

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

November 2008

Staff Discussion Paper

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## Table of Contents

<b>1</b>	<b>INTRODUCTION</b> .....	<b>1</b>
<b>2</b>	<b>DATA SOURCES USED IN THIS DISCUSSION PAPER</b> .....	<b>1</b>
2.1	Estimation procedures for bycatch and discards in the Alaska groundfish fisheries .....	2
2.2	Proportion of GOA groundfish catch that is observed .....	3
2.3	Spatial analysis of bycatch patterns.....	8
<b>3</b>	<b>REVIEW OF EXISTING CLOSURES</b> .....	<b>9</b>
<b>4</b>	<b>CHINOOK SALMON BYCATCH</b> .....	<b>10</b>
4.1	Bycatch by area, gear type, and target fishery .....	10
4.2	Timing of Chinook bycatch.....	12
4.3	Location of Chinook bycatch .....	13
4.4	Factors affecting bycatch: hatchery releases of Chinook salmon .....	14
4.5	Impacts of bycatch: river of origin of GOA Chinook .....	15
<b>5</b>	<b>CHINOOK SALMON STOCKS AND DIRECTED FISHERIES</b> .....	<b>16</b>
5.1	GOA Chinook salmon stocks .....	17
<b>6</b>	<b>C. BAIRDI TANNER CRAB BYCATCH</b> .....	<b>19</b>
6.1	Mortality Rates .....	19
6.2	Bycatch in Federal groundfish fisheries, by area, gear type, and target fishery .....	19
6.3	Timing of bycatch in Federal groundfish fisheries .....	22
6.4	Location of <i>C. bairdi</i> bycatch.....	23
6.5	Bycatch of <i>C. bairdi</i> in the State waters Pacific cod pot fishery.....	24
<b>7</b>	<b>C. BAIRDI TANNER CRAB STOCKS AND DIRECTED FISHERIES</b> .....	<b>26</b>
<b>8</b>	<b>MANAGEMENT OPTIONS TO REDUCE BYCATCH</b> .....	<b>29</b>
8.1	Draft alternatives .....	29
8.2	Estimating trigger limits .....	31
8.3	Determining appropriate area closures and preliminary strawman closures .....	32
8.4	Voluntary bycatch cooperatives .....	36
<b>9</b>	<b>ACTION BY THE COUNCIL</b> .....	<b>36</b>
<b>10</b>	<b>LITERATURE CITED</b> .....	<b>37</b>
<b>11</b>	<b>COLOR FIGURES</b> .....	<b>A</b>

## List of Tables

Table 1	Total catch, observed catch, and percent observed catch by area and year .....	8
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 .....	10
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 .....	11
Table 4	Bycatch of Pacific salmon in Gulf of Alaska groundfish trawl fisheries, by species, 1990-2008 .....	14
Table 5	Chinook salmon bycatch by reporting area, 2003-2008, in Gulf of Alaska groundfish fisheries.....	15
Table 6	Chinook salmon bycatch by gear type, in Gulf of Alaska groundfish fisheries, 2003-2008 .....	15
Table 7	Chinook salmon bycatch by target fishery, in Gulf of Alaska groundfish fisheries, 2003-2008 .....	16
Table 8	Chinook salmon bycatch in the pelagic pollock trawl fishery, by reporting area, 2003-2008 .....	16
Table 9	Chinook salmon bycatch by month, 2003-2008, in Gulf of Alaska groundfish fisheries .....	17
Table 10	Hatchery releases of juvenile Chinook salmon, by country, compared to GOA groundfish bycatch, in millions of fish .....	18
Table 11	Chinook salmon GOA commercial catch, by area, compared to GOA groundfish bycatch, 2003-2007, in 1000s of fish.....	20
Table 12	Various calculations of mortality rates for harvested crab.....	23
Table 13	<i>C. bairdi</i> bycatch by reporting area, 2003-2008, in GOA Federal groundfish fisheries .....	24
Table 14	<i>C. bairdi</i> bycatch by gear type, in GOA Federal groundfish fisheries, 2003-2008 .....	24
Table 15	<i>C. bairdi</i> crab bycatch in GOA groundfish trawl fisheries, 1993-2007 .....	25
Table 16	Bycatch of <i>C. bairdi</i> Tanner crabs in Gulf of Alaska Federal groundfish fisheries, by gear type and target fishery, 2003-2008. ....	26
Table 17	<i>C. bairdi</i> crab bycatch by month, 2003-2008, in GOA Federal groundfish fisheries .....	26
Table 18	<i>C. bairdi</i> bycatch in Federal and State groundfish fisheries, 2003-2008.....	28

## List of Figures

Figure 1	Chinook bycatch in GOA Groundfish Trawl Fisheries.....	15
Figure 2	Average Chinook bycatch and groundfish catch by vessels using pelagic and non-pelagic trawl gear, by month, 2003-3007.....	17
Figure 3	Annual bycatch of <i>C. bairdi</i> Tanner crab and groundfish catch, by Federal trawl and pot fishery sectors, 2003-2008.....	25
Figure 4	Average bycatch of <i>C. bairdi</i> Tanner crab and total groundfish catch by month, for non-pelagic trawl and pot sectors, in Federal fisheries, 2003-2007.....	27
Figure 5	Federal and State <i>C. bairdi</i> bycatch in GOA groundfish fisheries.....	29
Figure 6	ADF&G trawl survey stations for Tanner and king crab abundance, and fishery management districts around Kodiak Islands.....	30
Figure 7	Location of high percentages of the Tanner crab harvest, based on 2005-2008 average.....	31
Figure 8	<i>C. bairdi</i> Tanner crab population estimates for Kodiak District based on ADF&G trawl surveys 1997-2006.....	32
Figure 9	<i>C. bairdi</i> Tanner crab population estimates for Alaska Peninsula District based on ADF&G trawl surveys 1997-2006.....	32
Figure 10	Chinook salmon strawman closures for pelagic trawl gear, based on high incidence of bycatch, averaged over 2003-2007.....	37
Figure 11	<i>C. bairdi</i> crab strawman closures in the central GOA, for non-pelagic trawl and pot gear, based on high incidence of bycatch, averaged over 2003-2007.....	38
Figure 12	<i>C. bairdi</i> crab strawman closures for pot gear in the western and central GOA, based on high incidence of bycatch, averaged over 2003-2007.....	39
Figure 13	Locations of existing trawl fishery and crab protection closures in the Gulf of Alaska.....	A
Figure 14	Locations of existing trawl fishery and crab protection closures in the Western Gulf of Alaska.....	B
Figure 15	Locations of existing trawl fishery and crab protection closures in the Central Gulf of Alaska.....	B
Figure 16	Mature male and female Tanner crab density, from the 2007 ADFG survey.....	C
Figure 17	Observed Chinook salmon bycatch in the pelagic pollock trawl fishery, averaged for 2003-2007.....	D
Figure 18	Observed Chinook salmon bycatch rate in the pelagic pollock trawl fishery, averaged for 2003-2007, number of crab per metric ton of groundfish.....	E
Figure 19	Observed Chinook salmon bycatch in the non-pelagic trawl fishery, averaged for 2003-2007.....	F
Figure 20	Observed Chinook salmon bycatch rate in the non-pelagic trawl fishery, averaged for 2003-2007, number of crab per metric ton of groundfish.....	G
Figure 21	Observed <i>C. bairdi</i> Tanner crab bycatch in the non-pelagic trawl fishery, averaged for 2003-2007.....	H
Figure 22	Observed <i>C. bairdi</i> Tanner crab bycatch rate in the non-pelagic trawl fishery, averaged for 2003-2007, number of crab per metric ton of groundfish.....	I
Figure 23	Observed <i>C. bairdi</i> Tanner crab bycatch in the non-pelagic trawl fishery, 2007 only.....	J
Figure 24	Observed <i>C. bairdi</i> Tanner crab bycatch in the Federal pot fishery, 2007 only.....	K
Figure 25	Observed <i>C. bairdi</i> Tanner crab bycatch in the Federal pot fishery, averaged for 2003-2007.....	L
Figure 26	Observed <i>C. bairdi</i> Tanner crab bycatch rate in the Federal pot fishery, averaged for 2003-2007, number of crab per metric ton of groundfish.....	M
Figure 27	Chinook salmon strawman closures for pelagic trawl gear, based on high incidence of bycatch.....	N
Figure 28	Chinook salmon strawman closures for pelagic trawl gear, based on high incidence of bycatch, compared to areas with high bycatch rates.....	O
Figure 29	<i>C. bairdi</i> crab strawman closures for non-pelagic trawl gear, based on high incidence of bycatch.....	P
Figure 30	<i>C. bairdi</i> crab strawman closures for non-pelagic trawl gear, based on top 10% incidence of crab bycatch, both in observer samples and extrapolated to observed hauls.....	Q
Figure 31	<i>C. bairdi</i> crab strawman closures for non-pelagic trawl gear, based on high bycatch rate (number of crab per metric ton of groundfish, averaged for 2003-2007).....	R
Figure 32	Comparison of <i>C. bairdi</i> crab strawman closures for non-pelagic trawl gear, high incidence of bycatch versus high bycatch rate.....	S
Figure 33	<i>C. bairdi</i> crab strawman closures for pot gear, based on high incidence of bycatch.....	T
Figure 34	<i>C. bairdi</i> crab strawman closures for pot gear, based on top 10% incidence of crab bycatch, both in observer samples and extrapolated to observed hauls.....	U

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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<sup>1</sup>. 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 *Chionoectes 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.

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<sup>1</sup> 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<sup>2</sup>.

### 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<sup>3</sup>, week end date, processing sector (CV, CP, or Mothership), gear, federal reporting area, special subarea;

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<sup>2</sup> 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.

<sup>3</sup> Targets include: A - Atka Mackerel, B - Bottom trawl Pollock, C - Pacific cod, D - Deepwater flatfish (GOA only), E - Alaska plaice, F - Other flatfish, H - Shallowwater 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](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.<sup>4</sup> The information for the central GOA and the western GOA is presented in Table 2 and Table 3, respectively.

<sup>4</sup> 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.

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%	--	--
>=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](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](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%	--	--
	>=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. The spatial

analysis uses data from 2003-2007, queried from the observer database by Jeannie Heltzel, NPFMC, in October 2008. 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 13 (page A at the end of the document) maps the existing closures in the entire GOA management area; Figure 14 and Figure 15 (page B) pinpoint the western and central regulatory areas, respectively, which are the focus of this discussion paper.

***Kodiak red king crab closures: Type I 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 <sup>a</sup>	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				
<b>Average 1990–2007</b>	<b>21,606</b>	15,454 <sup>a</sup>				
<b>Average 2003–2007</b>	<b>25,312</b>	4,818				
2008 (through 10/25/08)	16,493	2,088				

<sup>a</sup> Combines chum, coho, sockeye, and pink salmon.

<sup>b</sup> 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
<b>Grand Total</b>		15,358	21,478	31,207	18,816	39,768	16,493	25,325

Source: NMFS catch accounting PSC data, October 2008.

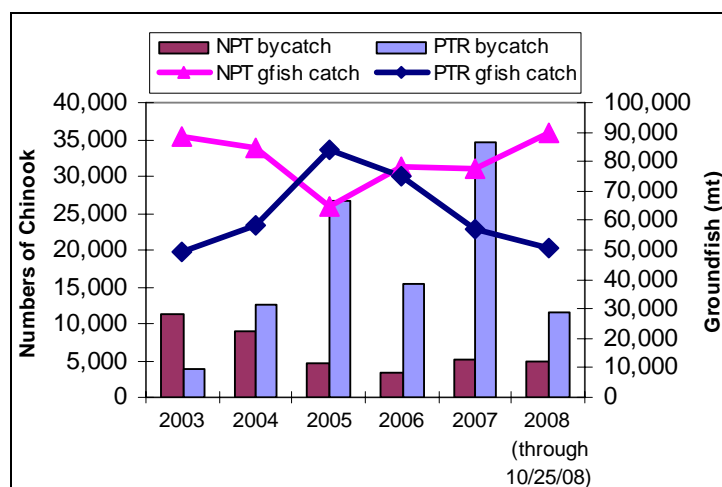
Table 6 identifies Chinook bycatch for 2003-2008, by gear type. Pelagic and non-pelagic trawling are almost entirely responsible for Chinook salmon bycatch. In 2005-2007, pelagic trawl gear accounted for over 80% of Chinook bycatch. The relationship between groundfish catch and pelagic and non-pelagic 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
<b>Grand Total</b>	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 25<sup>th</sup>, 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. 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 <sup>5</sup>	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
<b>Western GOA</b>	610	738	2,013	5,951	4,529	3,364	2,035	3,105
<b>Central GOA</b>	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

<sup>5</sup> Since this discussion paper was last revised, 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.

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.

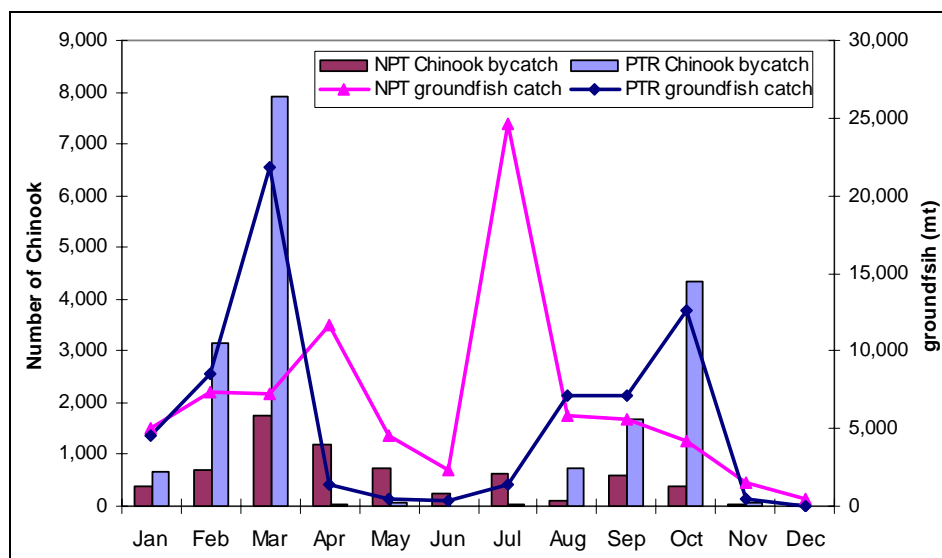
**Table 9 Chinook salmon bycatch by month, 2003-2008, in Gulf of Alaska groundfish fisheries**

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, 2003-2007**



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 following series of maps, that the data represents only a small proportion of the GOA fishing effort.

All of the following maps use observer data that has been extrapolated to the haul level<sup>6</sup>. Figure 17 and Figure 19, on pages D and F at the end of this document, map the average observed number of Chinook for 2003-2007, in fisheries using pelagic and non-pelagic trawl gear, respectively. Figure 18 and Figure 20 (pages E and G) illustrate the average bycatch rate, mapping the number of Chinook per metric ton of groundfish, for the same years and the same fisheries.

#### 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.

**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	<b>263.1</b>	.031
2000	0.5	53.0	209.5	<b>263.0</b>	.027
2001	0.5	45.5	212.1	<b>258.1</b>	.015
2002	0.3	52.8	222.1	<b>275.2</b>	.013
2003	0.7	50.2	210.6	<b>261.5</b>	.015
2004	1.17	49.8	173.6	<b>224.6</b>	.021
2005	0.84	43.5	184.0	<b>228.3</b>	.031
2006	0.78	41.3	181.2	<b>223.3</b>	.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).

<sup>6</sup> 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.

#### 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 <sup>a</sup>	Total	Total GOA groundfish Chinook bycatch
2003	431	49	20	19	3	7	<b>529</b>	15
2004	497	39	29	29	3	18	<b>615</b>	21
2005	462	36	29	14	3	14	<b>558</b>	31
2006	379	32	19	20	2	13	<b>465</b>	19
2007	359	41	18	17	2	13	<b>450</b>	40

<sup>a</sup> 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 7<sup>th</sup> 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 Columbia 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 remainder 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	<i>C. opilio</i> Tanner crab	<i>C. bairdi</i> Tanner crab	Pot	Trawl	Longline	Dredge
		Pot	Pot	Pot				
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% <sup>a</sup>				

<sup>a</sup> 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 negligible. 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<sup>7</sup> 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
<b>Grand Total</b>		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

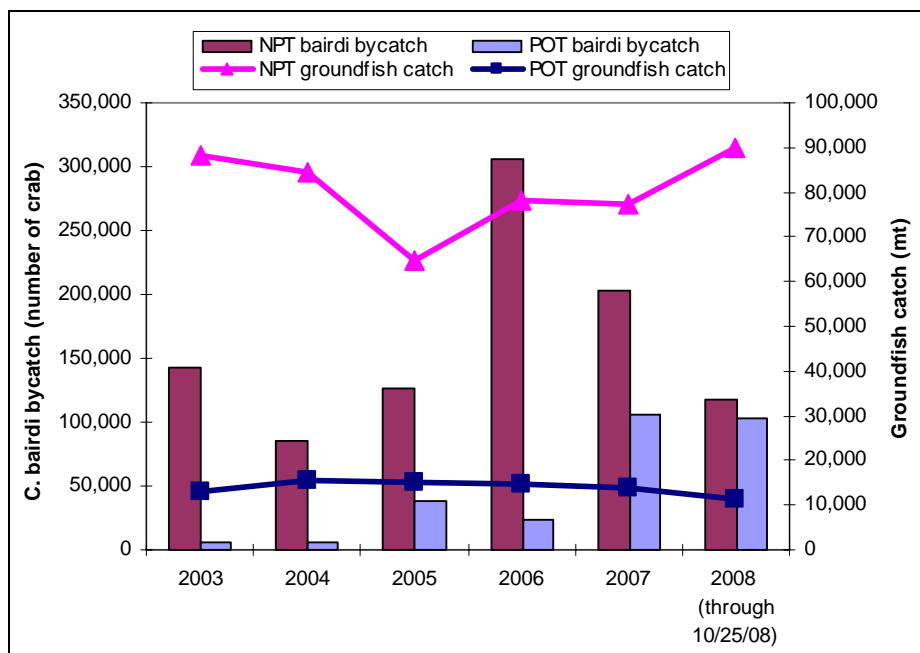
Gear type	2003	2004	2005	2006	2007	2008 (through 10/25/08)	Average 2003-2007
Hook and line	21	28	1,770	596	272	1,638	538
Non-pelagic trawl	142,206	84,885	126,285	306,592	202,547	117,103	172,503
Pot	6,520	5,950	43,341	24,672	105,583	103,255	37,213
Pelagic trawl	110	667	136	407	1,554	67	575
<b>Grand Total</b>	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).

<sup>7</sup> 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	<i>C. bairdi</i> Tanner	Year	<i>C. bairdi</i> 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
<b>Average 1993-2007</b>	<b>108,540</b>		
<b>Average 2003-2007</b>	<b>167,145</b>		

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.

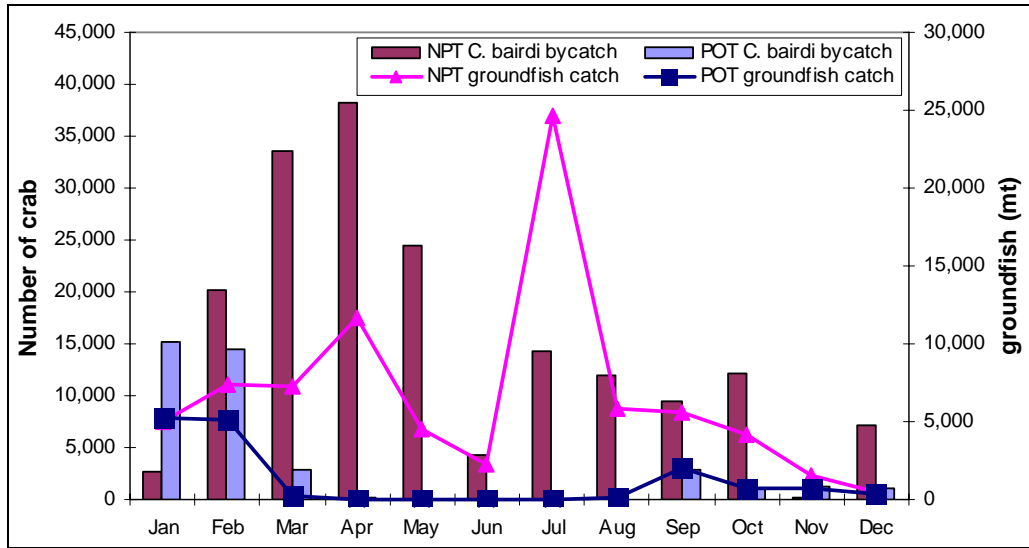
**Table 17** *C. bairdi* crab bycatch by month, 2003-2008, in GOA Federal groundfish fisheries

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 following series of maps, that the data represents only a small proportion of the GOA fishing effort.

All of the following maps use observer data that has been extrapolated to the haul level<sup>8</sup>. Figure 21 and Figure 24 Observed *C. bairdi* Tanner crab bycatch in the Federal pot fishery, 2007 only

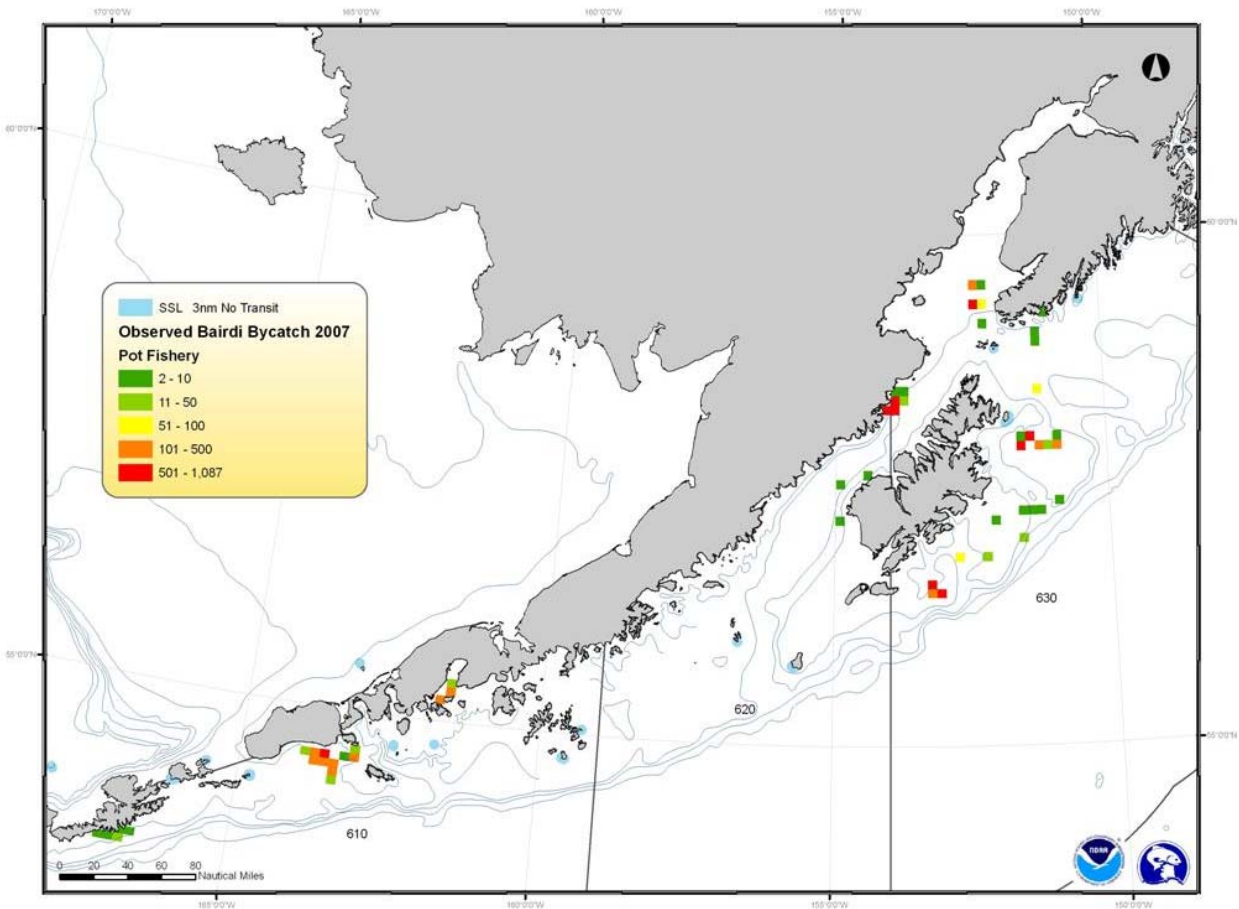


Figure 25 (on pages D and K, at the end of this document) map the average observed number of *C. bairdi* for 2003-2007. Figure 22 and

Figure 26, also on pages I and M, illustrate the average bycatch rate, mapping the number of *C. bairdi* per metric ton of groundfish, for the same years. Because 2007 was a year of high bycatch in both gear types, maps illustrating the location of bycatch just in that year are also provided (Figure 23 and Figure 24, on pages J and K), and show a smaller footprint for the fisheries, particularly the pot fishery. 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 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.

<sup>8</sup> Observers do not sample the entire haul from a fishing tow, but rather collect one or several basket samples. The number of *C. bairdi* collected within the basket sample is extrapolated by the Observer Program to represent the number of *C. bairdi* 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.

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.

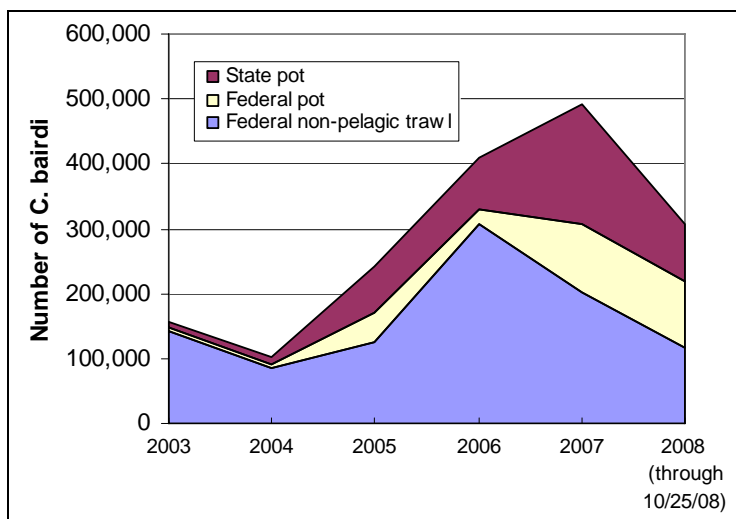
Table 18 identifies the *C. bairdi* bycatch attributable to the State managed Pacific cod pot fishery, which varied from approximately 6,600 crab in 2003, to 184,566 crab in 2007<sup>9</sup>. The contribution of the State managed fishery to overall *C. bairdi* bycatch in the GOA ranged from a low of 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 noting 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
<b>Grand Total</b>	<b>155,372</b>	<b>102,610</b>	<b>244,265</b>	<b>410,997</b>	<b>494,522</b>	<b>307,559</b>
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



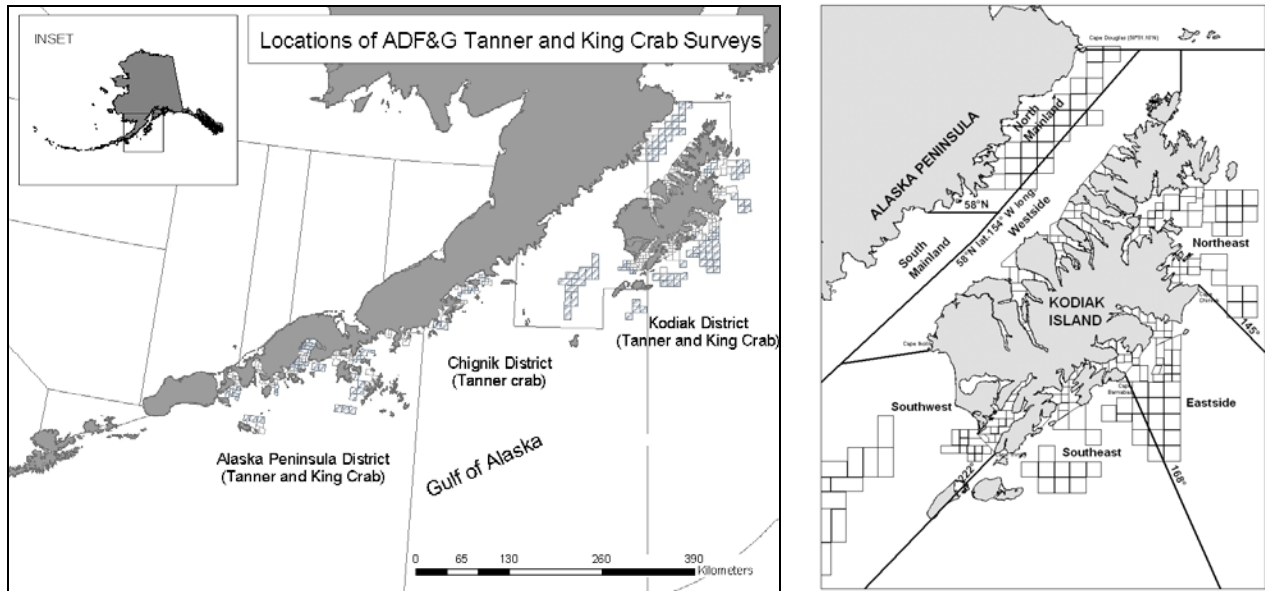
Source: NMFS catch accounting PSC data, October 2008.

<sup>9</sup> 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



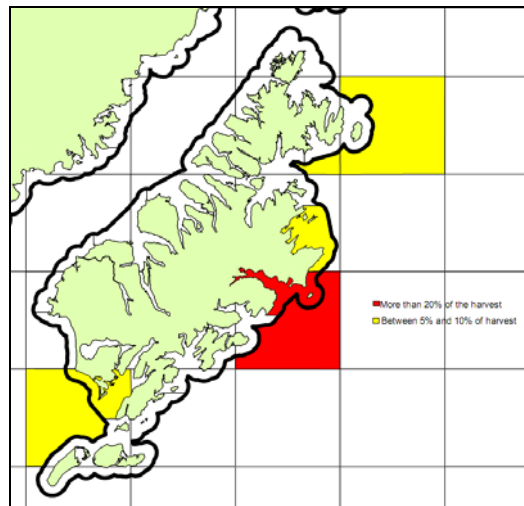
Source: K Spalinger, ADFG

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. 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).

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, ADFG

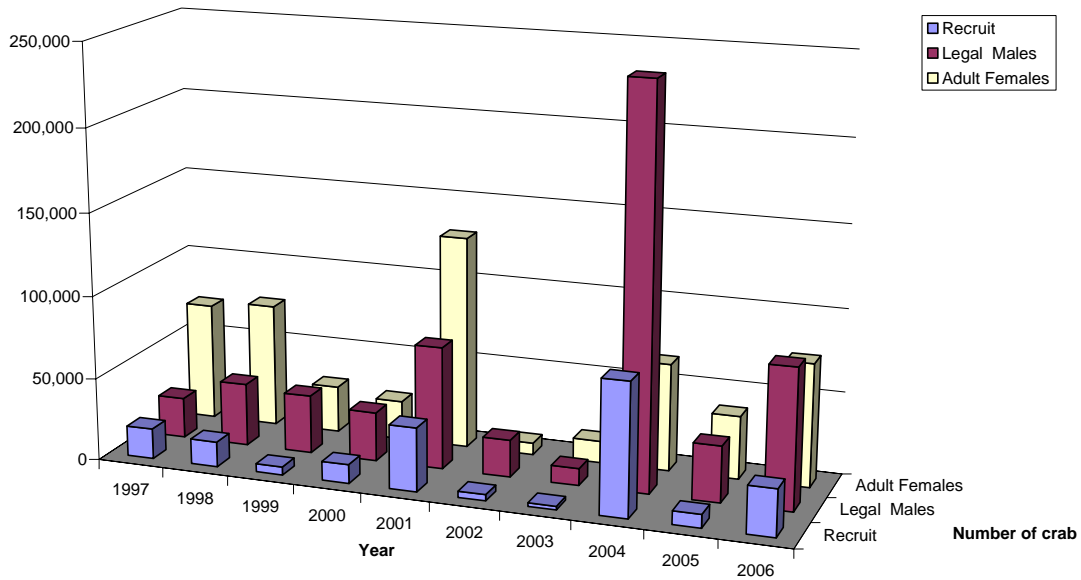
Population estimates for 1997-2006, based on the ADFG surveys, are provided in Figure 8 and Figure 9 for the Kodiak and the South Peninsula District (Spalinger 2006). For the South Peninsula this estimate represents an increase from the previous survey. Recent survey results indicate an increase in females from 2006–2007 (Spalinger 2007). Maps of the mature male and female Tanner crab density, from the 2007 ADFG survey, are included as Figure 16, on page C at the end of this document.

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).

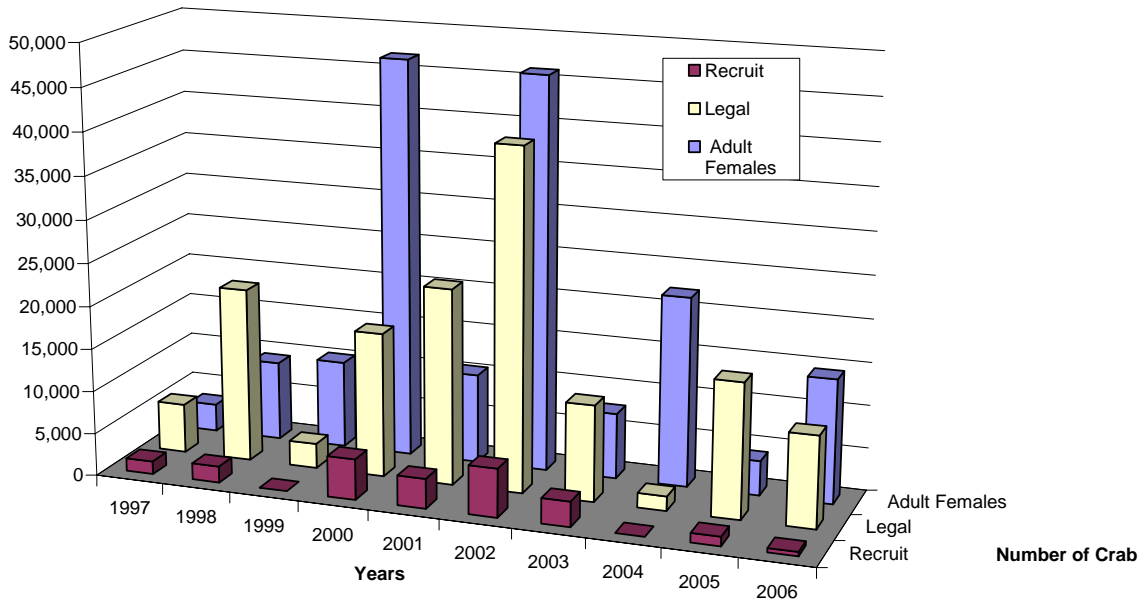
The Kamishak and Barren Islands District of the Cook Inlet management region has also been closed to commercial fishing (since 1991) due to concerns of low crab abundance. In these regions the male abundance is estimated at 6.1 million crabs, with a near historic low in mature males, while female abundance 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.

**Figure 8** *C. bairdi* Tanner crab population estimates for Kodiak District based on ADF&G trawl surveys 1997-2006



**Figure 9** *C. bairdi* Tanner crab population estimates for Alaska Peninsula District based on ADF&G trawl surveys 1997-2006



## 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 tied 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 Alternatives 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. An average of bycatch in 2003-2007 is used for the analysis. There are many problems with this approach, some of which have already been described above. The observed fishing trips represent only a relatively small proportion of total fishing trips in the western and central GOA. Areas with high numbers of bycatch also tend to be the areas where most of the catch is occurring. This issue is addressed by looking at bycatch rates (e.g. crab/mt groundfish) instead of looking at absolute bycatch numbers. However, bycatch rates are also problematic 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.

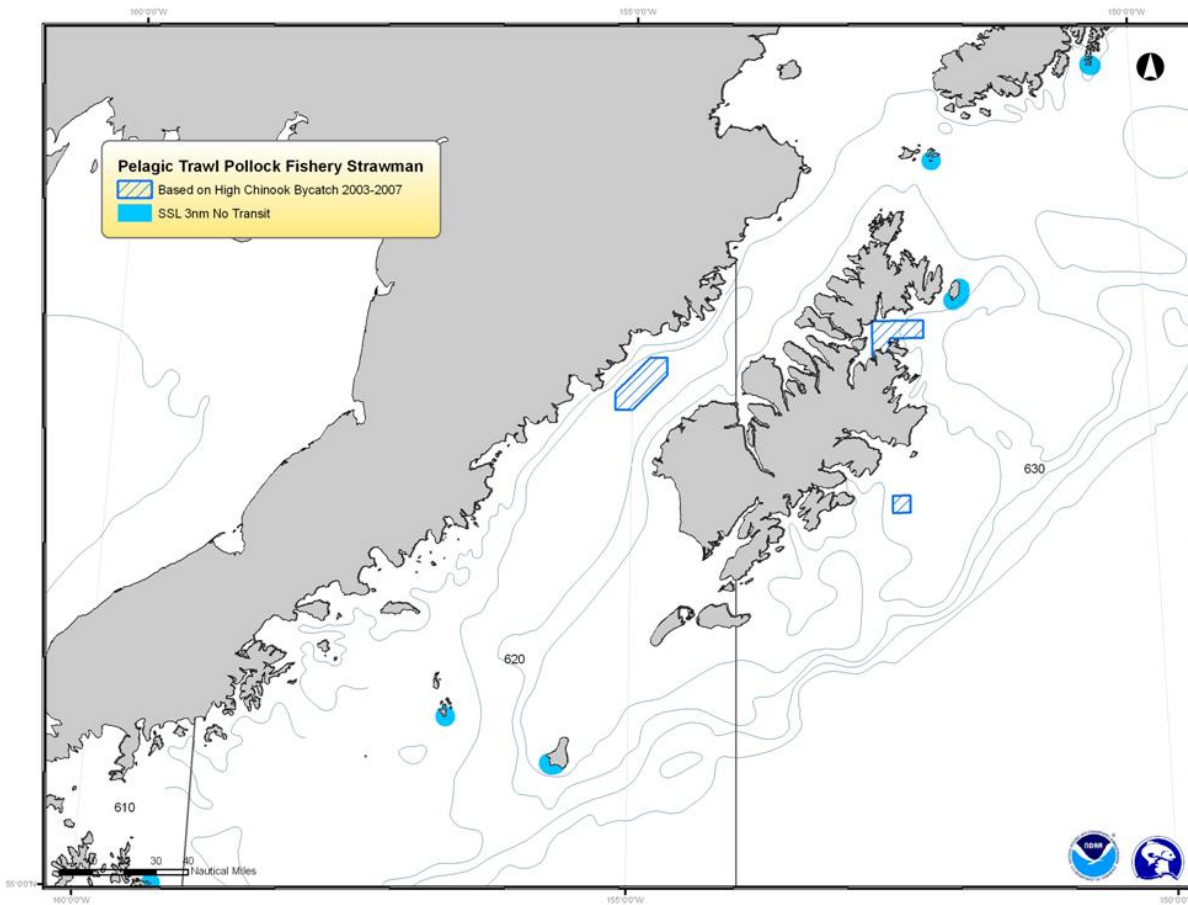
Additionally, bycatch patterns (as with abundance patterns for Tanner crab) are highly variable from year to year. The correlation between the location of fishery catch and salmon and crab bycatch has not been fully investigated, but preliminary analysis seems to indicate that the variability is as much 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.

### 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 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 (Figure 27 and Figure 28, on pages N and O, at the end of this document). The closures were identified by selecting areas with the highest category of observed bycatch, 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, and rate of observed salmon per mt of groundfish, for the pelagic trawl fishery. This methodology results in two closure areas, both of which occur in the central GOA (Figure 10).

**Figure 10** Chinook salmon strawman closures for pelagic trawl gear, based on high incidence of bycatch, averaged over 2003-2007



### Strawman closures for *C. bairdi* Tanner crab

For *C. bairdi* crab, staff has looked at separate strawman closure areas for vessels using non-pelagic trawl gear and those using pot gear. 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 29 and Figure 33, on pages N and T at the end of this document) looks at areas of high incidence of bycatch. The closures were identified by selecting areas with the highest category of observed bycatch, 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 over a map of the bycatch rates by area for that gear type, and also included on the map are any existing closures that pertain to that gear type. The areas that are identified in the figures are also areas where the much of the catch is taken. Implementing these closures will be disruptive to the fishery, and displacement of effort will occur, which may result in lower catch per unit effort which could also lead to other bycatch concerns. The non-pelagic trawl and pot closures identified through this method occur in completely different areas, and there is no overlap between them. Figure 11, below, illustrates the non-pelagic trawl and pot strawman closures on the same map, for the central GOA. Figure 12 identifies only pot strawman closures, but for both the western and central GOA. There are seven individual pot closure areas identified, five in the central GOA and two in the western GOA.

Figure 11 *C. bairdi* crab strawman closures in the central GOA, for non-pelagic trawl and pot gear, based on high incidence of bycatch, averaged over 2003-2007

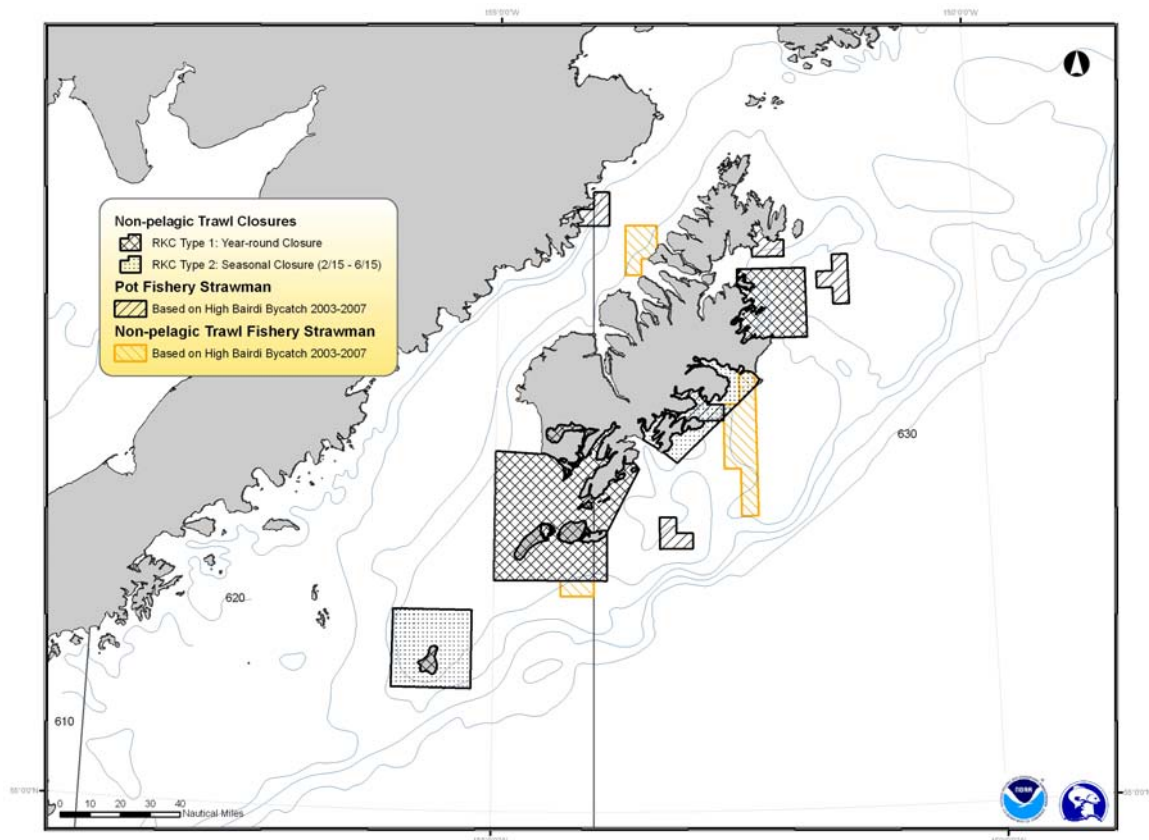
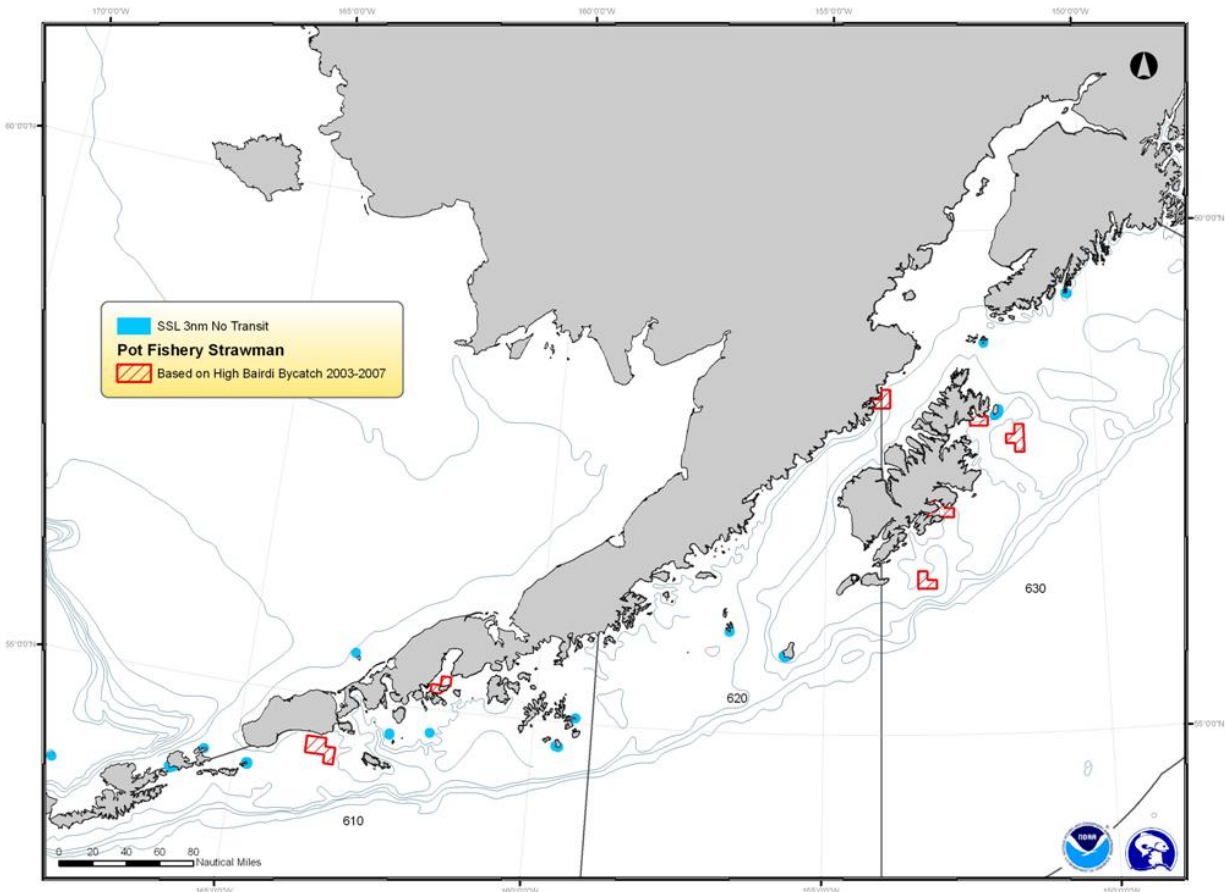




Figure 12 *C. bairdi* crab strawman closures for pot gear in the western and central GOA, based on high incidence of bycatch, averaged over 2003-2007



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.

Another way to look at high incidence bases closure areas on an analysis of the top 10% of records of high bycatch (Figure 30 and Figure 34, on pages Q and U). Closure areas resulting from this analysis are mainly similar to the strawman closures identified just by looking at high incidence overall. The map plots both high bycatch records from observer samples, and high bycatch records from extrapolated observed hauls, and shows that there is very little difference between them for non-pelagic trawl gear, and no difference for pot gear.

For non-pelagic trawl gear, staff also provided another set of strawman closures identifying areas based on the bycatch rate (Figure 31, on page R). This approach results in fewer total closures areas than by looking at high incidence, and the closure areas do not overlap (see Figure 32 on page S 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.

## 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 exists 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.

A voluntary cooperative program could be modeled after the AFA catcher vessel Intercooperative Agreement among the nine catcher vessel cooperatives in the BSAI pollock fishery (Gruver 2003). Some aspects of this inter-cooperative agreement which would be useful to include in a GOA co-op alternative include provisions for: allocation, monitoring and compliance of the PSC caps amongst the catcher vessel fleet; establishment of penalties for co-ops which exceed allocations; promoting compliance with PSC limits while allowing for maximum harvest of allocated groundfish; and the reduction of PSC bycatch in the groundfish fishery. For the BSAI cooperative, Sea State is retained to provide data gathering, analysis and reporting services to implement the bycatch management agreement, and in doing so provides timely hot spot reports to the fleet, as well as summaries of bycatch characteristics, trends and/or fishing behaviors which may be having an effect on bycatch rates (Gruver 2003). Fleets are notified of avoidance areas for Chinook salmon and have previously agreed within the cooperative to avoid these areas as notified. Specific cooperative measures would need to be created for the characteristics of the GOA groundfish fishery; however measures from the BSAI cooperatives may prove useful in designing appropriate programs for salmon and crab bycatch co-ops in the GOA. An extensive discussion of the BSAI intercooperative agreement is included in the Draft Environmental Impact Statement for Bering Sea Chinook Salmon Bycatch (NMFS 2008).

## 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 Color figures

Figure 13 Locations of existing trawl fishery and crab protection closures in the Gulf of Alaska

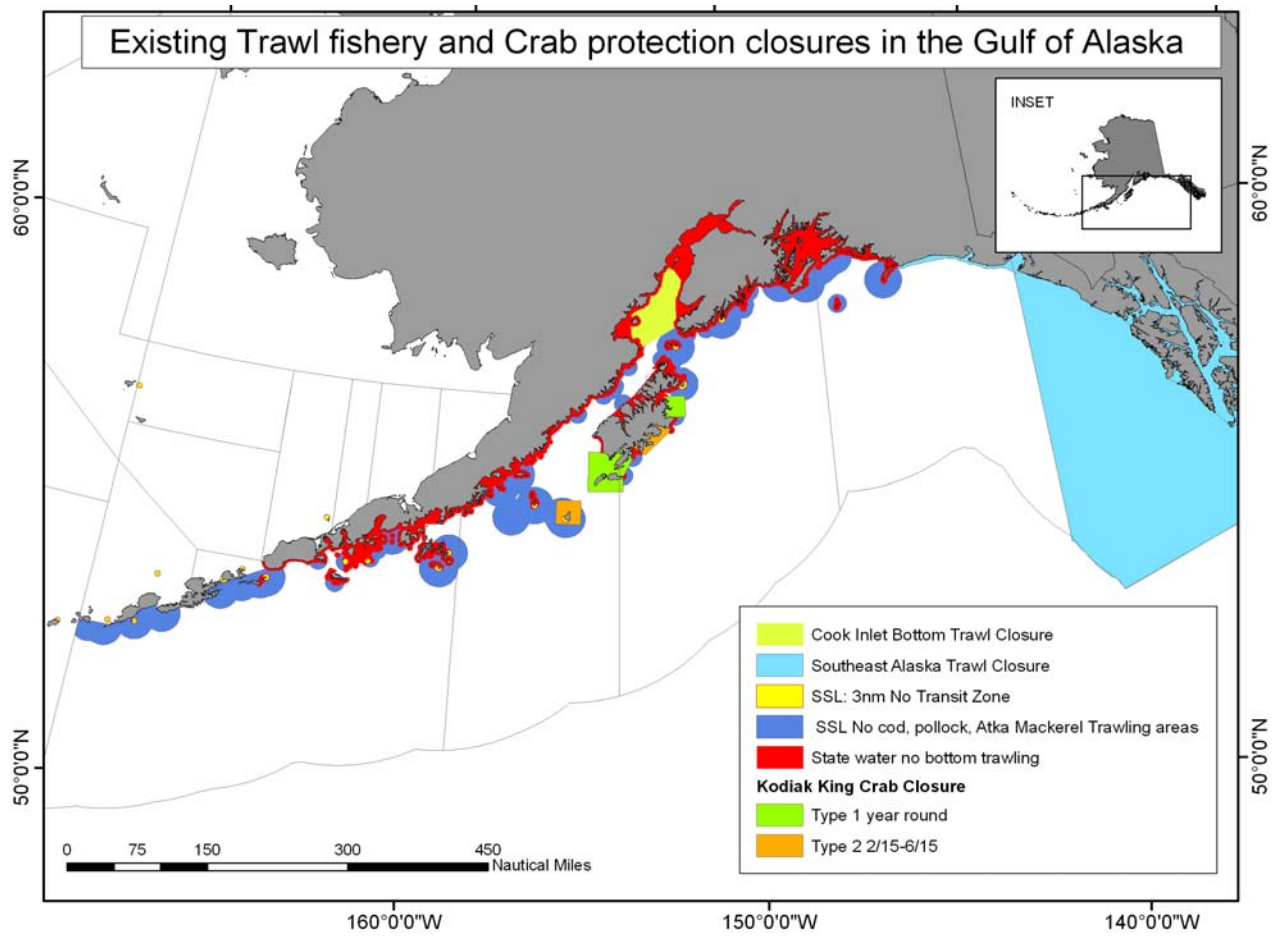


Figure 14 Locations of existing trawl fishery and crab protection closures in the Western Gulf of Alaska

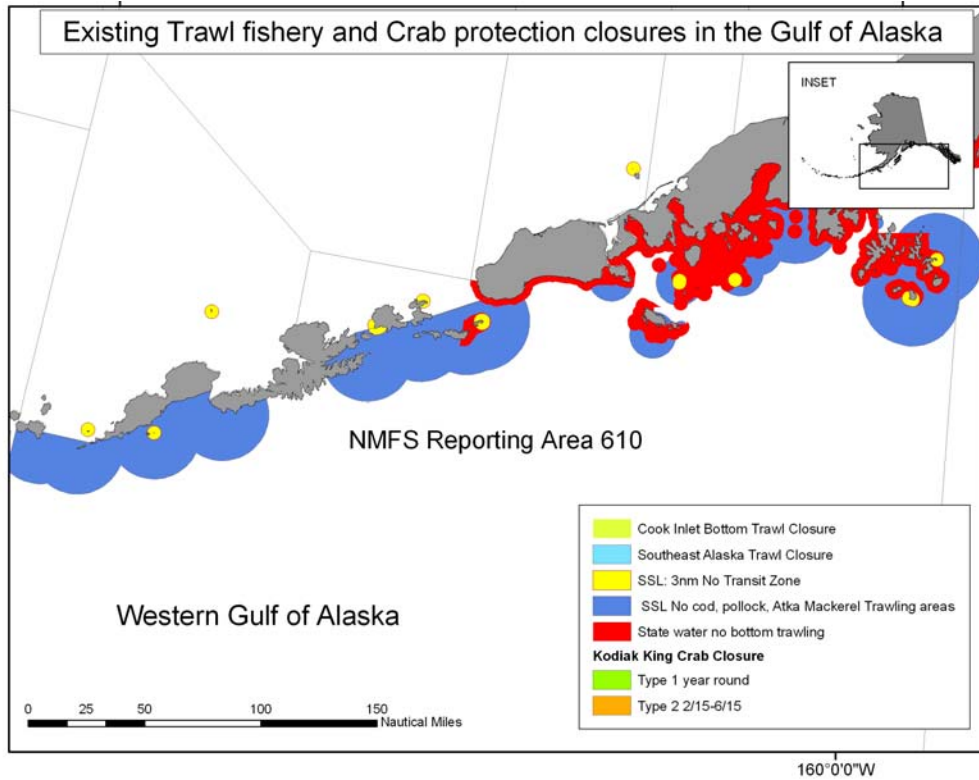


Figure 15 Locations of existing trawl fishery and crab protection closures in the Central Gulf of Alaska

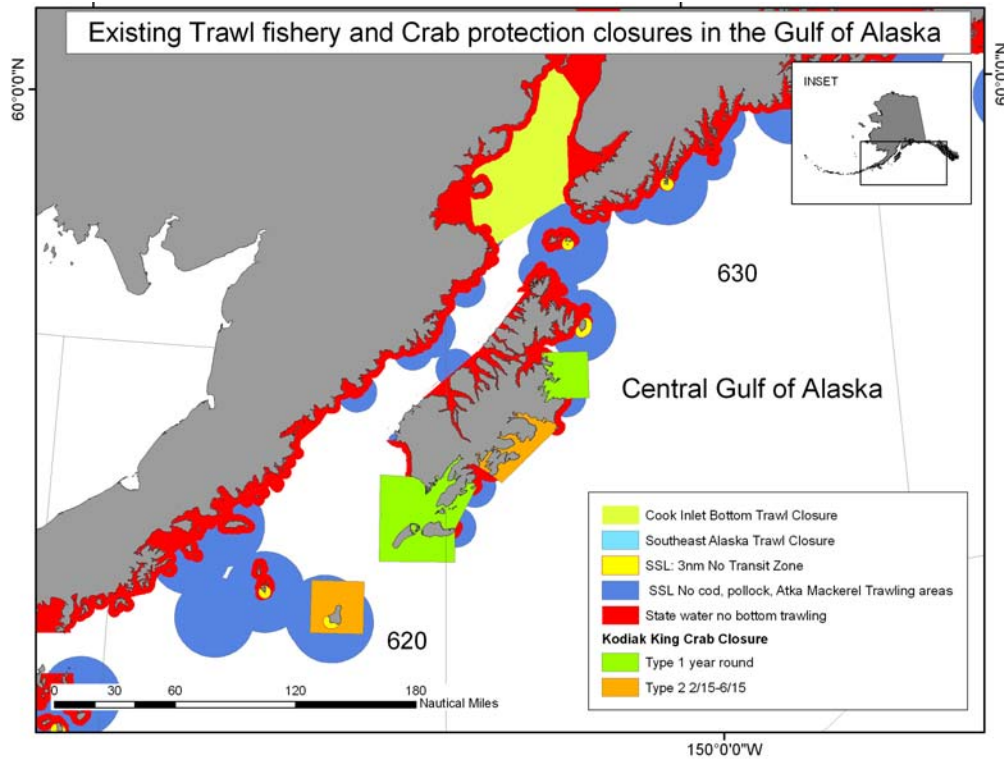
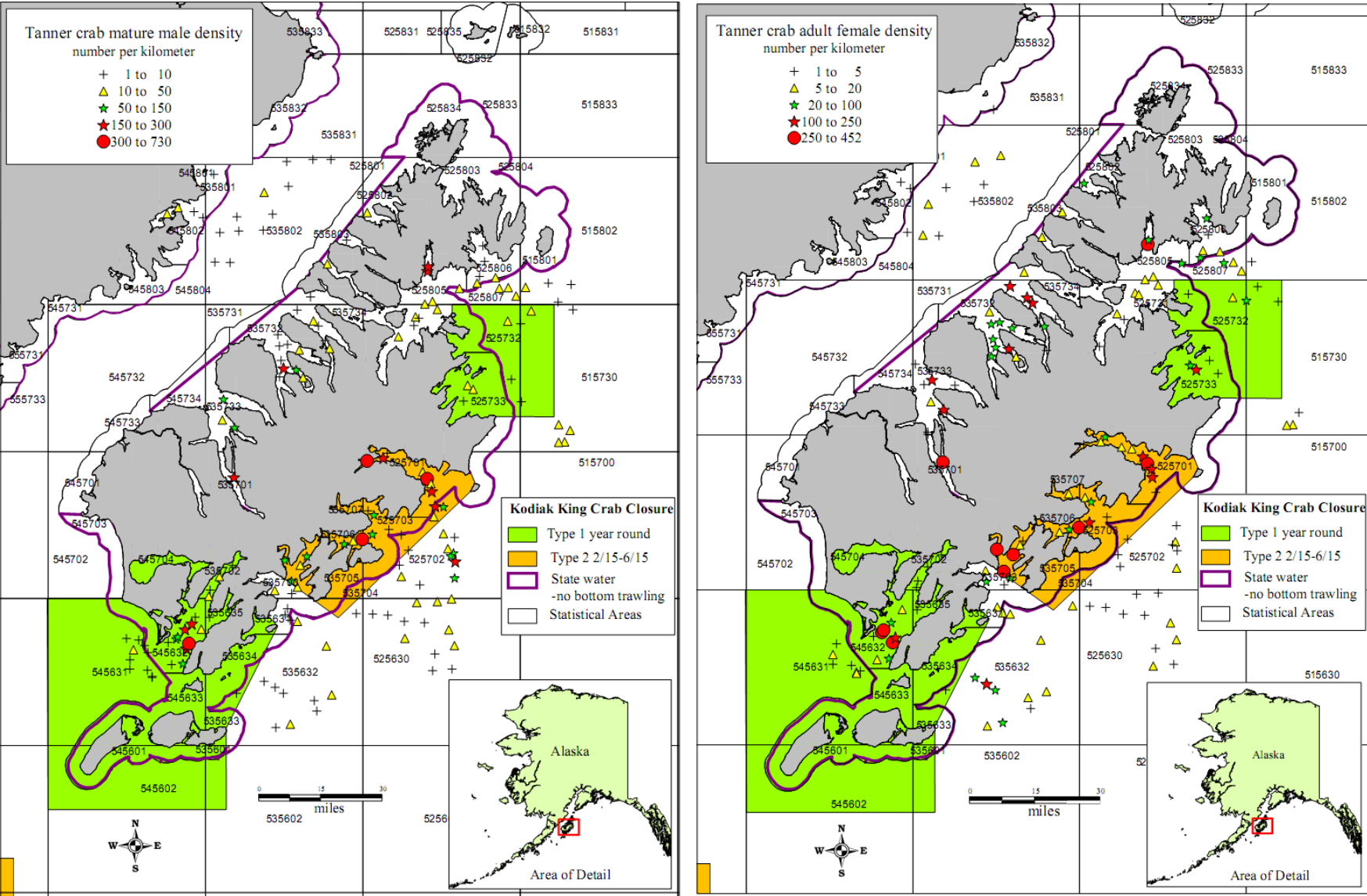




Figure 16 Mature male and female Tanner crab density, from the 2007 ADFG survey.



Source: K. Spalinger and N. Sagalkin, ADFG

Figure 17 Observed Chinook salmon bycatch in the pelagic pollock trawl fishery, averaged for 2003-2007

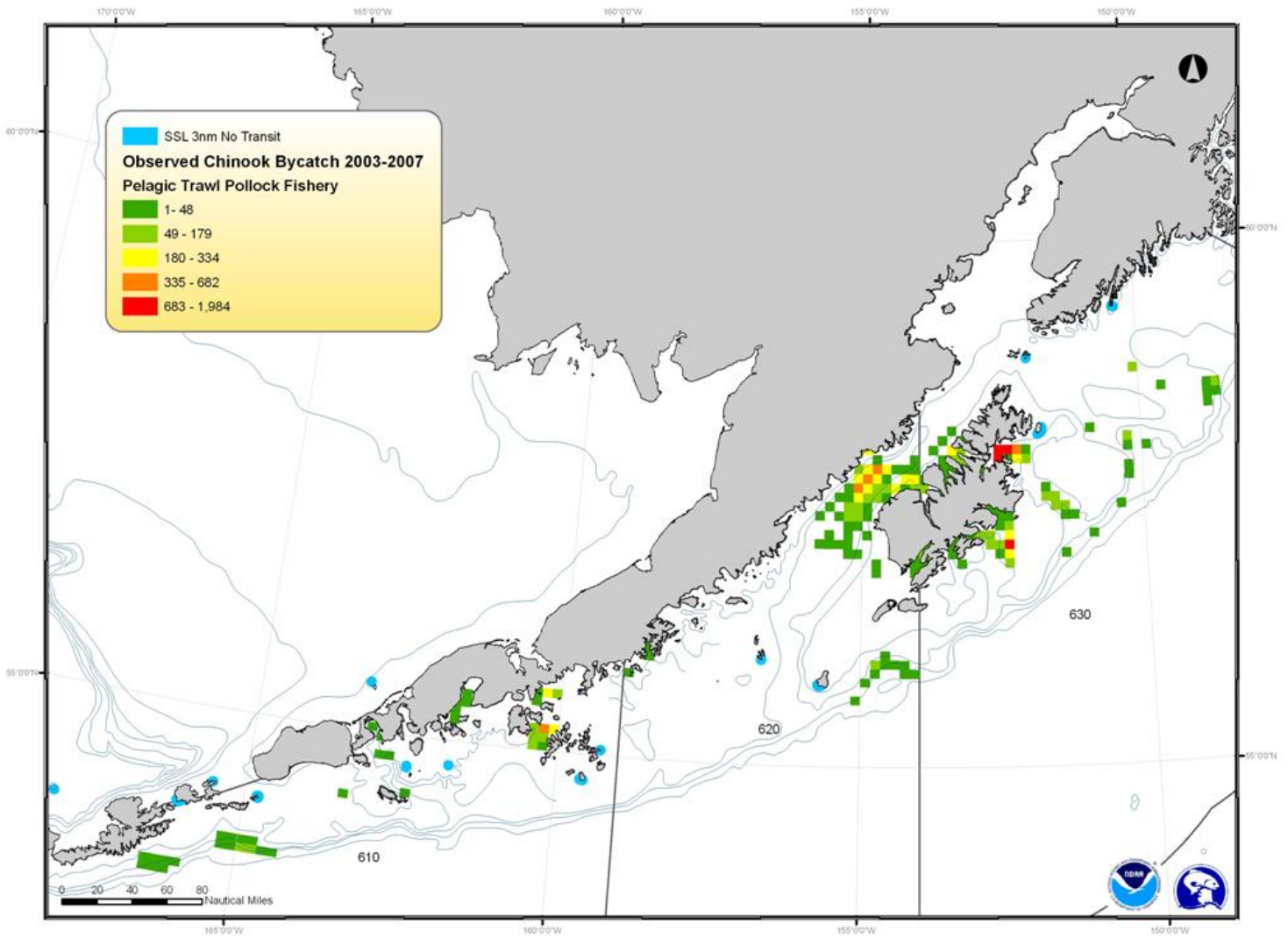


Figure 18 Observed Chinook salmon bycatch rate in the pelagic pollock trawl fishery, averaged for 2003-2007, number of crab per metric ton of groundfish

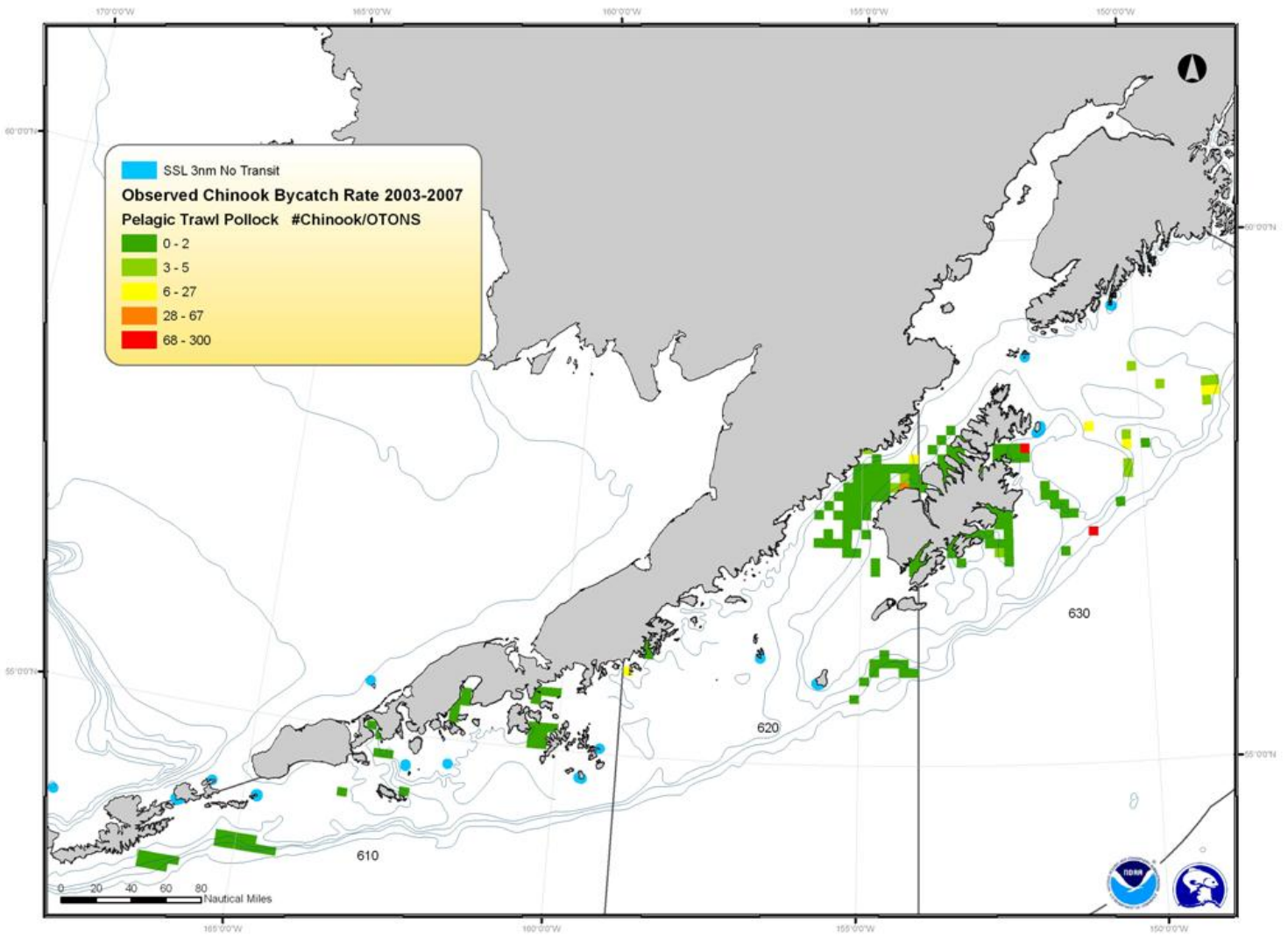


Figure 19 Observed Chinook salmon bycatch in the non-pelagic trawl fishery, averaged for 2003-2007

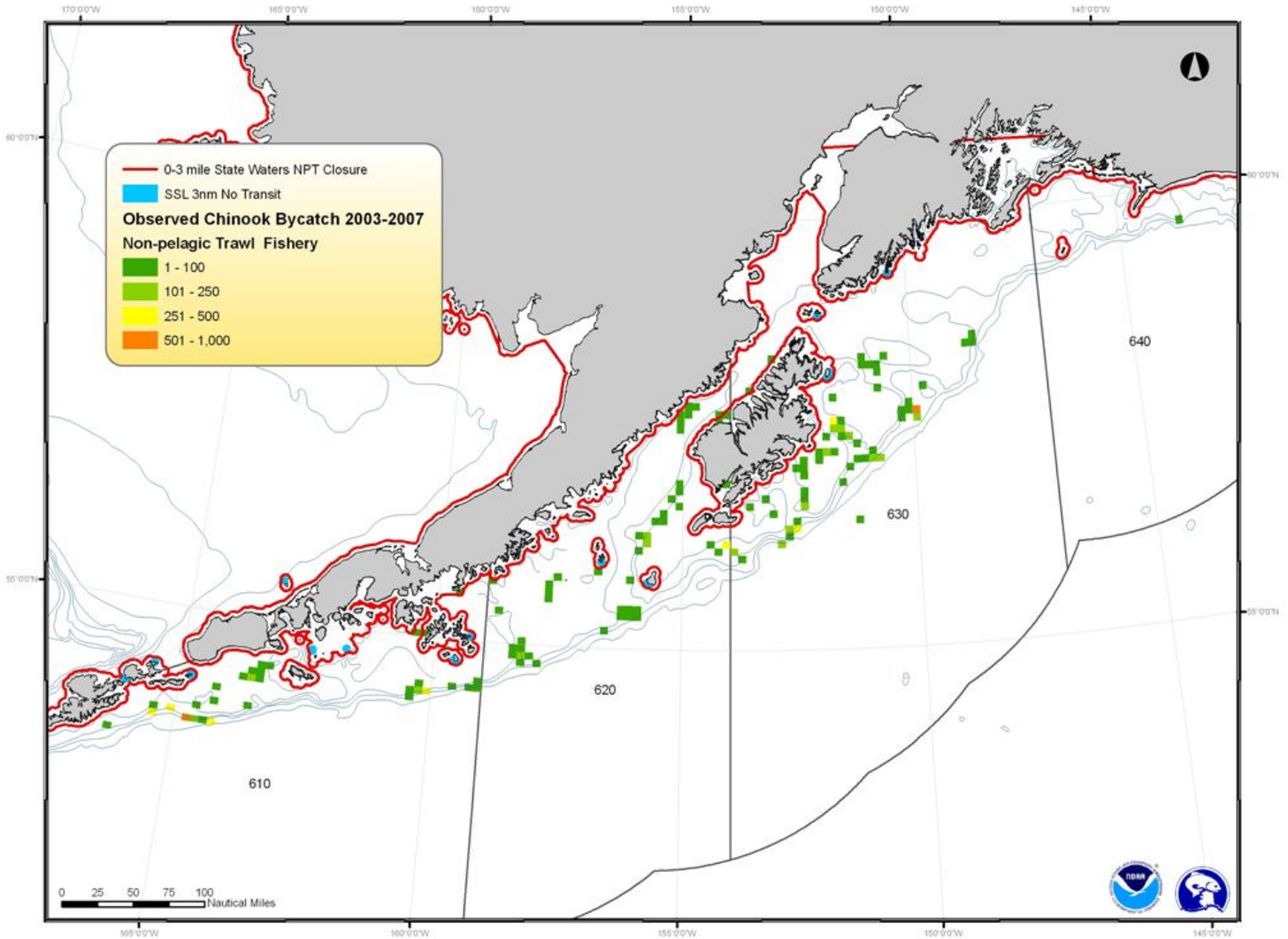




Figure 20 Observed Chinook salmon bycatch rate in the non-pelagic trawl fishery, averaged for 2003-2007, number of crab per metric ton of groundfish

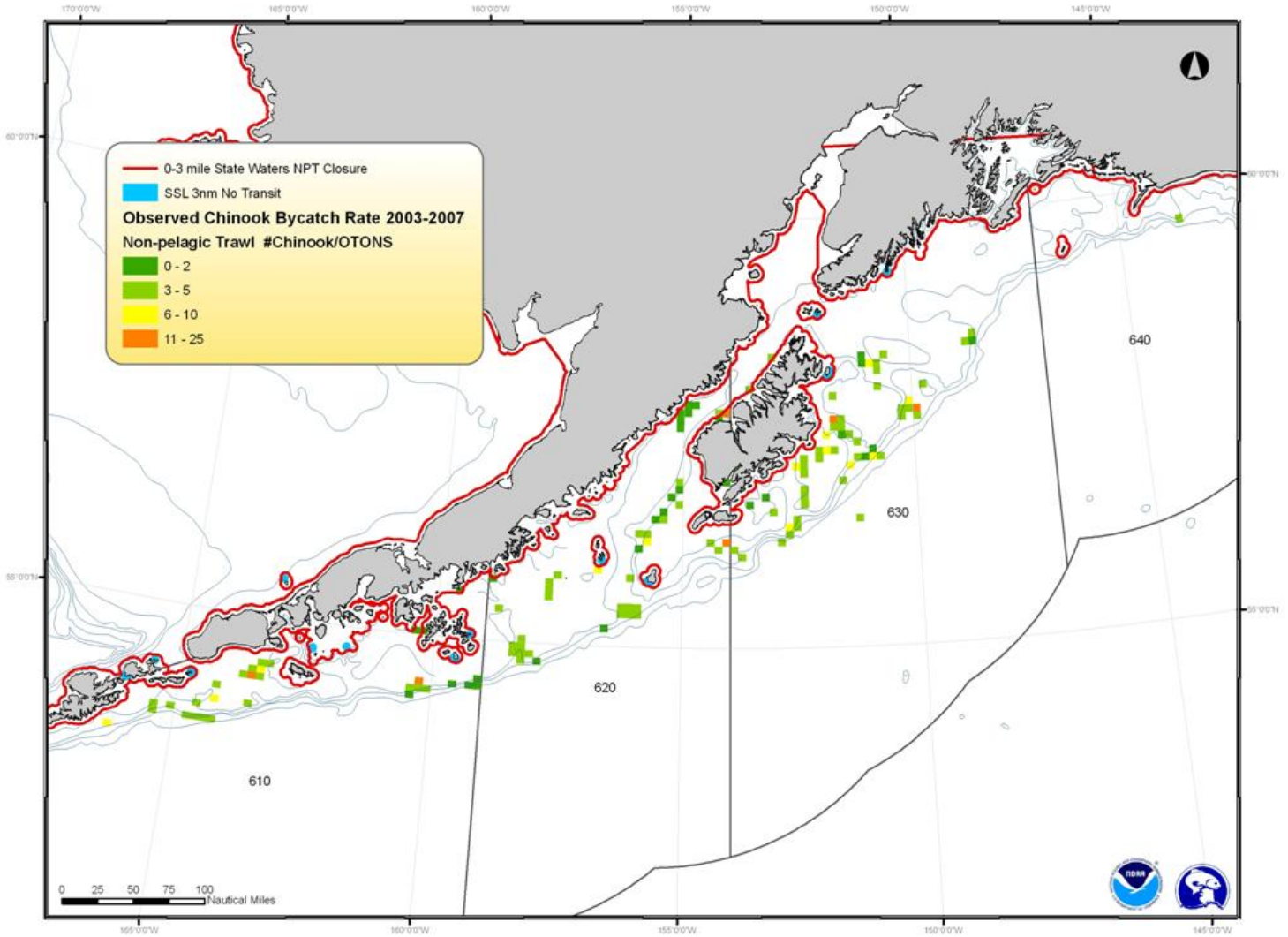


Figure 21 Observed *C. bairdi* Tanner crab bycatch in the non-pelagic trawl fishery, averaged for 2003-2007

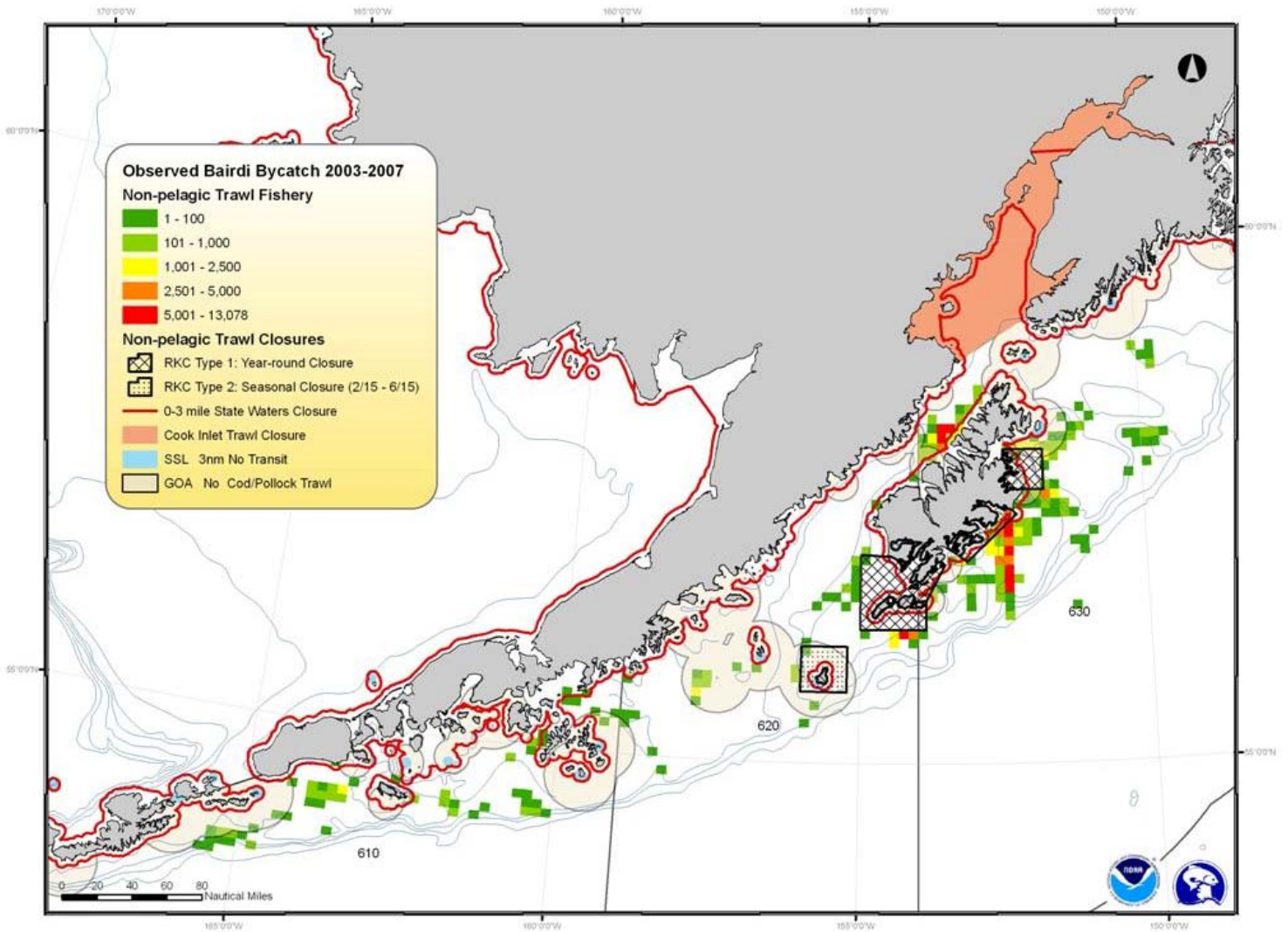


Figure 22 Observed *C. bairdi* Tanner crab bycatch rate in the non-pelagic trawl fishery, averaged for 2003-2007, number of crab per metric ton of groundfish

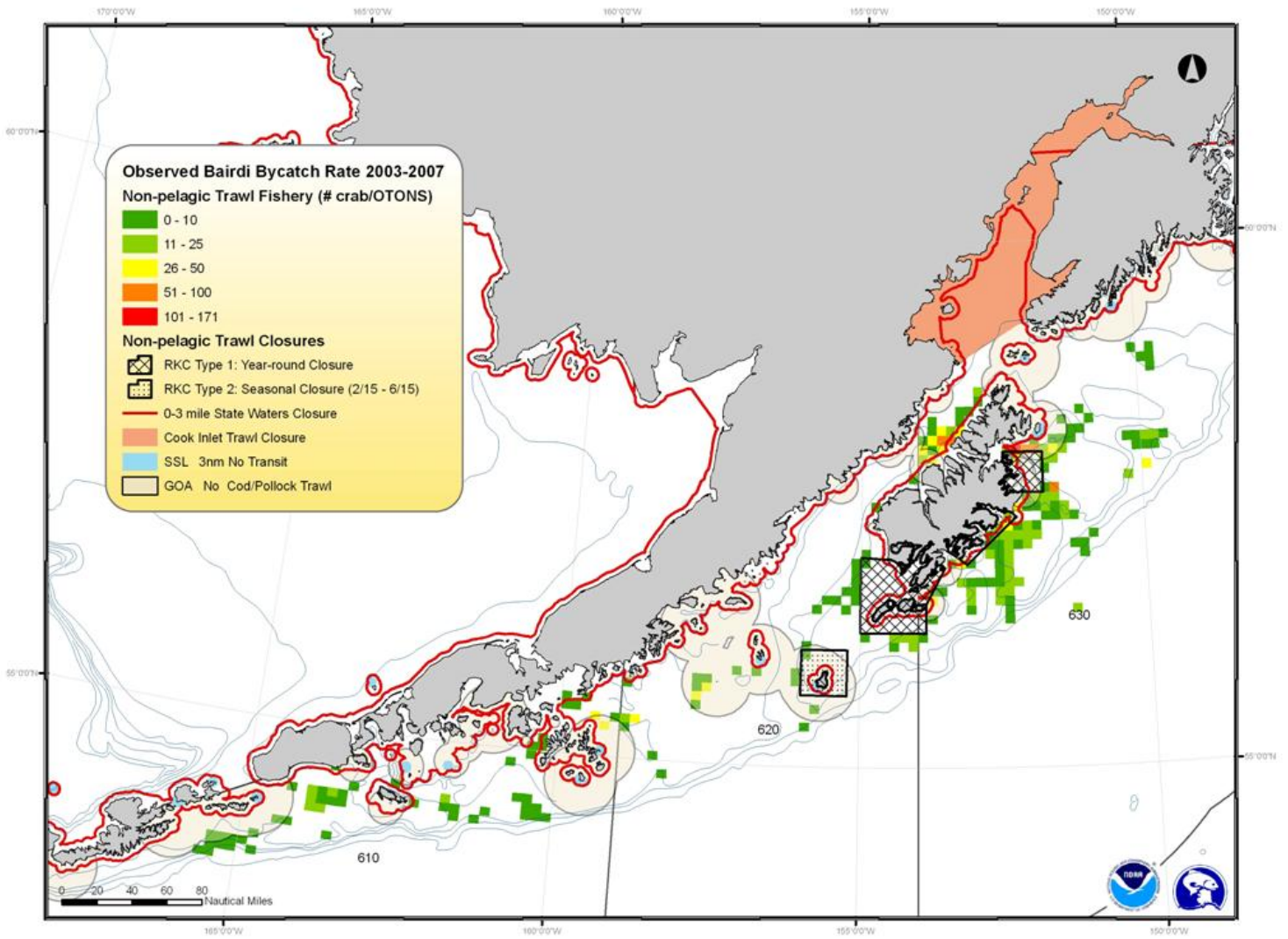




Figure 23 Observed *C. bairdi* Tanner crab bycatch in the non-pelagic trawl fishery, 2007 only

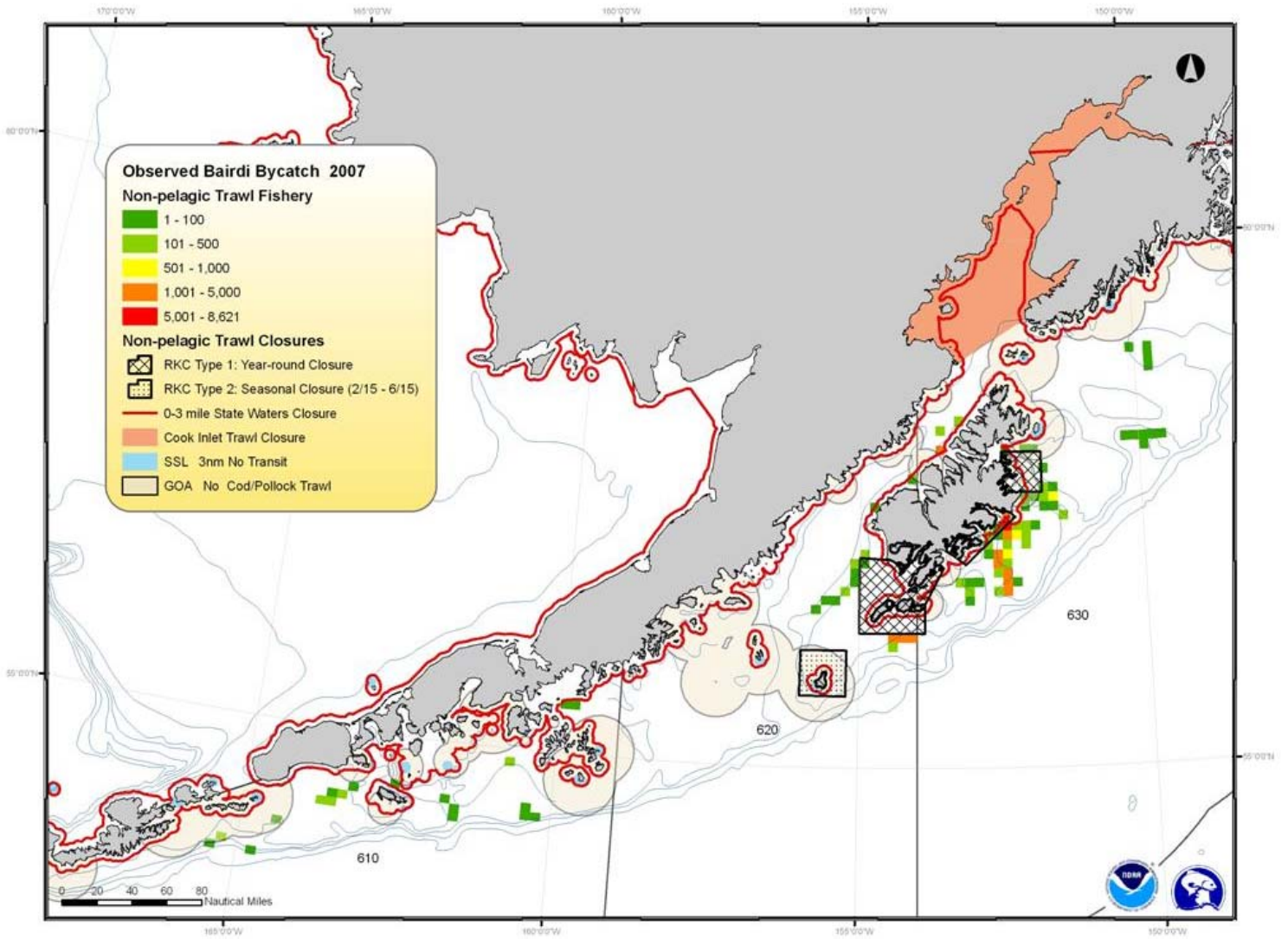




Figure 24 Observed *C. bairdi* Tanner crab bycatch in the Federal pot fishery, 2007 only

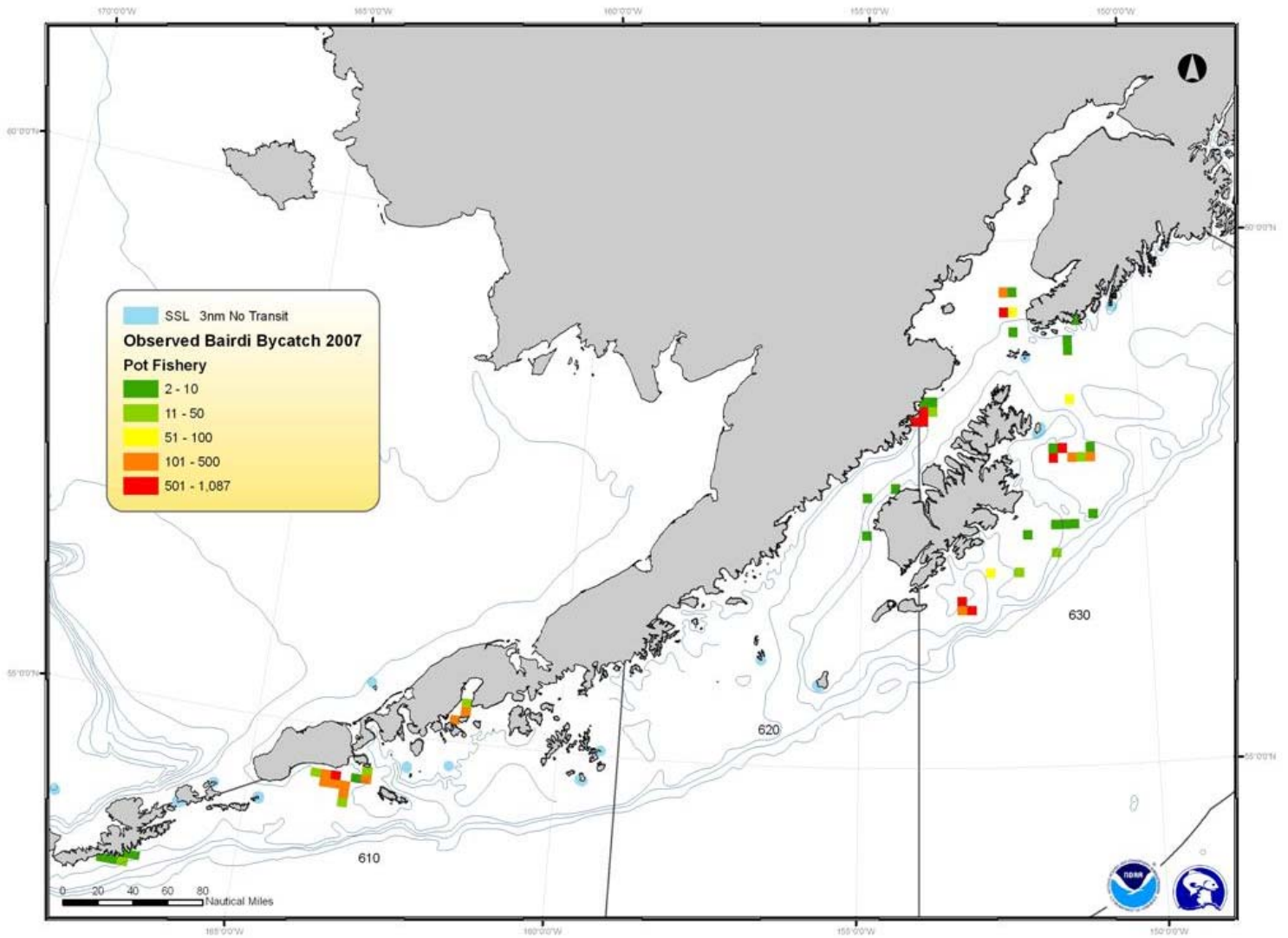


Figure 25 Observed *C. bairdi* Tanner crab bycatch in the Federal pot fishery, averaged for 2003-2007

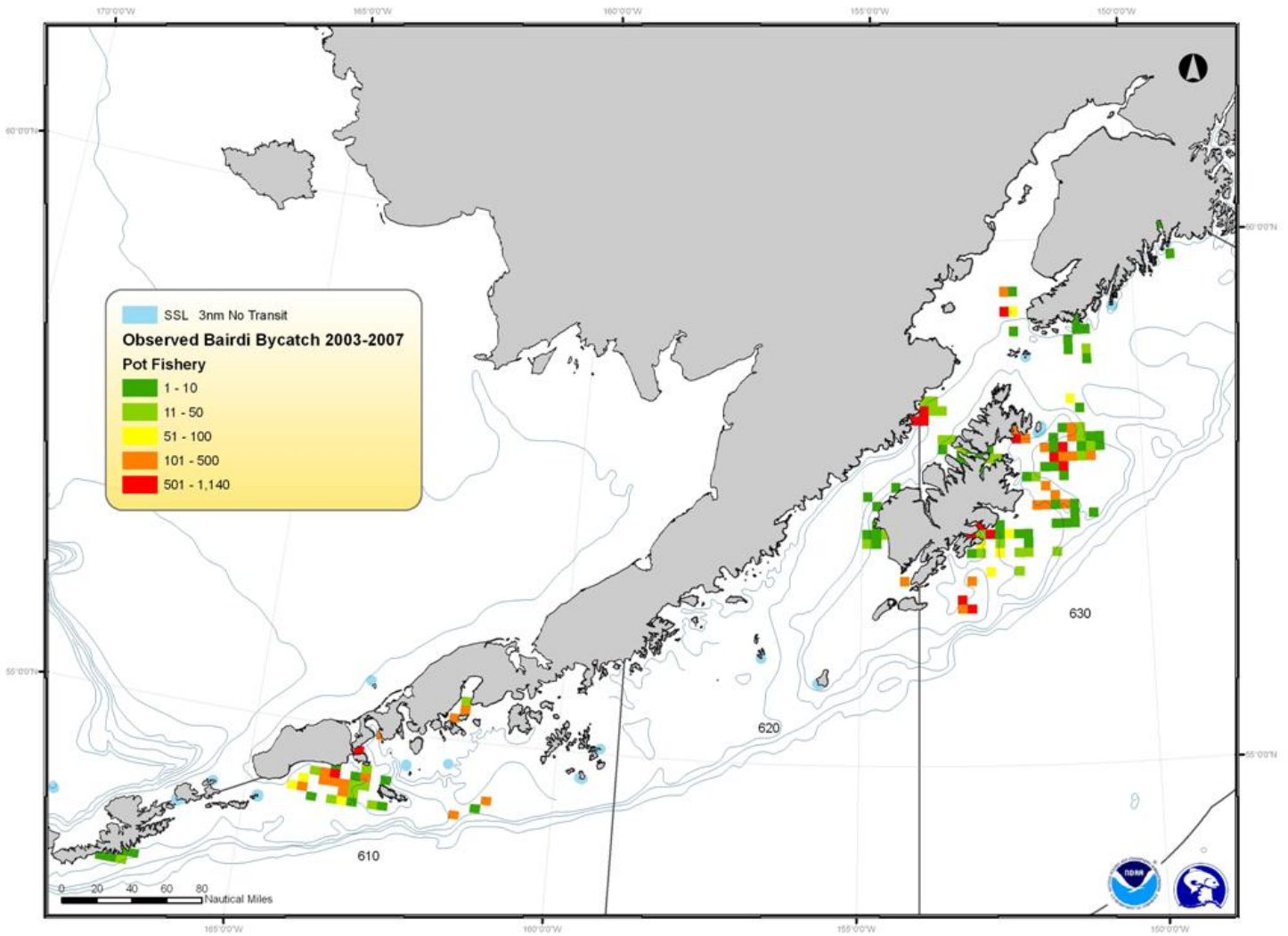


Figure 26 Observed *C. bairdi* Tanner crab bycatch rate in the Federal pot fishery, averaged for 2003-2007, number of crab per metric ton of groundfish

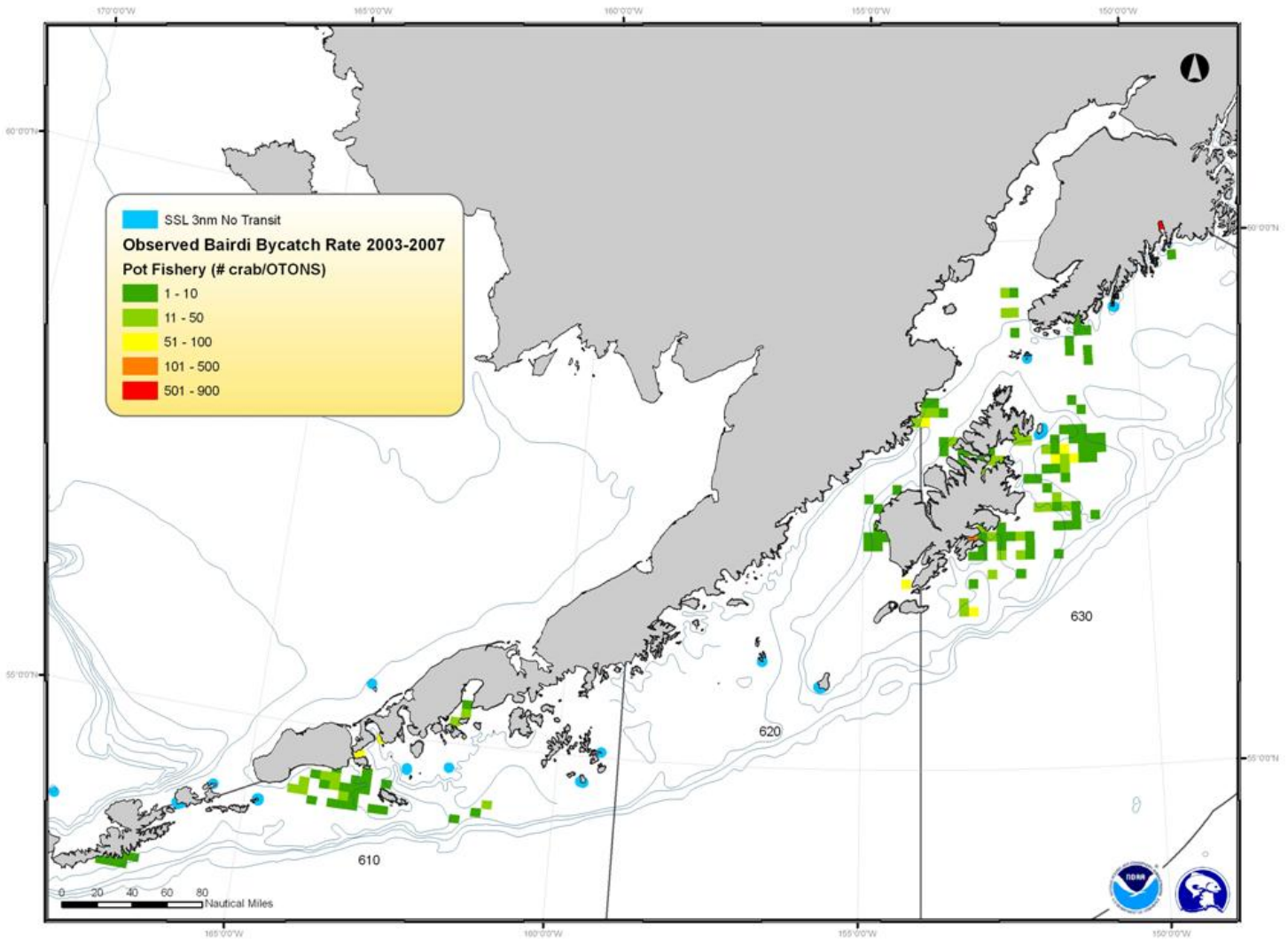


Figure 27 Chinook salmon strawman closures for pelagic trawl gear, based on high incidence of bycatch

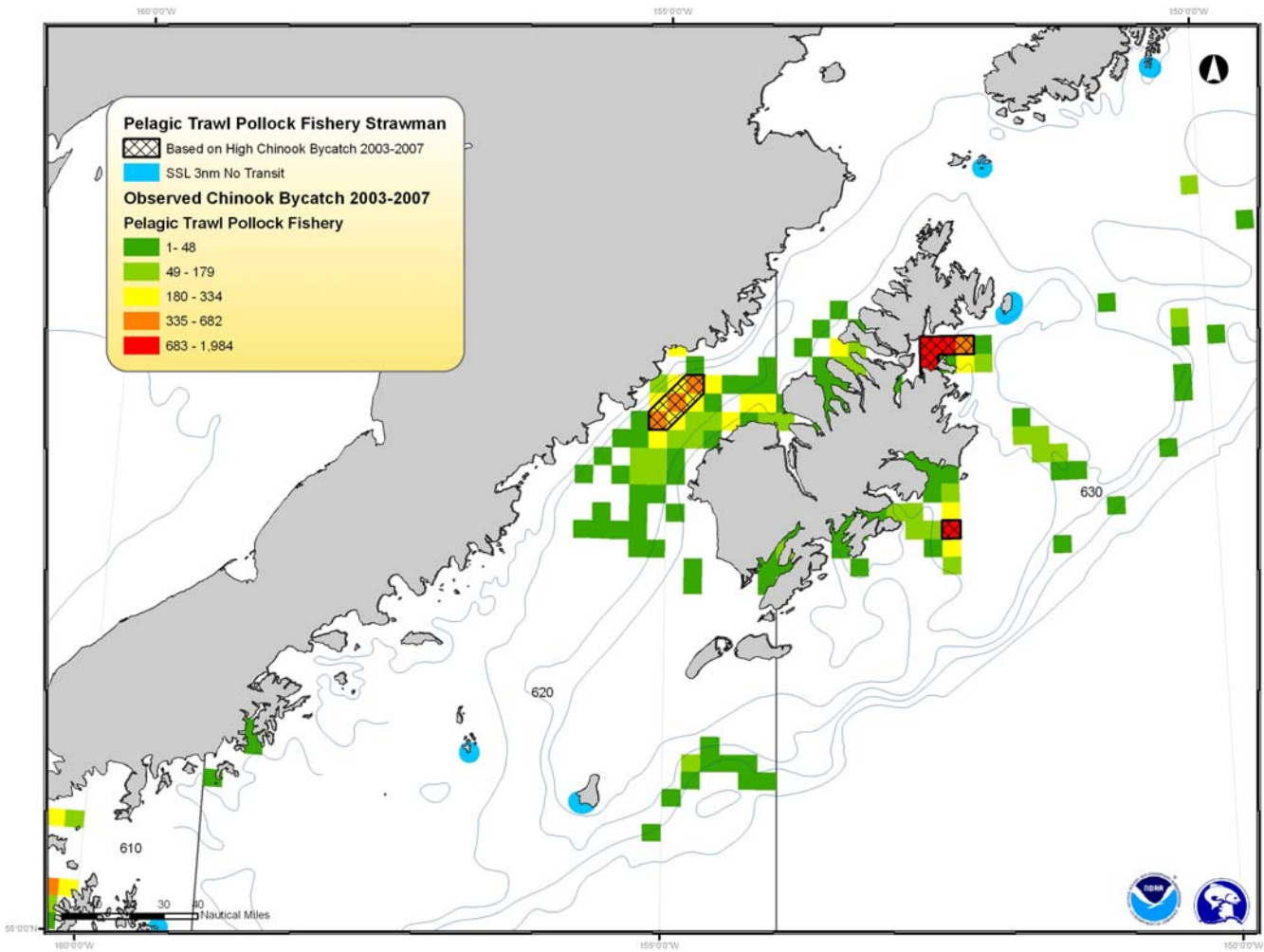




Figure 28 Chinook salmon strawman closures for pelagic trawl gear, based on high incidence of bycatch, compared to areas with high bycatch rates

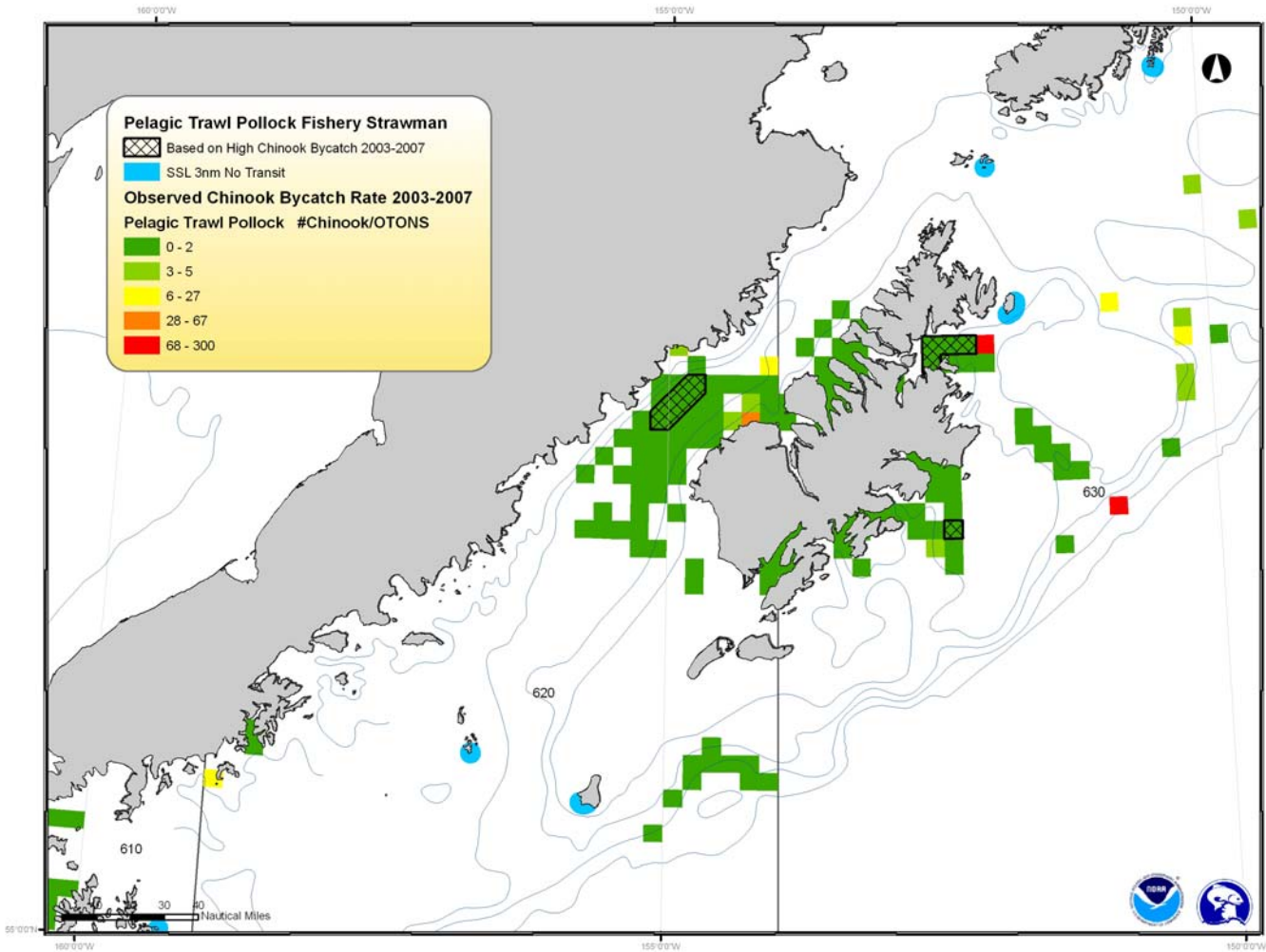


Figure 29 *C. bairdi* crab strawman closures for non-pelagic trawl gear, based on high incidence of bycatch

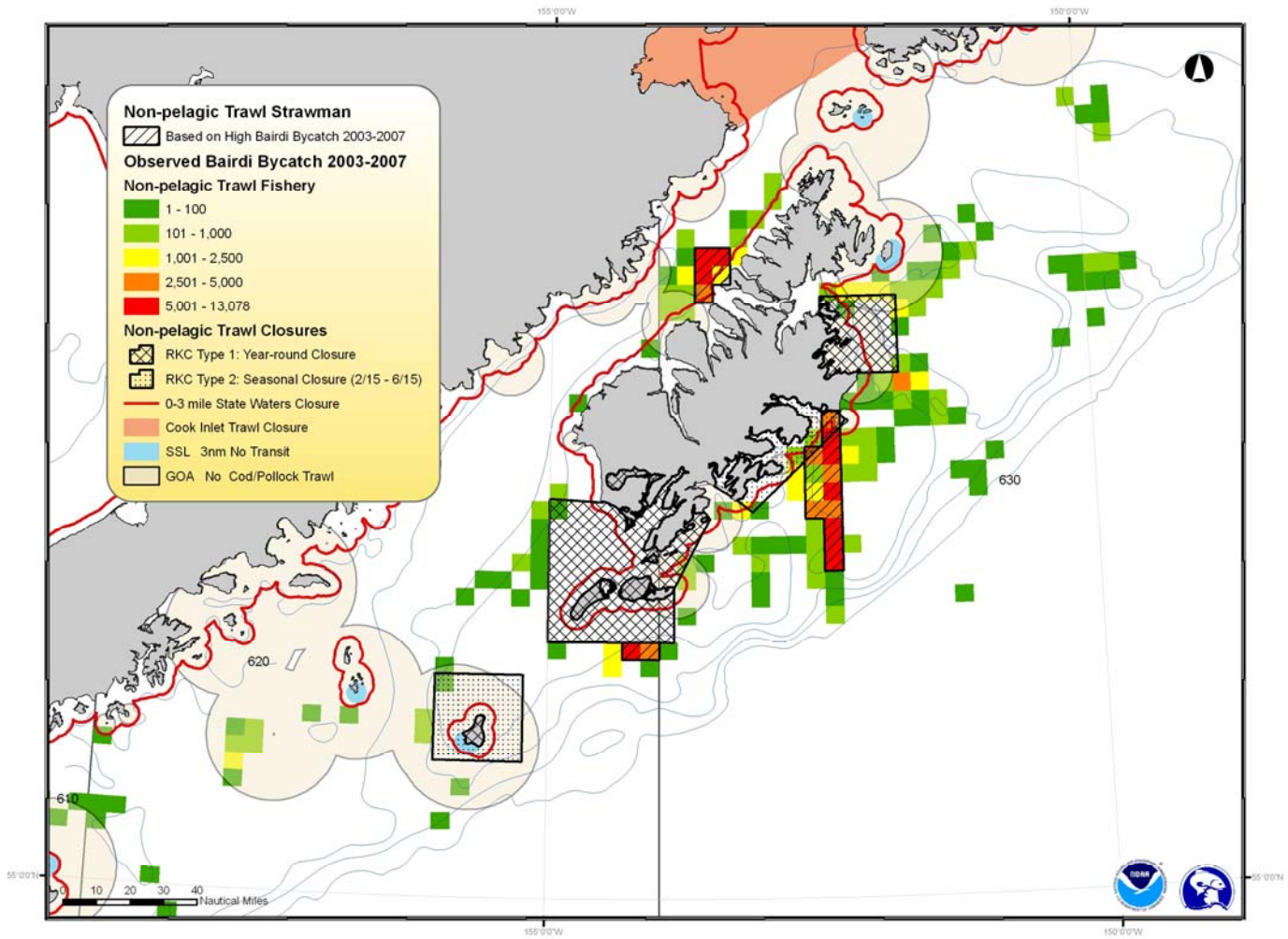


Figure 30 *C. bairdi* crab strawman closures for non-pelagic trawl gear, based on top 10% incidence of crab bycatch, both in observer samples and extrapolated to observed hauls

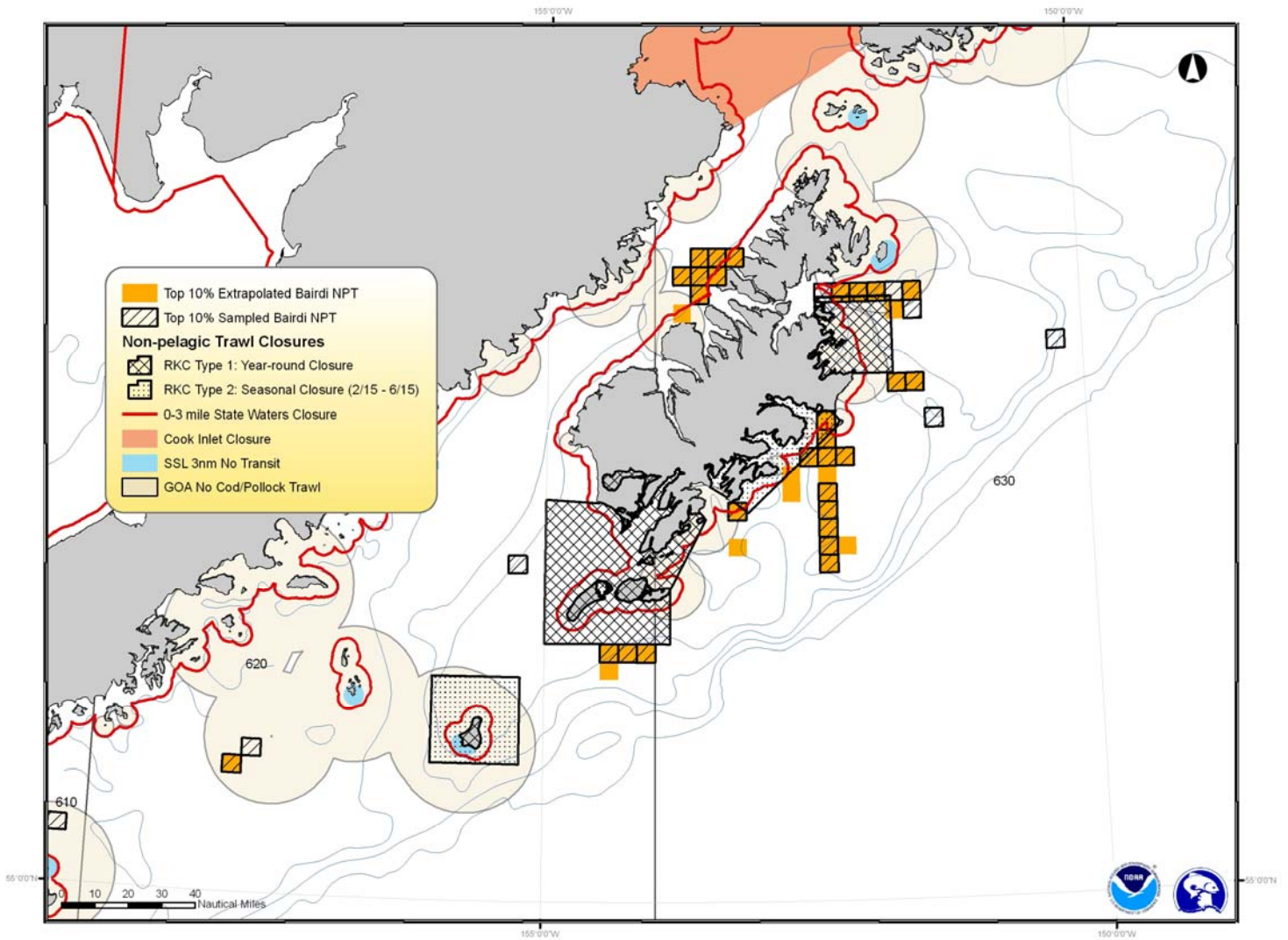


Figure 31 *C. bairdi* crab strawman closures for non-pelagic trawl gear, based on high bycatch rate (number of crab per metric ton of groundfish, averaged for 2003-2007)

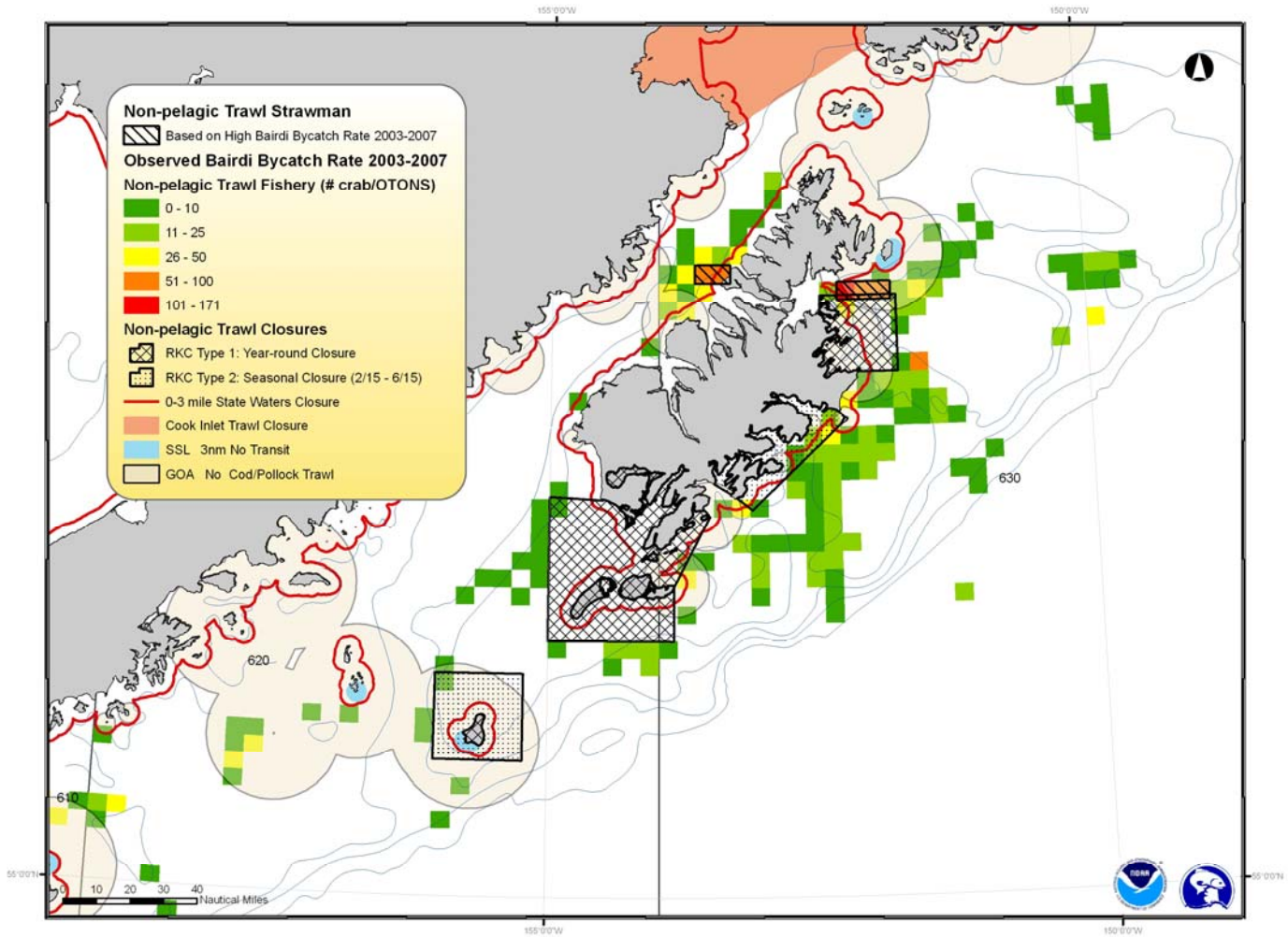




Figure 32 Comparison of *C. bairdi* crab strawman closures for non-pelagic trawl gear, high incidence of bycatch versus high bycatch rate

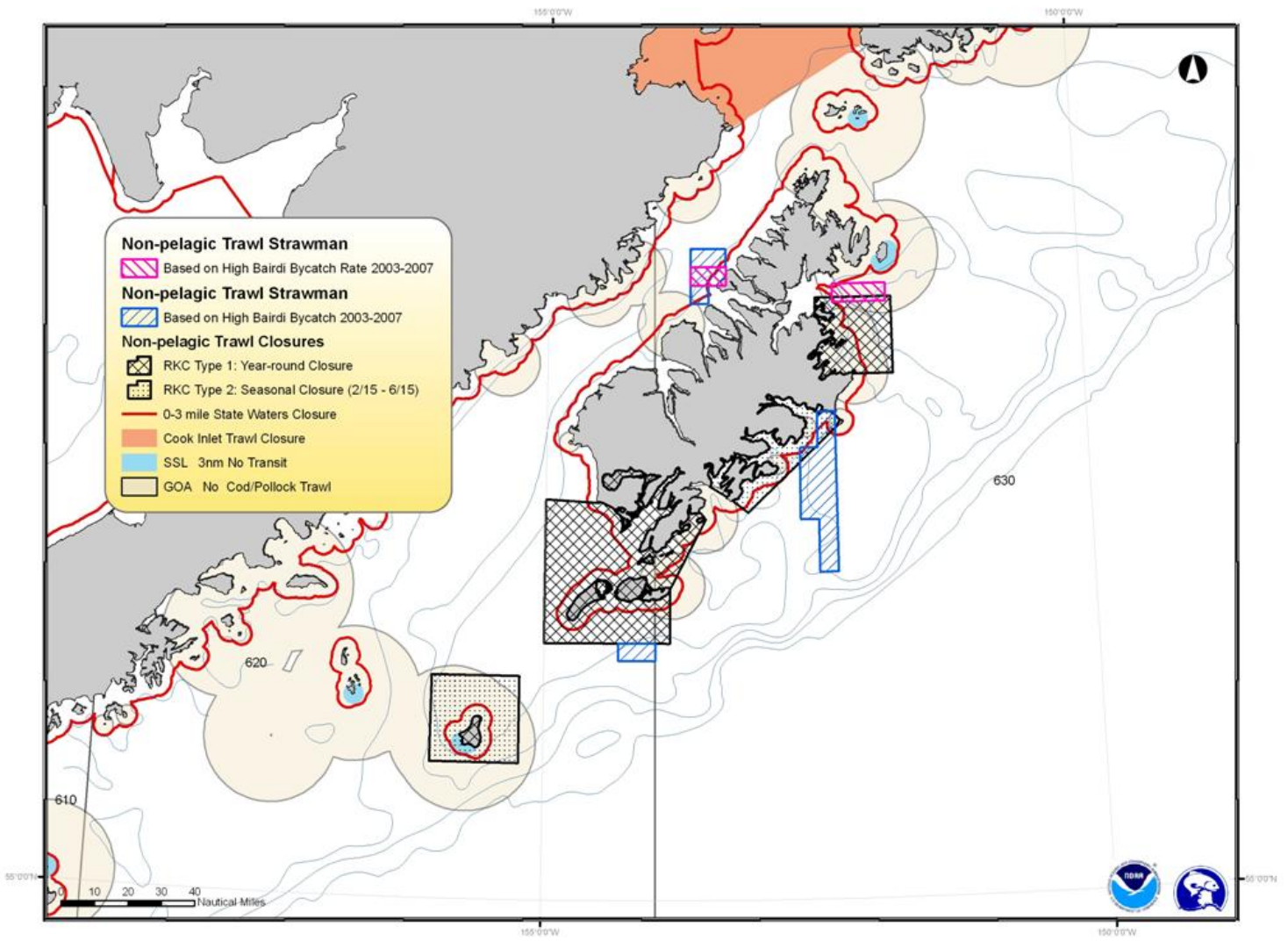


Figure 33 *C. bairdi* crab strawman closures for pot gear, based on high incidence of bycatch

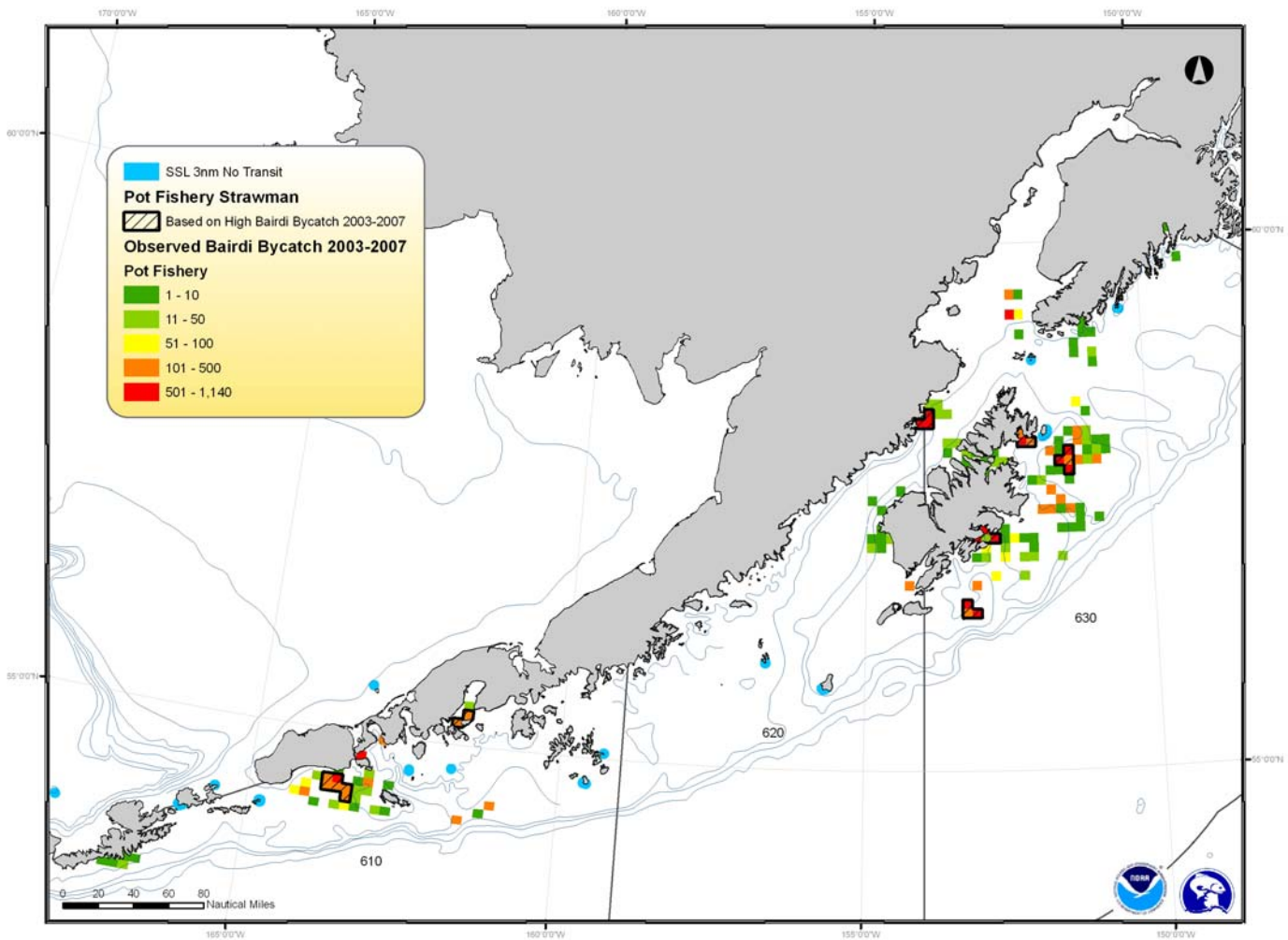


Figure 34 *C. bairdi* crab strawman closures for pot gear, based on top 10% incidence of crab bycatch, both in observer samples and extrapolated to observed hauls

