4 to 6 years of age, usually giving birth to a single pup each year. At birth, pups are about 3.3 ft (1 m) in length and weigh 35-50 lbs (16-22.5 kg). Adult females, also known as cows, stay with their pups for a few days after birth before beginning a regular routine of alternating foraging trips at sea with nursing their pups on land. Female Steller sea lions use smell and distinct vocalizations to recognize and create strong social bonds with their newborn pups. Pups have a dark brown to black "lanugo" coat until 4 to 6 months old, when they molt to a lighter brown. By the end of their second year, pups are on the same color as adults. Females usually mate again with males within 2 weeks after giving birth. Males can live to be up to 20 years old, while females can live to be 30.

Habitat
Steller sea lions prefer the colder temperate to sub-arctic waters of the North Pacific Ocean. Haul outs and rookeries usually consist of beaches (gravel, rocky or sand), ledges, rocky reefs. In the Bering Sea and Okhotsk Sea, sea lions may also haul out on sea ice, but this is considered atypical behavior.


Steller Sea Lion Critical Habitat (AK)
(click for larger view PDF)

Critical habitat has been defined for Steller sea lions as a 20 nautical mile buffer around all major haul-outs and rookeries, as well as associated terrestrial, air and aquatic zones, and three large offshore foraging areas (50 CFR 226.202 on Aug. 27, 1993).

Distribution
Steller sea lions are distributed mainly around the coasts to the outer continental shelf along the North Pacific Ocean rim from northern Hokkaiddo, Japan through the Kuril Islands and Okhotsk Sea, Aleutian Islands and central Bering Sea, southern coast of Alaska and south to California. The population is divided into the Western and the Eastern "distinct population segments" (DPSs) at 144° West longitude (Cape Suckling, Alaska). The Western DPS includes Steller sea lions that reside in the central and western Gulf of Alaska, Aleutian Islands, as well as those that inhabit the coastal waters and breed in Asia (e.g., Japan and Russia). The Eastern DPS includes sea lions living in southeast Alaska, British Columbia, California, and Oregon.

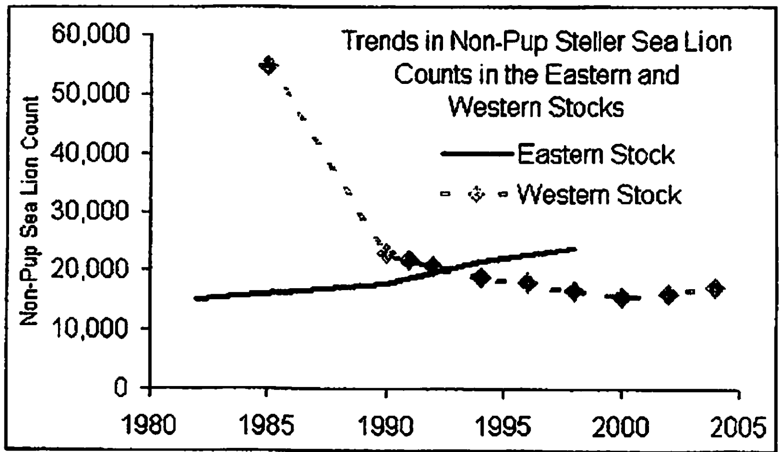

Steller Sea Lion Critical Habitat (CA, OR)
(click for larger view PDF)

Population Trends
For management purposes, Steller sea lions inhabiting U.S. waters have been divided into two DPSs: the Western U.S. and the Eastern U.S. The differentiation is based primarily on genetic and physical differences, but also on differing population trends in the two regions. There are approximately 39,000-45,000 Steller sea lions in the Western U.S. and 44,500-48,000 in the Eastern U.S.

The Western DPS declined by 75% between 1976 and 1990, and decreased another 40% between 1991 and 2000 (the average annual decline during this period was 5.4%). Since the 1970s, the most significant drop in numbers occurred in the eastern Aleutian Islands and the western Gulf of Alaska. The extent of this decline led NMFS to list the Steller's sea lion as threatened range-wide under the

Endangered Species Act (ESA) in April 1990. In the 1990s, the decline continued in the Western portions of the range leading NMFS to divide the species into two distinct population segments (DPS), Western and Eastern, and list the Western DPS as endangered in 1997. Population surveys suggest that the Eastern U.S. DPS is stable or increasing in the northern part of its range (Southeast Alaskan and British Columbia), while the remainder of the Eastern DPS and all the Western DPS is declining.

More information on population trends can be found in NMFS' marine mammal stock assessment reports.



Graph: NOAA's National Marine Mammal Laboratory

Threats
Anthropogenic (or human-induced) threats to Steller sea lions include boat strikes, contaminants/pollutants, habitat degradation, illegal hunting/shooting, offshore oil and gas exploration, direct and indirect interactions with fisheries, and subsistence harvests by natives in Alaska and Canada (150-300 taken a year). In the 1800s, they were targeted by hunters for their meat (food), fur hides (clothing), oil, and various other products. In the early 1900s, fishermen killed and placed bounties on this species, which they blamed for stealing fish from them. Some Steller sea lions were killed to limit their predation on fish in aquaculture facilities (fish farms), but intentional killing of Steller sea lions has not been permitted since they were protected under the Marine Mammal Protection Act (MMPA) and listed under the ESA.

Steller sea lions' direct and indirect interactions with fisheries is currently receiving significant attention and may possibly be an important factor in their decline. Direct fishing impacts are largely due to fishing gear (drift and set gillnets, longlines, trawls, etc.) that has the potential to entangle, hook, injure, or kill sea lions. These pinnipeds have been seen entangled in fishing equipment with what are considered "serious injuries." Steller sea lions are also indirectly threatened by fisheries because they have to compete for food resources and critical habitat may be modified by fishing activities.

Conservation Efforts
Protective zones, catch/harvest limits, various procedures and other measures have been implemented around major haul-outs and rookeries in order to safeguard their critical habitat. The IUCN Red List of Threatened Species considers this species to be "Endangered."

Regulatory Overview
The Steller sea lion was listed under the ESA as threatened throughout its range on December 4, 1990. This listing included animals from Alaska, California, Oregon and Washington in the U.S., as well as Canada, Japan, and Russia.

On June 4, 1997, the population west of 144° W longitude was listed as an endangered DPS (the Western DPS) under the ESA; the population east of 144° W remained listed as threatened as the Eastern DPS.

Under the MMPA, all Steller sea lions are classified as "strategic stocks" and are considered "depleted".

Critical habitat has been designated (50 CFR 226.202 on Aug. 27, 1993) for Steller sea lions as a 20 nautical mile buffer around all major haul-outs and rookeries, as well as associated terrestrial, air, and aquatic zones, and three large offshore foraging areas. NMFS has also designated no-entry zones around rookeries (50 CFR 223.202). NMFS has implemented a complex suite of fishery management measures designed to minimize competition between fishing and the endangered population of Steller sea lions in critical habitat areas.

A recovery plan was developed for Steller sea lions in 1992. A revised recovery plan, which discusses separate recovery actions for the threatened and endangered populations, was issued in 2008.

Key Documents
(All documents are in PDF format.)

Title	*Federal Register*	Date
Recovery Plan (2008)	73 FR 11872	03/05/2008
▪ 1992 Recovery Plan	n/a	12/1992
Protection Measures for the Groundfish Fisheries Off Alaska	68 FR 204	01/02/2003
ESA Listing Rule - Endangered Status for Western population	62 FR 24345	05/05/1997
Critical Habitat Designation	58 FR 45269	08/27/1993
ESA Listing Rule - Threatened Status for Eastern and Western populations	55 FR 49204	11/26/1990
Stock Assessment Reports	n/a	various

More Information

- NMFS Alaska Region and Science Center Information on Steller Sea Lions
- NMFS National Marine Mammal Laboratory Steller Sea Lion Information and Research
- NMFS Environmental Impact Statement (EIS) on Steller Sea Lion and Northern Fur Seal Research
- NMFS Southwest Regional Office: CA Pinniped Rookeries & Haul-out Sites
- Marine Mammal Commission Steller Sea Lion Species Information
- U.S. Fish & Wildlife Service Steller Sea Lion Species Profile

LIVE SCIENCE.

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Devastation of Trawling Visible from Space

By Andrea Thompson, LiveScience Staff Writer
posted: 20 February 2008 ET

Bottom trawling for fish stirs up billowing plumes of sediment that can be seen from space and destroys entire seafloor ecosystems, new imagery reveals.

The technique, used all over the world, is a way to catch fish in deeper parts of the ocean with huge, deep nets, now that many near-shore fish populations have been virtually wiped out from over-fishing. Several studies have shown the significant impact that trawling has on ecosystems, killing corals, sponges, fish and other animals.

New and previously released satellite images show the extent of the plumes of material kicked up. And a video of the seafloor reveals how trawling denudes an underwater world.

"Bottom trawling is the most destructive of any actions that humans conduct in the ocean," said zoologist Les Watling of the University of Hawaii. "Ten years ago, Elliott Norse [of the Marine Conservation Biology Institute] and I calculated that, each year, worldwide, bottom trawlers drag an area equivalent to twice the lower 48 states. Most of that trawling happens in deep waters, out of sight. But now we can more clearly envision what trawling impacts down there by looking at the sediment plumes that are shallow enough for us to see from satellites."

Watling presented his findings Friday at the annual meeting of the American Association for the Advancement of Science in Boston.

Persistent plumes

As nets are dragged across the seafloor, they can crush coral reefs, drag boulders across the bottom, and trap fish and animals not intended to be caught, called bycatch. All this activity stirs up sediments from the seafloor, which create the persistent plumes in the wake of the fishing ships.

Watling and his colleagues say that the plumes visible in satellite images are likely just the "tip of the iceberg" as most trawling is in waters that are deep enough that the plume remains hidden by the water above.

"Bottom trawling repeatedly plows up the seafloor over large areas of the ocean," said fellow presenter John Amos of SkyTruth, a digital mapping non-profit group aimed at environment issues based in West Virginia. (Images of these plumes can be seen on the group's website.)

Bans and restrictions

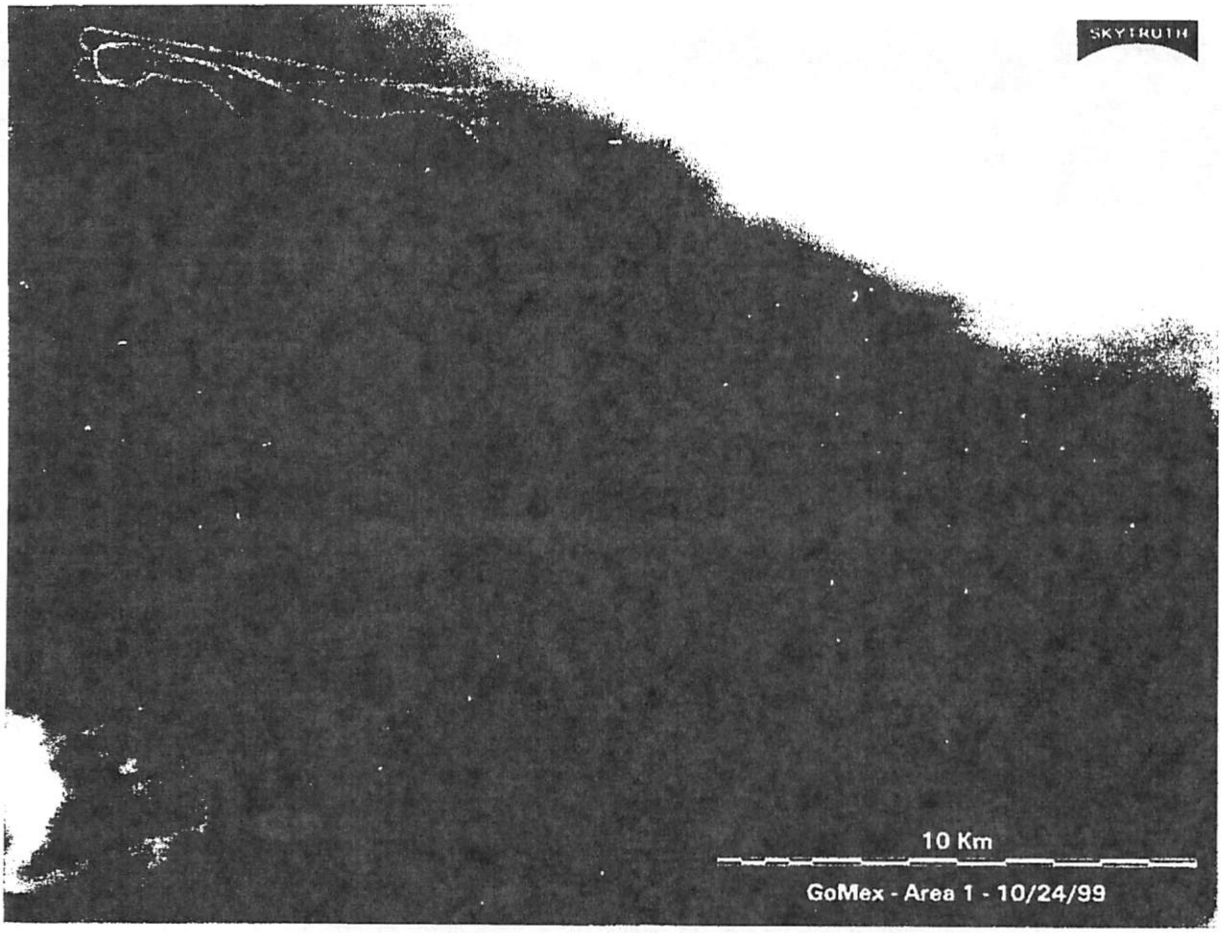
Scientific studies showing the impacts that trawling has on ecosystems have led to increasing restrictions on the practice.

In 2005, the General Fisheries Commission for the Mediterranean banned trawling there below depths of 1,000 meters (3, 289 feet). The United States closed large deep-sea areas off the coast of Alaska to bottom trawling in 2006. Many South Pacific nations have also put a stop to the practice, and the United Nations began deliberations on a trawling moratorium in the high seas in 2006.

But there are still tens of thousands of trawlers operating in the Gulf of Mexico, off the coast of many Latin American countries, off the west coast of Africa, in Chinese waters, and the North Sea.

"We're a long way from protecting the ocean floor from bottom trawling," Norse told LiveScience.

- Video: Bottom Trawling — A Tale of Two Sites
- The Hand of Man: No Seas Remain Pristine
- Images: Life Under the Sea


SKYTRUTH
10 Km
GoMex - Area 1 - 10/24/99

Gray Whale *(Eschrichtius robustus)*

Status | Taxonomy | Species Description | Habitat | Distribution | Population Trends | Threats | Conservation Efforts | Regulatory Overview | Key Documents | More Info

Status
ESA Endangered - Western North Pacific population
MMPA Depleted - Western North Pacific population
Delisted from ESA - Eastern North Pacific population

Gray Whale
(Eschrichtius robustus)
Photo: Merrill Gosho, NOAA

> **Did You Know?**
>
> · Gray whales make one of the longest annual migrations of any mammal, traveling about 10,000 miles (16,000 km) round trip.
>
> · Gray whales were once called "devil fish" because of their violent reactions when harpooned by whalers.
>
> · Currently, gray whales are known for their curiosity toward boats, and are the focus of whale watching and ecotourism along the southern portion of their migration.

Taxonomy
Kingdom: Animalia
Phylum: Chordata
Class: Mammalia
Order: Carnivora
Family: Eschrichtiidae
Genus: *Eschrichtius*
Species: *robustus*

Species Description
Gray whales are mysticetes, or baleen whales. Gray whales are the only species in the family Eschrichtiidae. These large whales can grow to about 50 ft (15 m) long, and weigh approximately 80,000 lb (35,000 kg). Females are slightly larger than males. They have a mottled gray body, with small eyes located just above the corners of the mouth. Their "pectoral fins" (flippers) are broad, paddle-shaped, and pointed at the tips. Lacking a dorsal fin, they instead have a "dorsal hump" located about two-thirds of the way back on the body, and a series of 8-14 small bumps, known as "knuckles," between the dorsal hump and the tail flukes. The tail flukes are more than 15 ft (3 m) wide, have S-shaped trailing edges, and a deep median notch. Calves are born dark gray and lighten as they age to brownish-gray or light gray. All gray whales are mottled with lighter patches, and have barnacles and whale lice on their bodies, with higher concentrations found on the head and tail.

Gray whales are frequently observed traveling alone or in small, unstable groups, although large aggregations may be seen on feeding and breeding grounds. Similar to other baleen whales, long-term bonds between individuals are rare. Gray whales are bottom feeders, and suck sediment and the "benthic" amphipods that are their prey from the sea floor. To do this, they roll on their sides and swim slowly along, filtering their food through coarse baleen plates, of which they have 130-180 on each side of the upper jaw. In doing so, they often leave long trails of mud behind them, and "feeding pits" in the sea floor.

Gray whales become sexually mature between 6-12 years, at an average of 8 years old. After 12-13 months of gestation, females give birth to a single calf. Newborn calves are approximately 14-16 ft (4.5-5 m) long, and weigh about 2,000 lb (920 kg). The average and maximum life span of gray whales is unknown, although one female was estimated at 75-80 years old after death (Jones and Swartz, 2002). The age of large whales in family Balaenopteridae can be estimated by counting the layers present in waxy ear plugs, which are formed in the auditory canal (Hohn

2002).

Killer whales (*Orcinus orca*) are the only non-human predator of gray whales.

Habitat
Gray whales are found mainly in shallow coastal waters in the North Pacific Ocean.

Distribution
There are two isolated geographic distributions of gray whales in the North Pacific Ocean: the Eastern North Pacific stock, found along the west coast of North America, and the Western North Pacific or "Korean" stock, found along the coast of eastern Asia.

Most of the Eastern North Pacific stock spends the summer feeding in the northern Bering and Chukchi Seas, but gray whales have also been reported feeding along the Pacific coast during the summer, in waters off of southeast Alaska, British Columbia, Washington, Oregon, and California. In the fall, gray whales migrate from their summer feeding grounds, heading south along the coast of North America to spend the winter in their breeding and calving areas off the coast of Baja California, Mexico. Calves are born in shallow lagoons and bays from early January to mid-February. From mid-February to May, the Eastern North Pacific stock of gray whales can be seen migrating northward with newborn calves along the West Coast of the U.S.

Photo-identification studies indicate that gray whales in this stock move widely within and between areas on the Pacific coast, are not always observed in the same area each year, and may have several year gaps between re-sightings in studied areas (Calambokidis and Quan 1999, Quan 2000, Calambokidis et al. 2002).

Population Trends
Systematic counts of Eastern North Pacific gray whales migrating south along the central California coast have been conducted by shore-based observers at Granite Canyon most years since 1967. The most recent abundance estimates are based on counts made during the 1997/98, 2000/01, and 2001/02 southbound migrations, and range from about 18,000-30,000 animals. For more information, see the Stock Assessment Reports.

In contrast, the Western North Pacific population remains highly depleted and its continued survival is questionable. This population is estimated to include fewer than 100 individuals.

Threats
Commercial whaling severely depleted both the eastern and western populations between the mid-1800s and early 1900s. Beginning in the mid-1930s, gray whales were protected under a ban on commercial hunting adopted by the League of Nations. This ban (which included right whales) was the first international agreement to protect a whale species from commercial whaling operations. The ban on commercial gray whale catches has continued since the late 1940s under the International Whaling Commission. Gray whales are still hunted by native people of Chukotka and Washington State and are subject to catch limits under the International Whaling Commission's "aboriginal subsistence whaling" scheme.

Other current threats include collisions with vessels, entanglement in fishing gear, habitat degradation, disturbance from ecotourism and whale watching, disturbance from low-frequency noise, and the possibility that illegal whaling or resumed legal whaling will remove animals at biologically unsustainable rates. The eastern stock's annual migration along the highly populated coastline of the western United States, and their concentration in limited winter and summer areas, may make them particularly vulnerable to impacts from commercial or industrial development or local catastrophic events.

Conservation Efforts
The Eastern North Pacific stock of gray whales was removed from the U.S. List of Endangered and Threatened Wildlife in 1994, based on evidence that they had recovered to near their estimated original population size and were not in danger of

extinction throughout all or a significant portion of their range. In 1999, a NMFS review [pdf] of the status of the Eastern North Pacific stock of gray whales recommended the continuation of this stock's classification as non-threatened. This determination was based on the continued growth of the population (at that time, rising at 2.5% annually and estimated at 26,600 individuals) and the lack of evidence of any imminent threats to the stock. NMFS continues to monitor the abundance of the stock, especially as it approaches its carrying capacity.

The 2008 IUCN Red List of Threatened Species lists gray whales as "least concern."

Regulatory Overview
All marine mammals, including gray whales, are protected under the Marine Mammal Protection Act of 1972, as amended. As of 1994, the Eastern North Pacific stock of gray whale is no longer listed as endangered under the Endangered Species Act of 1973.

The Western North Pacific stock of gray whales has not recovered. It is listed as "Endangered" under the ESA and "depleted" under the MMPA.

Key Documents
(All documents are in PDF format.)

Title	***Federal Register***	**Date**
U.S.-Russia Agreement on Monitoring the IWC's Aboriginal Subsistence Quota for Gray Whales 2008	n/a	2008
Status Review of the Eastern North Pacific Stock	n/a	08/1999
Final Rule to Delist the Eastern North Pacific Population	59 FR 31094	06/16/1994
Notice of Determination to Delist the Eastern North Pacific Stock of Gray Whales	58 FR 3121	01/07/1993
ESA Listing Rule	35 FR 18319	12/02/1970
Stock Assessment Reports	n/a	various

More Information

- NMFS National Marine Mammal Laboratory Gray Whale Information and Research
- NMFS Southwest Fisheries Science Center Gray Whale Information
- *Kids' Times*: Gray Whale [pdf]
- NOAA's National Marine Sanctuaries
  - Channel Islands Sanctuary Gray Whale Species Card with video
  - Cordell Bank Sanctuary Gray Whale Species Card with video
  - Gulf of the Farallones Sanctuary Gray Whale Species Card
  - Monterey Bay Sanctuary Gray Whale Species Card with video
- Marine Mammal Commission Gray Whale Information
- Makah Tribe Gray Whale Hunt from NMFS Northwest Regional Office
- U.S. Fish & Wildlife Service Gray Whale Species Profile

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