MEMORANDUM

TO: Council, SSC and AP Members

FROM: Clarence G. Pautzke
Executive Director

DATE: January 3, 1995

ESTIMATED TIME
3 HOURS

SUBJECT: Crab Bycatch Issues

NOTE: The Council and Board of Fisheries will address this same agenda item under Tab III Crab Bycatch Issues.

ACTION REQUIRED

Review overall bycatch issues and consider next steps.

BACKGROUND

Management of crab bycatch in the groundfish fisheries has been based on time/area closures, bycatch management areas, allowable bycatch rates, and bycatch limits. Given the relatively poor status of many crab stocks, crab industry representatives have expressed conservation concerns about possible negative impacts of crab bycatch. At the December meeting, the State representative to the Council indicated that in January, the State would propose alternatives for comprehensive management of crab bycatch in the groundfish fisheries. This section reviews recent action to protect crab stocks and provides an overview of crab bycatch in the groundfish, crab, and scallop fisheries. It should assist the Council and Board to determine whether or not to change the current bycatch management regime.

Bristol Bay red king crab emergency rule trawl closure

In November 1994, the Council reviewed an analysis of red king crab bycatch in the Bering Sea and alternative areas for trawl closures to protect the crab stock. Survey data showed that although a majority of red king crab are found in Area 512, areas to the west also have concentrations of red king crab. Bycatch data from trawl fisheries showed a similar distribution. To protect these crab, the Council recommended an emergency rule to close all trawling from 162° to 164°W longitude, 55°45' to 57°N latitude, shown in the attached Figure 1. Also, the Council recommended 100% observer coverage with daily catch reporting on all trawlers fishing in Areas 511 and 516. It appears that NMFS will be going forward with the emergency rule with several modifications, which includes moving the southern boundary northward to 56°N latitude, requiring observers on trawl vessels targeting flatfish in Zone 1 outside the closed area, and allowing pelagic trawling for pollock within the closed area but with 100% observer coverage.

Pribilof blue king crab trawl closure

In April 1994, the Council adopted a trawl closure area around the Pribilof Islands to protect blue king crab populations. That area is shown in Figure 2. The Secretary of Commerce approved it December 30, and the closure will be implemented in mid-February.

Bycatch caps for red king and C. bairdi Tanner crab

Prohibited species catch limits (PSC) for king and Tanner crab taken in Bering Sea groundfish fisheries were established in 1987 by Amendment 10, and further modified in 1989 by Amendment 12a, and in 1991 by Amendment 16. Current limits for trawl fisheries are 200,000 red king crab in Zone 1 (Areas 511, 512, and 516), one million C. bairdi Tanner crab in Zone 1, and 3 million C. bairdi in Zone 2 (Areas 513, 517, and 521). These caps are apportioned among various trawl fisheries during the annual specification process. Bycatches for 1992-1994 (through 12/10) are shown below:

Year	red king	ZONE 1 bairdi	ZONE 2 bairdi
1992	110,520	853,269	2,326,578
1993	181,769	1,036,289	2,181,420
1994	244,634	752,886	1,692,628

At the December 1994 meeting, the Advisory Panel made several recommendations regarding crab bycatch. The following is excerpted from their minutes:

> *"The AP believes that the red king crab and bairdi crab bycatch caps are too high and a plan amendment to reduce those caps should be prepared immediately. Motion passes 14/4. The AP believes that the Council should take steps to establish mortality rates for king crab and Tanner crab bycatch in all trawl fisheries. Motion passes 18/0 (21 present)."*

Snow crab bycatch in trawl fisheries

In June 1994, the Council requested staff to provide additional information on snow crab (opilio) bycatch in the groundfish fisheries to determine whether or not a comprehensive analysis of PSC caps or other program is warranted. A summary of the information is provided in Attachment 1. Bycatch of snow crab in BSAI groundfish fisheries totalled 10.5 million crab in 1991, 14.5 million crab in 1992, and 14.8 million crab in 1993. Results indicated that most snow crab were taken as bycatch in the yellowfin sole and rock sole/other flatfish trawl fisheries in Area 513 and 514, and bycatch consisted primarily of small crab (1.6-3.1"), amounting to 0.1 to 0.2 percent of the opilio stock.

Crab bycatch in directed crab fisheries

Crabs are also taken as bycatch in directed crab fisheries. Mortality of crabs taken as bycatch is assumed to be nil, and no bycatch limits have been set. ADF&G has tabulated the number of crabs taken as bycatch in Bering Sea crab fisheries from observer data (Attachment 2). Bycatch, by major crab fishery, is summarized in the following tables:

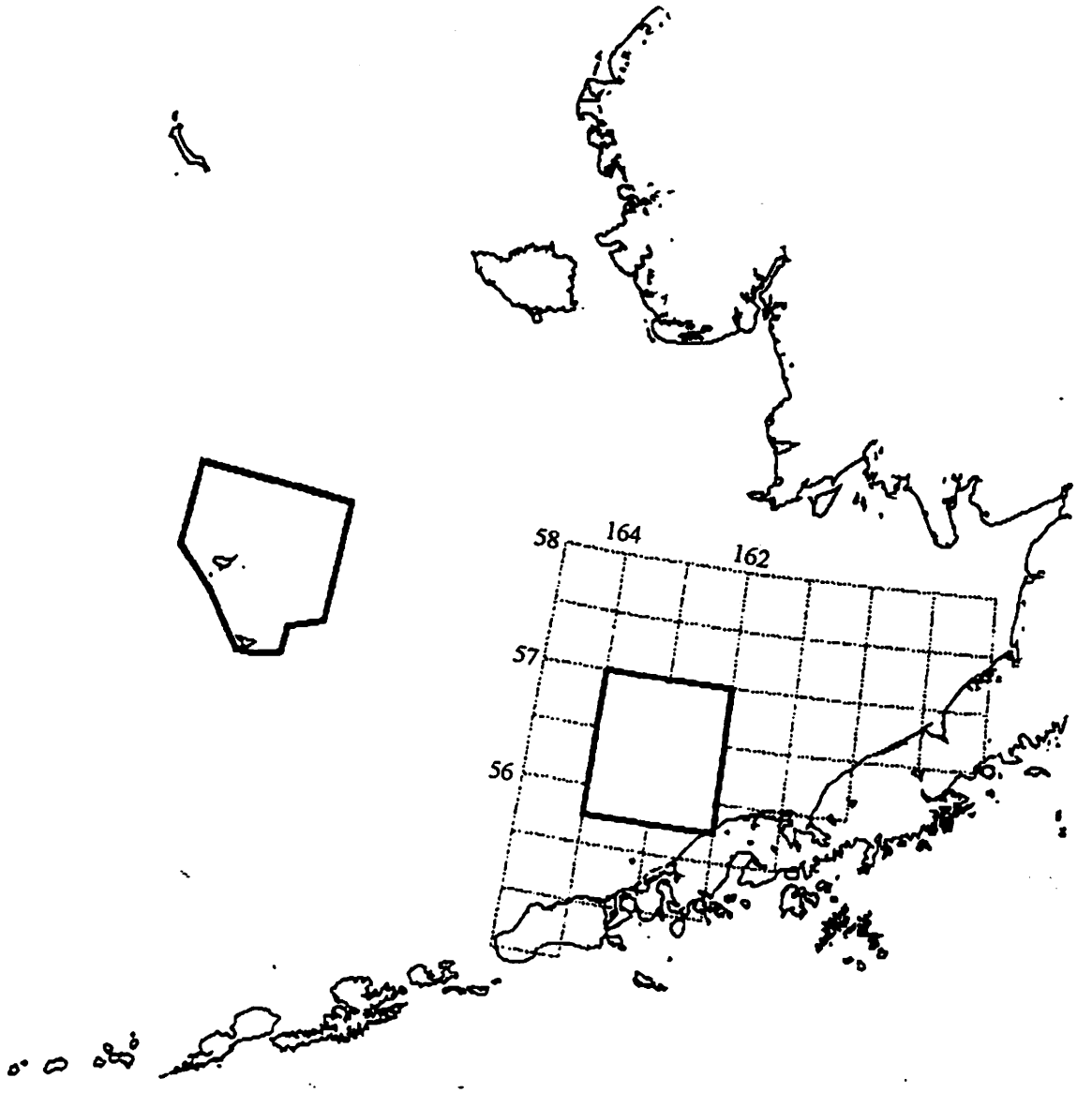
Fishery	Year	red king	blue king	bairdi	opilio
red king crab	1992	4,714,194	not reported	1,543,952	20,586
bairdi crab	1992	1,477,695	81,650	25,958,176	2,758,365
opilio crab	1992	33,731	32,677	14,740,655	6,024,441
TOTAL	1992	6,225,620	114,327	42,242,783	8,803,392

Fishery	Year	red king	blue king	bairdi	opilio
red king crab	1993	5,502,508	not reported	3,968,374	20,012
bairdi crab	1993	233,272	90,047	18,150,624	1,485,835
opilio crab	1993	24,466	34,591	6,710,425	4,635,880
TOTAL	1993	5,760,246	124,638	28,829,423	6,141,727

Crab bycatch in scallop fisheries

The Bering Sea scallop fishery catches crabs as bycatch, and bycatch limits are proposed as a Category 1 measure under the recently adopted federal FMP. Beginning in 1993, the State set bycatch limits for crab in all areas, and instituted an observer program to monitor this fishery. Bycatch limits for the Bering Sea were set at 17,000 king crab and 260,000 Tanner crab (all species of Chionoecetes). All scallop fisheries outside Cook Inlet have 100% observer coverage. Staff from ADF&G will provide a report on crab bycatch in this fishery.

Figure 1. Area in the Eastern Bering Sea recommended by the Council to be closed to all trawling for the first part of 1995 by Emergency Rule. The Pribilof Island trawl closure area, adopted by the Council in April, is also shown.



Pribilof Islands Trawl Closure

The Council reviewed alternatives to curtail trawl activities around the Pribilof Islands to protect blue king crab and Korean hair crab stocks so they may rebuild to and be maintained at exploitable levels. The Council adopted the closed area in Alternative 8 (Figure 2), which provides the most benefit to crab populations and habitat, while least affecting trawl fisheries. All trawling in this area will be banned year-round starting in 1995.

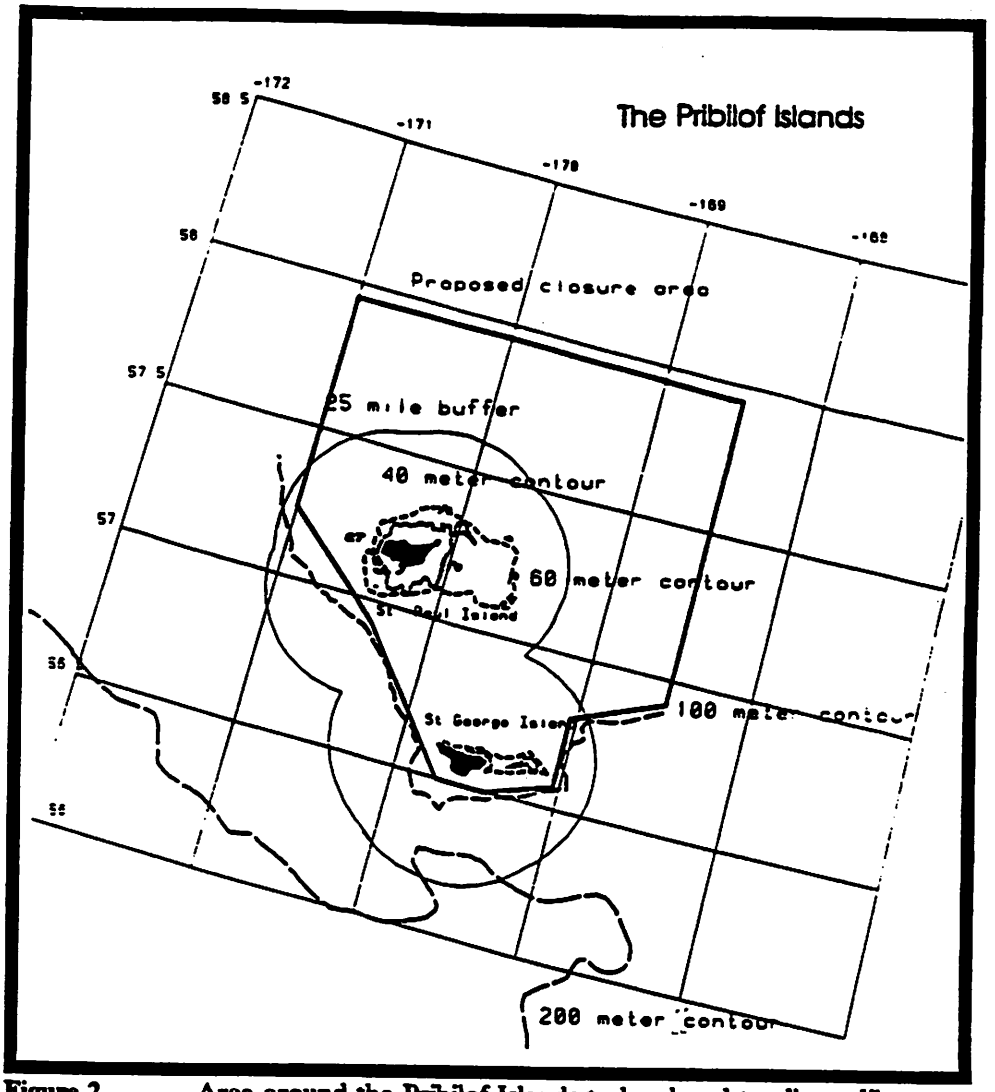


Figure 2. Area around the Pribilof Islands to be closed to all trawliing.

Pribilof Islands Habitat Conservation Area: Trawling is prohibited at all times in the EEZ within the area bounded by a straight line connecting the following pairs of coordinates in the following order:

(57° 57.0', 168° 30.0')
(56° 55.2', 168° 30.0')
(56° 48.0', 169° 2.4')
(56° 34.2', 169° 2.4')
(56° 30.0', 169° 25.2')
(56° 30.0', 169° 44.1')
(56° 55.8', 170° 21.6')
(57° 13.8', 171° 0.0')
(57° 57.0', 171° 0.0')
(57° 57.0', 168° 30.0')

Discussion Paper:
Snow Crab (C. opilio) Bycatch in the Groundfish Trawl Fisheries

Prepared by NMFS and Council Staff

In June, the Council reviewed information on Chionoecetes opilio (snow crab) bycatch in the BSAI groundfish fisheries. NMFS data showed that a total of 14,476,797 snow crabs were caught as bycatch in the 1992 BSAI trawl fisheries (**Table 1**). The data also showed that bycatch in the groundfish fisheries is concentrated in regulatory areas 513 and 514 (**Table 2**), which are shown in **Figure 1**. No size information on these crabs was provided, however, making it difficult to estimate the impacts of bycatch on the directed snow crab fishery.

The Council requested staff to provide additional information on snow crab bycatch for the September meeting. Specifically, the Council requested information on the following: historical bycatch by fishery, breeding habitat, bycatch mortality, percentage of total biomass, percentage of TAC, information on age composition and adult equivalents, bycatch avoidance potential like the Sea State Program, and observer methodology and identification. This discussion paper was written to summarize available information, which should assist the Council with determining whether or not a comprehensive analysis of PSC caps or other program is warranted.

Snow Crab Biology

Snow crabs are distributed on the continental shelf of the Bering Sea, Chukchi Sea, and in the western Atlantic Ocean as far south as Maine. In the Bering Sea, snow crabs are rare at depths greater than 200 meters. The eastern Bering Sea (EBS) population within U.S. waters is managed as a single stock, however, the distribution of the population extends into Russian waters to an unknown degree.

Growth patterns of snow crab in the EBS are extremely complex and not well understood. While 50% of the females are mature at 50 mm, the mean size of mature females varies from year to year over a range of 63 mm to 72 mm carapace width (CW). Breeding habitat can be inferred from the distribution of female snow crab larger than 50 mm CW (**Figure 2**). Females cease growing with a terminal molt upon reaching maturity, and rarely exceed 80 mm CW. Males similarly cease growing upon reaching a terminal molt when they acquire the large claw characteristic of maturity. The median size of maturity for males is 65 mm CW (approximately 4 years old). Males larger than 60 mm grow at about 20 mm per molt, but individuals vary widely in this regard.

Only adult males are harvested. Average sizes of crab taken in the EBS fishery ranged from 105 mm to 118 mm (0.5 kg to 0.63 kg) for the years 1977 to 1994. Only 1% of snow crabs in the fishery exceed 140 mm. The legal size limit is 78 mm and is thought to allow at least one opportunity to breed based upon a median size of maturity of 65 mm CW. Small males are not marketable and processors generally do not purchase crabs smaller than 102 mm CW (4.0 inches).

Female snow crabs are able to store spermatophores in seminal vesicles and fertilize subsequent egg clutches without mating. At least two clutches can be fertilized from stored spermatophores, but the frequency of this occurring in nature is not known. Presumably this reproductive strategy evolved to maintain reproductive potential of populations at times when distributional factors prevent females from finding mates. Because of this reproductive strategy, fishery managers may not need to be as concerned with sex ratios of adult snow crab as they are with respect to king crab.

Snow crab feed on an extensive variety of benthic organisms including bivalves, brittle stars, crustaceans (including other snow crabs), polychaeta and other worms, gastropods, and fish. In turn they are

consumed by a wide variety of predators including Pacific cod, halibut and other flatfish, eel pouts, sculpins, and skates. In the northern part of their range, they are preyed upon by bearded seals and sometimes make up all of the seal's stomach contents.

Snow Crab Abundance and Landings

Abundance of snow crab increased dramatically from 1983 to 1991 (**Table 3**), but has since declined. The 1993 NMFS Bering Sea trawl survey indicated the total abundance of large males (over 4 inches) at 135 million crab, a 48% decrease from 1992 (**Table 4**). Small (3-4") legal-size males also declined in abundance, consistent with the decline in large males observed since 1991. A continued westward shift of the population was also observed, with the highest sampling densities north and west of the Pribilof Islands. Abundance of small female crab increased 66% in 1993 and sublegal (<3.1") male crab showed a 92% increase in abundance. Recruitment of these small crab should result in increased snow crab landings in 1995 or 1996 (Stevens et al. 1993, Morrison and Gish 1994).

Landings from the directed snow crab fishery increased steadily from 11,852 tons in 1983 to 73,402 tons in 1990, then jumped to 149,073 in 1991. Landings have since declined, with 1992 landings of 143,020 tons (227.4 million crab), 104,700 tons in 1993, and only 67,938 tons (114.8 million crab) in 1994. Participation in the fishery, as measured by numbers of vessels, has increased steadily since the mid-1980's, with 254 vessels participating in 1993 and a record high 273 vessels in 1994. Combined with a declining exploitable biomass, seasons are becoming shorter in duration. The 1993 fishery lasted only two months from January 15 - March 15. A summary of 1993 regulations is shown in **Figure 3.**

Bycatch of Snow Crab in the Groundfish Trawl Fisheries

Crab bycatch is estimated by the National Marine Fisheries Service through the Observer Program. Bycatch data for crab are available for the 1991, 1992, and 1993 groundfish trawl fisheries in the BSAI and GOA trawl fisheries by target fishery and regulatory areas (**Table 5**), which are shown in **Figure 1.** The observer database categorizes crab bycatch into king crab, Tanner crab (C. bairdi), and "other" crab categories. In the Bering Sea, the "other crab" is comprised almost entirely of snow crab, whereas in the GOA, "other" crab consists mostly of C. tanneri and C. angulatus, with the bycatch of snow crab virtually nil. Bycatch of "other" crab in the GOA trawl fisheries is relatively low for the years examined (less than 30,000 crabs per year), so this analysis focuses primarily on BSAI fisheries. Bycatch of snow crab in BSAI groundfish fisheries totalled 10.5 million crabs in 1991, 14.5 million crabs in 1992, and 14.8 million crabs in 1993. Data show that the yellowfin sole fisheries in 513 and 514 consistently have the highest bycatch in numbers of snow crab, followed by the rock sole/other flatfish target fishery in the same areas. Together, these fisheries accounted for 5,629,807 crabs (54%) of the BSAI snow crab bycatch in 1991, 12,779,142 (88%) in 1992, and 13,726,499 (87%) in 1993. Much of the 1991 remainder was taken by pollock fisheries in statistical area 521.

Length frequencies of crab taken as bycatch, provided by the NMFS Observer Program, indicate that size of snow crab bycatch depends on year, target fishery, and regulatory area. Data summarizing snow crab bycatch length frequency for 1991, 1992, and 1993 trawl fisheries in regulatory areas 511, 513, 514, 517, 521, and 522 was provided, and are shown in **Figures 4-9.** As previously stated, the highest bycatch in numbers occurs in the yellowfin sole and other flatfish fisheries in areas 513 and 514. The size of snow crab taken is generally small, with most crab about 40-80 mm (1.6"-3.1") in carapace width. In 1991, opilio taken as bycatch were generally larger (to 140 mm) in these two areas. In the other regulatory areas (511, 517, 521, and 522), fewer crab were taken as bycatch in all years, but all sizes of crab were represented. Marketable size crab (>102 mm) were taken in bottom pollock, rock sole, and other flatfish fisheries in other areas in 1991 and 1992.

Conversion of length data to age data for purposes of estimating snow crab bycatch as a percentage of total biomass and snow crab GHL would require additional analysis. However, for reference, respective abundance estimates for 1991, 1992, and 1993 were 11.3 billion, 7.8 billion, and 11.7 billion snow crabs of all sizes in the Bering Sea (Stevens et al. 1993). Corresponding BSAI snow crab bycatches were 10.5 million, 14.5 million and 14.8 million crabs, or 0.09%, 0.19%, and 0.13% of the total crab available in those years.

Discard Mortality

Few studies have estimated mortality of crabs taken as bycatch and discarded. One hundred percent mortality is assumed for Tanner crab and king crab bycatch in groundfish fisheries. For Tanner crab taken as bycatch in the weathervane scallop fishery, Urban et al. (1994) recorded that 13-35% were dead or moribund before being discarded, with the highest mortality rate occurring on small (< 40 mm cw) and large (>120 mm cw) crabs. Delayed mortality resulting from injury or stress was not estimated. In the directed crab pot fishery, handling mortality of trap-captured crabs has been assumed to be negligible (Schmidt and Pengilly 1993).

In a study of crab taken from research trawls, Hays (1973) tested snow crab for discard mortality. Large males (> 110 mm CW) were held on deck in air (5 to 10 degrees C.) to simulate handling in Japanese commercial fisheries. The results were as follows:

Storage time (hrs):	0	6	12	24	48
No. alive/No. held:	8/10	10/10	7/10	3/10	0/10

Stevens (1990) studied the survival of red king crab and Tanner crab in sole fisheries and found that overall survival (including delayed mortality) was 21 to 22% for crab that were taken in an August joint-venture fishery and delivered to a processing vessel. Delayed mortality of both species increased with total time in captivity. Mortality of king crab increased with size of trawl catches, but mortality of Tanner crab was not affected. However, mortalities would be expected to be much higher during the molting period and immediately after it, when crab are soft. Data collected by Stevens (1990) were done on hardshelled crab, and may not be representative of other times of the year. Unlike king and Tanner crab, EBS snow crab molt in the summer (June and early July) and molting occurs somewhat later in more northerly areas. Higher discard mortality rates for snow crab may thus be expected in the summer months.

Bycatch Avoidance Program

A bycatch avoidance program for snow crab, like the Sea State Program for salmon, may not be a viable alternative at this time. A potential problem is that observers are already fully utilized. In addition to collecting, compiling, and analyzing biological information, the Sea State program has burdened the observer program with additional duties. A program for snow crab may be more complicated than salmon (i.e., more data to collect, enter, and analyze), and may result in re-prioritizing observer duties away from collecting biological data (e.g. length frequency information) from the fisheries (J. Berger, NMFS, personal communication).

PSC Caps

Establishing a prohibited species (PSC) cap could be considered as an alternative to restrict the amount of snow crab taken as bycatch in the groundfish fisheries. Current regulations for the BSAI and GOA groundfish fisheries provide a number of regimes to manage the incidental take of PSC, or bycatch of Pacific halibut, Pacific herring, Pacific salmon, Steelhead trout, and King and Tanner crab. One example

of bycatch management would be time and area closures triggered by attainment of an established PSC limit. PSC limits can be in the form of a percentage of biomass, such as herring in the BSAI, an established number, as with king and Tanner crab in the BSAI, or an estimated mortality rate, as with halibut in both the BSAI and GOA.

Fisheries are closed when PSC caps are reached. For example, the 1994 rock sole/other flatfish trawl fishery was closed on February 25 in Zone 1 (Areas 511, 512, 516) due to attainment of the red king crab PSC cap; Zone 2 (Areas 513, 517, and 521) was closed to this fishery on May 7 due to attainment of the Tanner crab PSC cap. Costs associated with establishing PSC caps would depend on how high the caps are set relative to crab biomass; low caps could have substantial impacts on groundfish fisheries.

Bycatch from trawl fisheries accounts for a very small portion of the total BSAI snow crab abundance, in the order of 0.1 to 0.2% yearly. Proportionally, this bycatch is less than for other crab species with PSC caps. In 1993, bycatch of PSC crab in trawl fisheries totalled 183,713 red king crab and 3,374,031 Tanner crab. Existing PSC crab caps for the BSAI trawl fisheries total 200,000 red king crab and 4,000,000 Tanner crab. Corresponding 1993 abundance was 38.8 million Bristol Bay red king crab and 254.9 million EBS Tanner crab of all sizes (Stevens et al. 1993). Hence, the caps represented 0.5% and 1.6% of the total number of BSAI king and Tanner crab, and the overall BSAI bycatch represented 0.5% and 1.3% of red king crab and Tanner crab, respectively.

Other Bycatch Restrictions

There are other methods to restrict the amount of bycatch taken. One program that has been established is the vessel incentive program (VIP) for the BSAI and GOA trawl fisheries. Enforcement of the VIP standards has proven difficult, and may not hold much potential for reducing snow crab bycatch. Another method that has been used to reduce bycatch has been to adjust seasonal starting dates for some groundfish fisheries in order that the fisheries are conducted during a time of relatively lower bycatch rates. Time/area closures may have some potential to reduce snow crab bycatch. The Council recently established hotspot time/area closures for chum salmon, and a permanent area closure to trawl gear to protect blue king crab around the Pribilof Islands. Although the highest snow crab bycatch occurs in statistical areas 513 and 514, additional analysis may identify more discrete areas of high bycatch (hotspots).

Literature Cited

Hays, M.L. 1973. Survival of Tanner crabs (Chionoectes bairdi) after capture in trawls and subsequent handling and storage aboard fishing boats. International North Pacific Fisheries Commission. 9p.

Morrison, R. and R.K. Gish. 1994. Annual Management Report for the Shellfish Fisheries of the Bering Sea Area, 1993. Alaska Department of Fish and Game Regional Information Report No. 4K94-29. July 1994.

Schmidt, D.C. and D. Pengilly. 1993. Review of harvest strategies used in the management of lithoid crab in Alaska. In: Kruse, Eggers, Marasco, Pautzke, and Quinn (Editors). Proceedings of the International Symposium on Management Strategies for Exploited Fish Populations, Alaska Sea Grant College Program, AK-SG-93-02:385-407.

Stevens, B.G. 1990. Survival of king and Tanner crabs captured by commercial sole trawls. Fishery Bulletin 88:731-744.

Stevens, B.G. R.A. MacIntosh, J.A. Haaga, and J.H. Bowerman. 1993. Report to the Industry on the 1993 Eastern bering Sea Crab Survey. NMFS-AFSC 93-14.

Urban, D, D. Pengilly, and I. Vining. 1994. The scallop observer program and statewide data analysis summary to the Board of Fisheries. Alaska Department of Fish and Game, Kodiak. 54 p.

Table 1. 1993 Bycatches (numbers of animals) of Opilio Tanner Crab occurring in trawl fisheries for groundfish in the Bering Sea/Aleutian Islands and Gulf of Alaska Management Areas.

BERING SEA/ALEUTIAN ISLANDS	
Target Fisheries	Number
Pollock	727,177
Pacific cod	165,638
Rock Sole/Other flatfish	4,257,881
Yellowfin sole	9,326,101
Total	14,476,797

GULF OF ALASKA	
Rockfish	2,591
Deep water flatfish	454
Shallow water flatfish	2,571
Sablefish	78
Total	5,694

Table 2. 1993 Bycatches (numbers of animals) of Opilio Tanner Crab occurring in the rocksole/"other flatfish" and yellowfin sole target fishery categories by reporting area in the Bering Sea/Aleutian Islands management area.

Target Fisheries	Reporting Area	Number
Rock Sole/Other flatfish	508	0
	509	2731
	513	2,752,190
	514	1,116,592
	516	1,449
	517	16,038
	519	0
	521	110,515
	523	0
	524	258,367
	540	0
	Total	4,257,882
Yellowfin Sole	508	0
	509	8,468
	513	5,167,494
	514	3,797,439
	516	0
	521	0
	524	352,700
	Total	9,326,101

Table 3. Bering Sea opilio crab fishery data 1980-1993 (source: Morrison and Gish 1994).

Year	GHL[a]	Season Total[a]	Number of Vessels	Number of Landings	Number of Pots Registered[b]	Number of Pots Pulled	Value Exvessel	Value Total[c]	Season Length[d]
1979/80	N/A	39.3	134	597	35,503	255,022	$ 0.21	$ 83.0	307
1981	39.5-91.0	50.5	153	867	39,789	435,742	$ 0.26	$ 13.1	229
1982	16.0-22.0	28.3	112	803	35,522	469,091	$ 0.73	$ 20.7	167
1983	15.8	24.8	109	462	15,39	287,127	$ 0.35	$ 8.7	120
1984[e]	49.0	26.0	52	367	12,493	173,591	$ 0.30	$ 7.8	320
1985[e]	98.0	64.9	75	718	15,325	372,045	$ 0.30	$ 19.5	333
1986[e]	57.0	96.6	88	992	13,750	543,744	$ 0.60	$ 60.0	252
1987	56.4	100.9	103	1,038	19,386	616,113	$ 0.75	$ 75.7	158
1988	110.7	130.8	171	1,285	38,765	766,907	$ 0.77	$100.7	120
1989	132.0	147.6	168	1,341	43,607	663,442	$ 0.75	$110.7	112
1990	139.8	161.8	189	1,565	46,440	911,613	$ 0.64	$102.3	148
1991	315.0	325.2	228	2,788	76,056	1,391,583	$ 0.50	$162.6	159
1992	333.0	313.0	250	2,763	77,858[f]	1,281,796	$ 0.50	$156.5	97
1993	207.2	230.8	254	1,836	65,081	971,046	$ 0.75	$171.9	59

[a]Millions of pounds.
[b]Same gear as *C. bairdi* fishery.
[c]Millions of dollars.
[d]In days.
[e]Partial closures only.
[f]Gear of *C. opilio* vessels only.

Table 4. Abundance estimates (millions of crabs) for eastern Bering Sea opilio crabs from NMFS trawl surveys, all districts combined (source: Stevens et al. 1993).

	Males				Females			
		Large	V. Large		Small	Large		Grand
Size[1] (mm) Width (in)	<102 <4.0	≥102 ≥4.0	≥110 ≥4.3	Total	<50 <2.0	≥50 ≥2.0	Total	Total
1982	*	*	22	2073	403	2256	2658	4732
1983	*	*	22	1858	673	1228	1913	3760
1984	1237	153	74	1391	610	582	1192	2583
1985	548	75	41	623	258	123	382	1004
1986	1179	83	46	1262	791	422	1212	2474
1987	4439	151	70	4590	2919	2929	5849	10438
1988	3467	171	90	3638	1235	2323	3556	7194
1989	3646	187	81	3833	1923	3791	5713	9546
1990	2860	420	189	3281	1463	2798	4261	7542
1991	3971	484	323	4455	3289	3575	6864	11319
1992	3158	256	165	3414	2434	1914	4348	7763
1993	5597	135	78	5732	3990	1983	5972	11704
East (%)[2]	54	47	52	54	48	48	48	51
Limits[3]								
Lower	3391	104	60	3526	2523	1308	4021	7547
Upper	7802	166	96	7937	5457	2657	7924	15860
± %	39	23	23	38	37	34	33	35

[1] Carapace width (mm).
[2] Proportion of size group in Eastern District.
[3] Mean ± 2 standard errors for most recent year.
* Estimates not available at present time.

Table 5. Bycatch of opilio crab (in numbers) in groundfish fisheries of the Bering Sea/Aleutian Islands and the Gulf of Alaska, 1991-1993, by target fishery and zone.

BYCATCH OF OPILIO TANNER CRAB BY TARGET FISHERY AND ZONE

YEAR	BERING SEA AND ALEUTIAN ISLANDS TARGET FISHERIES	ZONE	NUMBER
1993	ATKA MACKEREL	540	10
			10
	POLLOCK BOTTOM	509	3,651
		513	38,047
		514	92,636
		517	143,176
		519	3,836
		521	210,906
		523	8,188
		524	22,076
			522,517
	PACIFIC COD	509	5,005
		512	45
		513	6,332
		514	96,282
		517	6,243
		518	120
		519	1,889
		521	129,767
		523	4,102
		524	41,455
		540	685
			291,924
	ROCKFISH	509	54
		519	6
		521	412
		523	4
		540	2
		541	1
			479
	OTHER SPECIES	521	666
			666
	POLLOCK	508	36

YEAR	GULF OF ALASKA TARGET FISHERIES	ZONE	NUMBER
	PACIFIC COD	610	511
		620	2,082
		630	866
		640	88
		649	132
		650	1
		659	8
			3,687
	DEEP WATER FLATFISH	610	177
		620	2,062
		630	178
			2,418
	SHALLOW WATER FLATFISH	620	75
		630	2,439
			2,514
	ROCKFISH	610	2,075
		620	304
		630	133
		640	83
			2,595
	OTHER SPECIES	610	4
		620	65
		630	9
			79
	SABLEFISH	610	8,749
		620	1,919
		630	479
		640	895
		649	205
		650	2,525
		659	2,510
			17,282

Table 5 (continued). Bycatch of opilio crab (in numbers) in groundfish fisheries of the Bering Sea/Aleutian Islands and the Gulf of Alaska, 1991-1993, by target fishery and zone.

MIDWATER	509	4,936
	513	30,088
	516	42
	517	22,748
	518	9
	519	73
	521	156,912
	523	898
	540	1
		215,743
ROCK SOLE/ OTHER FLATFISH	508	18
	509	2,728
	513	2,752,187
	514	1,116,574
	516	1,449
	517	15,990
	521	110,473
	524	258,203
		4,257,622
SABLEFISH	517	16
	518	94
	519	36
	521	1
	540	384
	541	169
	542	28
		728
GREENLAND TURBOT	509	8
	517	645
	518	512
	519	145
	521	572
	523	201
	524	4
	540	65
		2,153
YELLOWFIN SOLE	509	22,637
	513	5,296,972
	514	3,796,975
	524	352,293
ARROWTOOTH FLOUNDER	610	13
		13

Table 5 (continued). Bycatch of opilio crab (in numbers) in groundfish fisheries of the Bering Sea/Aleutian Islands and the Gulf of Alaska, 1991-1993, by target fishery and zone.

		9,468,877			
NO RETAINED SPECIES	509	2			
		2			
1992					
POLLOCK BOTTOM	511	5,790			
	513	64,068			
	517	59,271			
	519	14,837			
	521	846,141			
	522	20,633			
		1,010,740			
PACIFIC COD	511	19,004	POLLOCK BOTTOM	610	261
	512	232		620	148
	513	27,698		630	331
	514	276			740
	515	204			
	516	27			
	517	32,634	PACIFIC COD	610	895
	518	1,731		620	180
	519	8,433		630	789
	521	166,058		640	7
	522	52,266		649	6
	540	673		659	3
		309,236			1,881
			DEEP WATER FLATFISH	620	176
ROCKFISH	518	1		630	423
	521	433			599
	522	98			
	540	225	SHALLOW WATER FLATFISH	630	20
		756			20
OTHER SPECIES	511	6			
	513	36	ROCKFISH	610	24
	519	1		620	150
	521	42		630	64
	522	99		640	113
		184		650	75
					426
POLLOCK MIDWATER	511	19,507			
	512	1,838	OTHER SPECIES	610	104

Table 5 (continued). Bycatch of opilio crab (in numbers) in groundfish fisheries of the Bering Sea/Aleutian Islands and the Gulf of Alaska, 1991-1993, by target fishery and zone.

	513	184,218		630	15
	514	140			119
	515	2,540			
	517	45,253			
	519	1,035	SABLEFISH	610	4,324
	521	3,252,204		620	463
	522	52,187		630	1,186
	540	1,079		640	984
		3,560,001		649	70
				650	718
				659	918
					8,663
ROCK SOLE/ OTHER FLATFISH	511	15,501			
	513	940,016			
	514	1,179,596			
	516	421			
	517	12,516			
	521	21,816			
	522	473			
		2,170,339			
SABLEFISH	511	2			
	517	98			
	518	134			
	519	62			
	521	207			
	522	131			
	530	5			
	540	299			
		938			
GREENLAND TURBOT	519	4			
	540	3			
		8			
ARROWTOOTH FLOUNDER	519	700			
		700			
YELLOWFIN SOLE	511	42,458			
	513	5,894,074			
	514	4,216,946			
	521	449,563			
	522	5,761			
		10,608,803			

Table 5 (continued). Bycatch of opilio crab (in numbers) in groundfish fisheries of the Bering Sea/Aleutian Islands and the Gulf of Alaska, 1991-1993, by target fishery and zone.

NO RETAINED SPECIES	511	59			
	514	786			
		845			
1991					
ATKA MACKEREL	515	22	POLLOCK BOTTOM	610	310
	517	685		620	12
	519	17		621	31
	540	123		630	643
		848		650	3
					999
POLLOCK BOTTOM	511	63,402			
	513	409,907	PACIFIC COD	610	318
	514	6		620	3
	515	45,287		621	7
	516	122		630	98
	517	106,802		640	1
	519	83,220		650	2
	521	1,986,602			428
	522	992			
		2,696,339	DEEP WATER FLATFISH	610	94
				620	2,684
PACIFIC COD	511	25,868		630	85
	513	2,016			2,863
	514	107			
	515	7,175			
	516	13	ROCKFISH	610	2,541
	517	92,352		620	311
	518	1,486		630	289
	519	2,551		640	72
	521	72,831		650	4
	522	7,334		680	4
	540	1,744			3,221
		213,476			
			POLLOCK MIDWATER	610	2
ROCKFISH	513	2			2
	517	72			
	521	795	SABLEFISH	610	531
	522	145		620	202
	540	47		621	1
		1,061		630	217
				640	262
				650	481
OTHER SPECIES	511	2		680	113

Table 5 (continued). Bycatch of opilio crab (in numbers) in groundfish fisheries of the Bering Sea/Aleutian Islands and the Gulf of Alaska, 1991-1993, by target fishery and zone.

	513	30,315	
	515	36	1,807
	517	613	
	519	279	
	521	29	
	522	903	
		32,177	
POLLOCK	511	3,001	
MIDWATER	513	66,534	
	515	12,281	
	517	31,180	
	518	2,015	
	519	15	
	521	1,544,616	
	522	24,043	
	540	2	
		1,683,686	
ROCK SOLE/	511	47,012	
OTHER FLATFISH	513	2,590,826	
	514	2,809,310	
	515	4,271	
	516	4,295	
	517	12,340	
	519	528	
	521	81,723	
	522	79,480	
	540	22	
		5,629,807	
SABLEFISH	511	1	
	515	24	
	517	6	
	518	8	
	519	1	
	521	2	
	522	1	
	540	70	
		114	
GREENLAND	515	217,253	
TURBOT	517	10,042	
	518	6,031	
	519	2,370	

Table 5 (continued). Bycatch of opilio crab (in numbers) in groundfish fisheries of the Bering Sea/Aleutian Islands and the Gulf of Alaska, 1991-1993, by target fishery and zone.

	521	220
	522	2
	540	2,174
		238,092
ARROWTOOTH	511	693
FLOUNDER	515	56
	517	2,408
	518	28
	519	170
	521	19,252
	522	4,887
	540	126
		27,620

The targets for which there is no zone information had zero bycatch

Figure 1. Regulatory areas in the Bering Sea/Aleutian Islands and Gulf of Alaska.

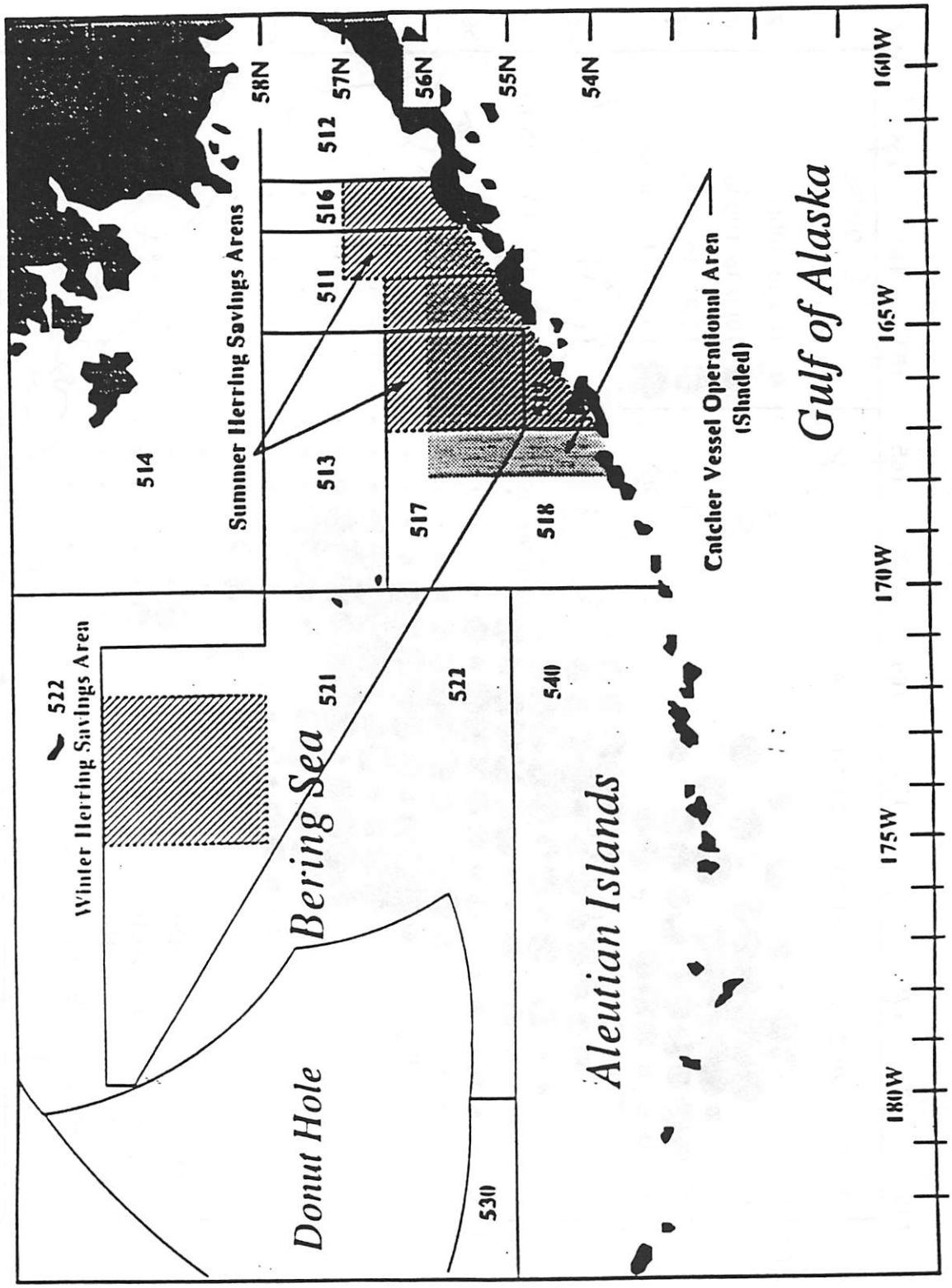


Figure 2. Distribution of female snow crab greater than 50 mm CW from the 1994 NMFS EBS crab survey.

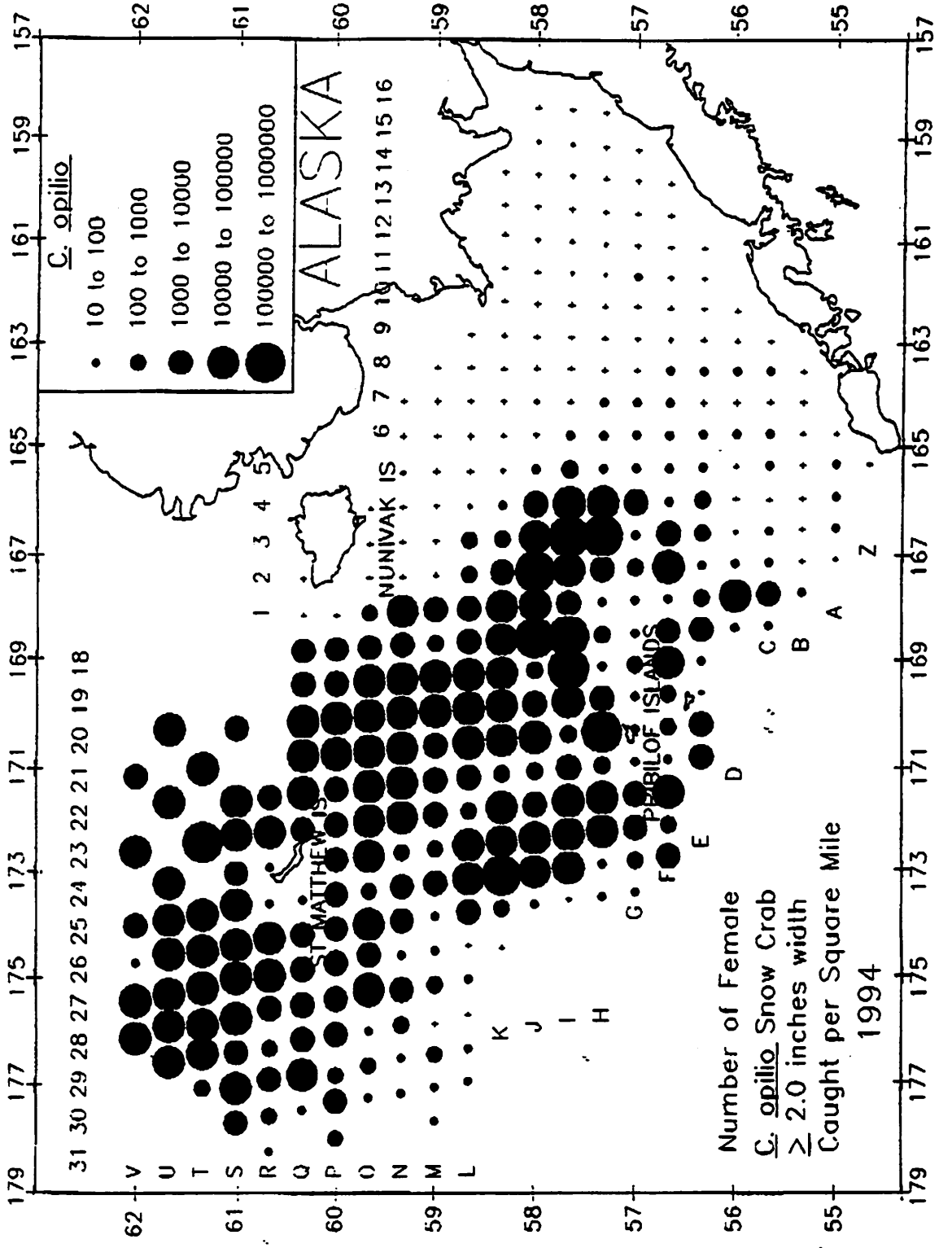
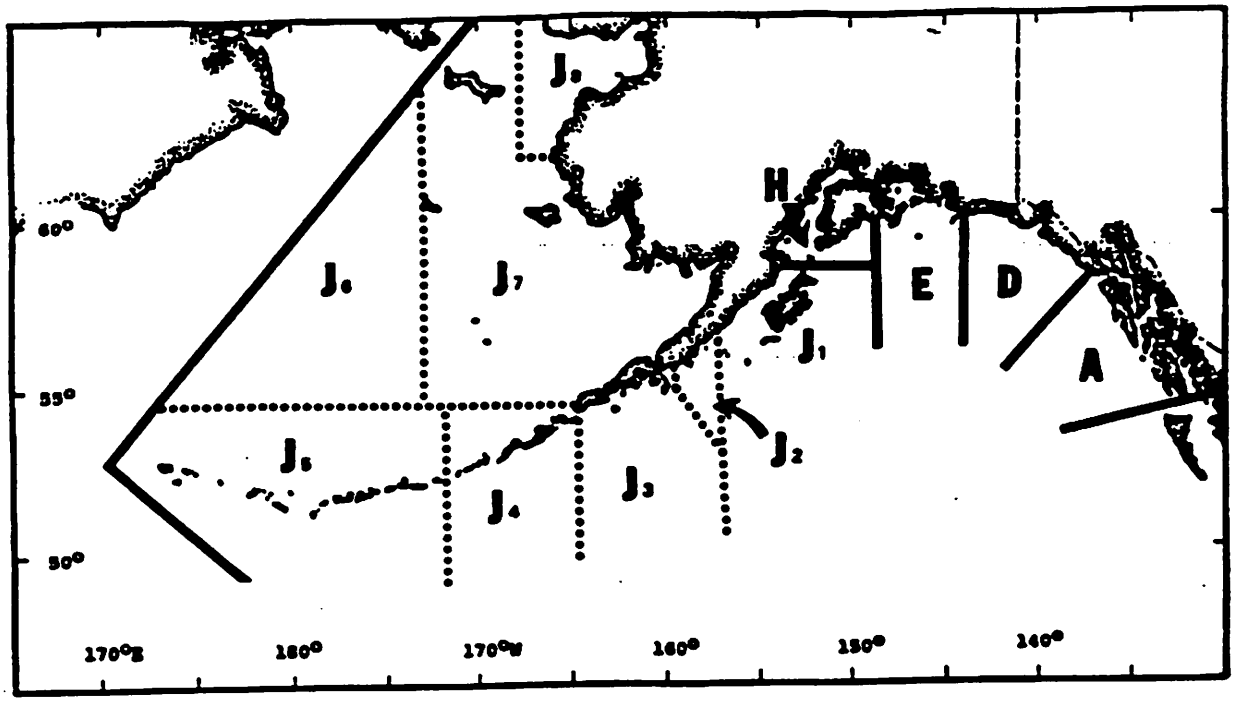


Figure 3. Summary of 1993 Tanner and snow crab regulations.



TANNER CRAB SEASON REGULATIONS SUMMARY

J8: BERING SEA DISTRICT EASTERN SUBDISTRICT NORTON SOUND SECTION
Reg: No open season

J7: BERING SEA DISTRICT EASTERN SUBDISTRICT
Reg: Nonexclusive
Pot Limit:
250, for Vessels over 125 feet
200 for Vessels 125 or less
Dates: *C. bairdi* -
East of 168° W. long., Concurrent With Area T.
Red King Crab Season and reopen again 10 days after Area T king crab season between 163° and 173° W. long.
If no Area T king crab season, open between 163° and 173° W. long. on November 1.
C. opilio - January 15
Size: *C. bairdi* - 5.5 inches
C. opilio - 3.1 inches

J6: BERING SEA DISTRICT WESTERN SUBDISTRICT
Reg: Nonexclusive
Pot Limit:
250, for Vessels over 125 feet
200 for Vessels 125 or less
Dates: *C. bairdi* - January 15
C. opilio - January 15
Size: *C. bairdi* - 5.5 inches
C. olilio - 3.1 inches

J5: WESTERN ALEUTIANS
Reg: Nonexclusive
Pot Limit: None
Dates: November 1
Size: *C. bairdi* - 5.5 inches

J4: EASTERN ALEUTIANS
Reg: Nonexclusive
Pot Limit: None
Dates: January 15
Size: *C. bairdi* - 5.5 inches

J3: SOUTH PENINSULA
Reg: Nonexclusive
Pot Limit:
40 or 75 Depending on GHL
Dates: January 15
Size: *C. bairdi* - 5.5 inches

J2: CHIGNIK
Reg: Nonexclusive
Limit:
40 or 75 Depending on GHL
Date: January 15
Size: *C. bairdi* - 5.5 inches

J1: KODIAK
Reg: Nonexclusive
Pot Limit: 75
Dates: January 15
Size: *C. bairdi* - 5.5 inches

H: COOK INLET
Reg: Superexclusive
Pot Limit: 40 or 75 depending on GHL in Southern District
Dates: January 15
Size: 5.5 inches

E: PRINCE WILLIAM SOUND
Reg: Superexclusive
Pot Limit: 100 or 175 Depending on Area
Dates: January 15
Size: 5.3 inches

D: YAKUTAT
Reg: Nonexclusive
Pot Limit: 100 in Yakutat Bay
Dates: January 15
Size: 5.5 inches

A: SOUTHEASTERN
Reg: Superexclusive
Pot Limit: 100 Pot Limit in Inside Waters
Dates: February 15
Size: 5.5 inches

KEY:
Registration ..... Reg: Opening Dates ..... Dates:
Guideline Harvest Level . GHL Minimum Legal Size .....Size:

Figure 4. Length Frequencies (carapace width, mm) of snow crab bycatch taken in 1991, 1992, and 1993 trawl fisheries in BSAI Regulatory Area 511. KEY to target fisheries: S1=bottom pollock, S2=turbot in 91 and pelagic pollock in 92 and 93, S3= arrowtooth in 91 and Pacific cod in 92 and 93, S4=rock sole, S5=yellowfin sole, S6=other flatfish, S7=other fishes.

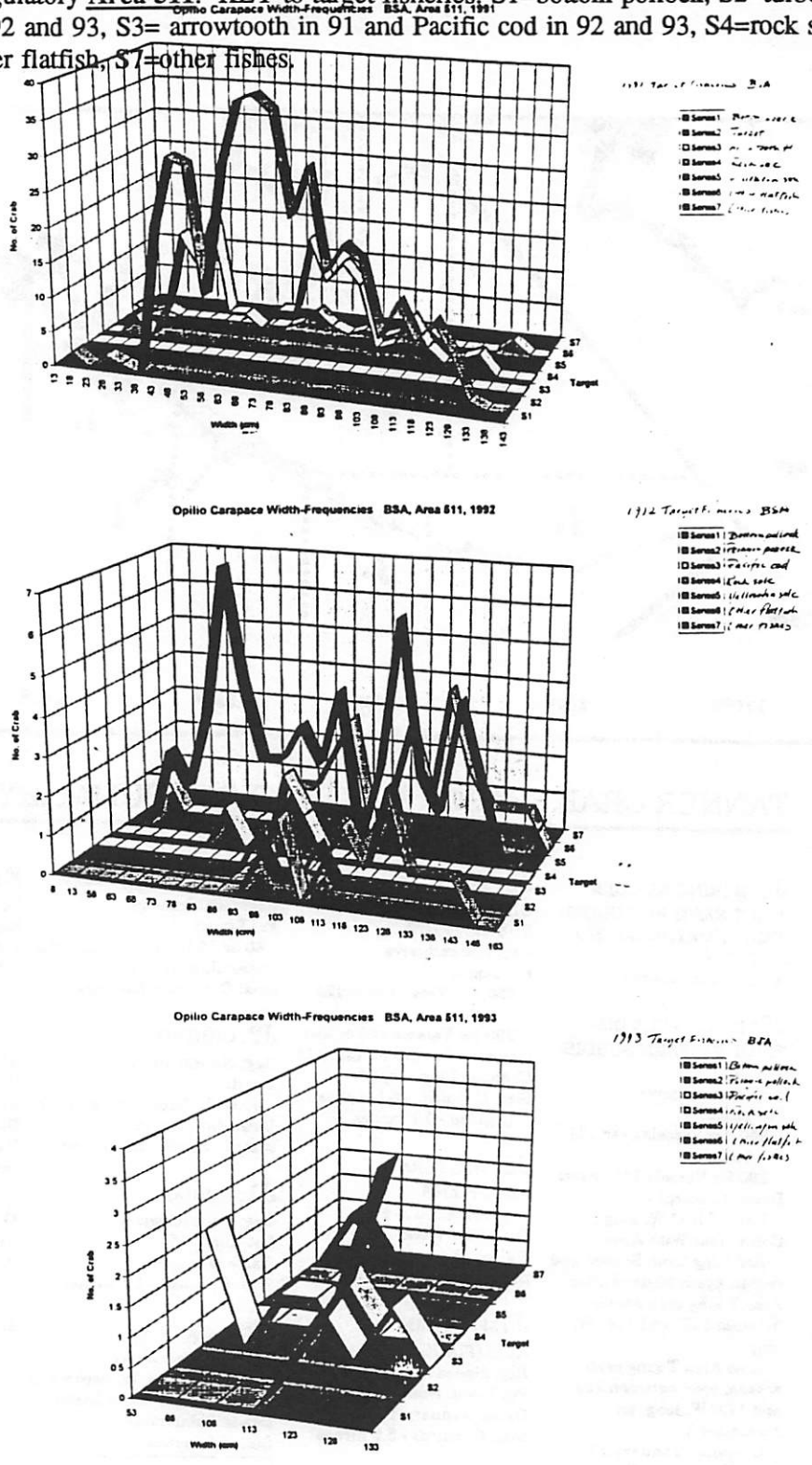
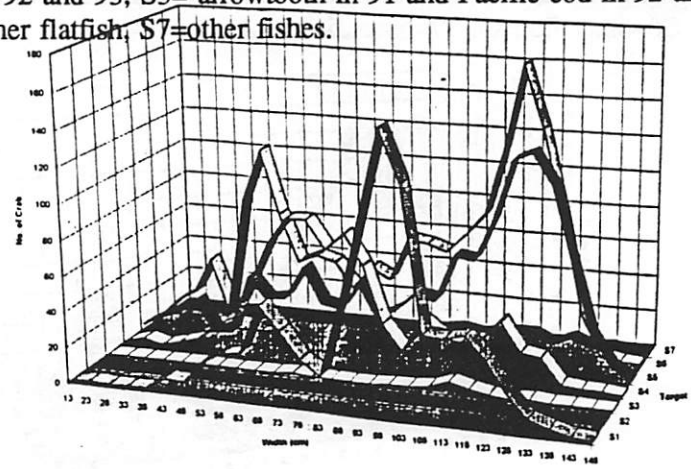
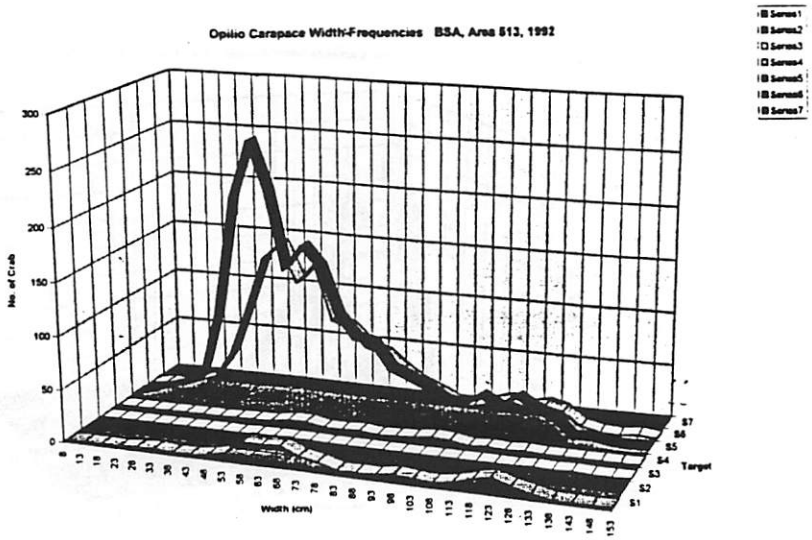


Figure 5. Length Frequencies (carapace width, mm) of snow crab bycatch taken in 1991, 1992, and 1993 trawl fisheries in BSAI Regulatory Area 513. KEY to target fisheries: S1=bottom pollock, S2=turbot in 91 and pelagic pollock in 92 and 93, S3= arrowtooth in 91 and Pacific cod in 92 and 93, S4=rock sole, S5=yellowfin sole, S6=other flatfish, S7=other fishes.





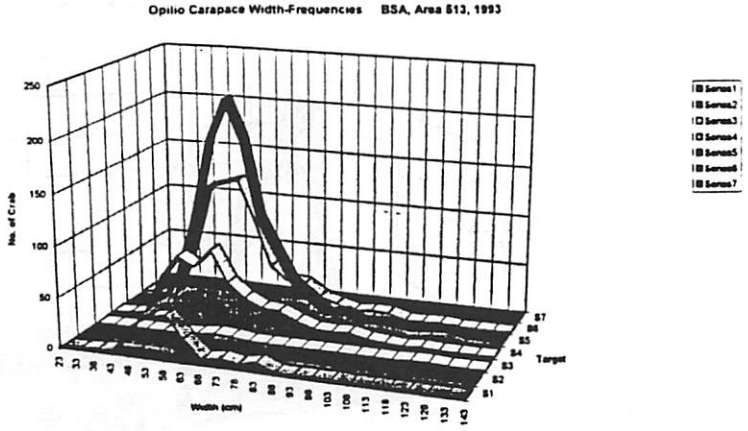
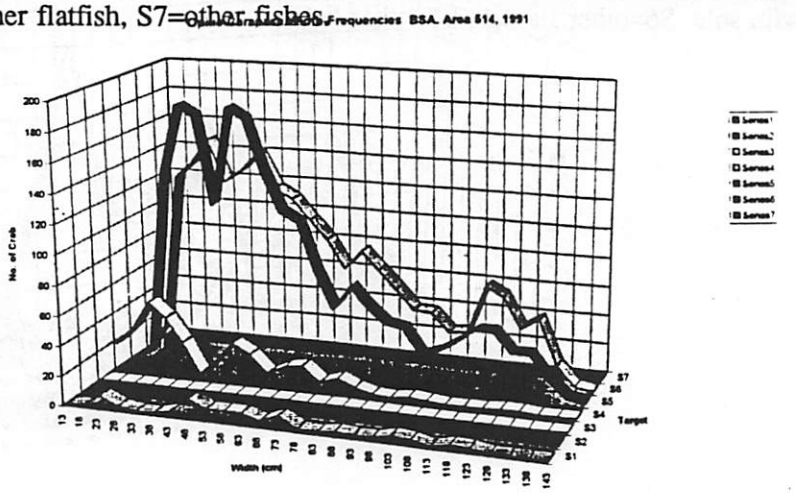
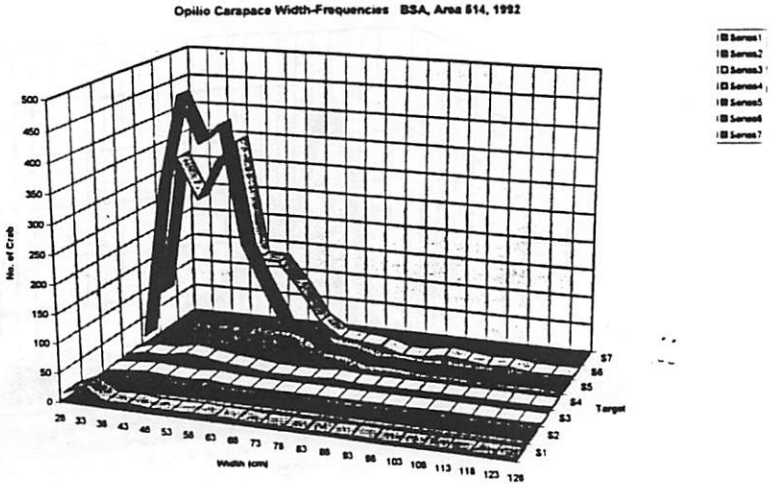


Figure 6. Length Frequencies (carapace width, mm) of snow crab bycatch taken in 1991, 1992, and 1993 trawl fisheries in BSAI Regulatory Area 514. KEY to target fisheries: S1=bottom pollock, S2=turbot in 91 and pelagic pollock in 92 and 93, S3= arrowtooth in 91 and Pacific cod in 92 and 93, S4=rock sole, S5=yellowfin sole, S6=other flatfish, S7=other fishes.





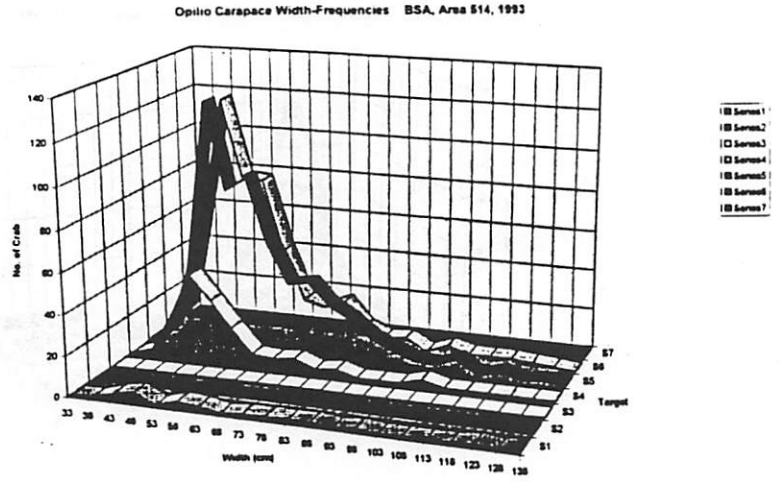
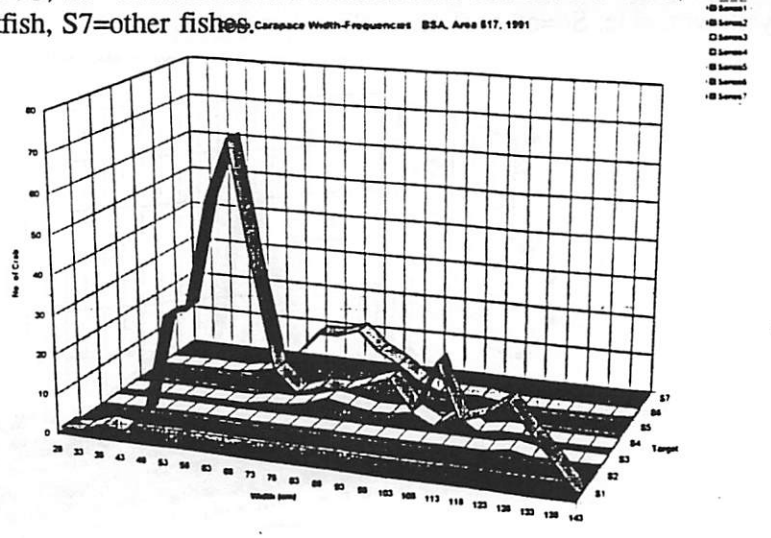
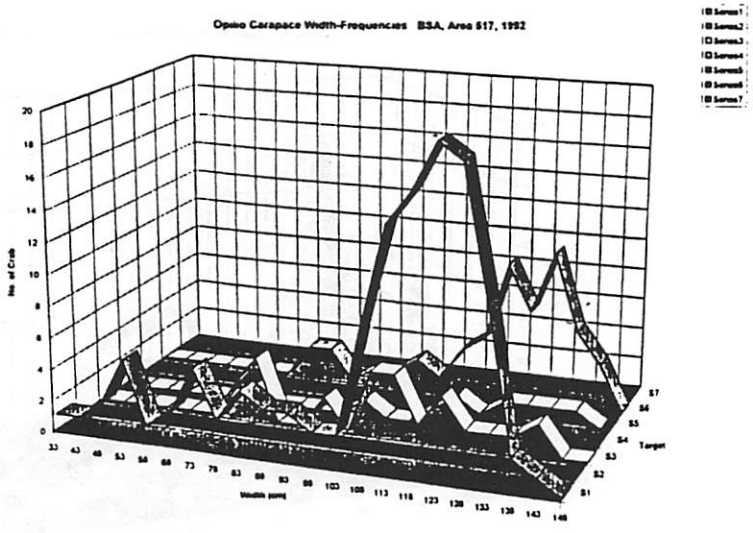


Figure 7. Length Frequencies (carapace width, mm) of snow crab bycatch taken in 1991, 1992, and 1993 trawl fisheries in BSAI Regulatory Area 517. KEY to target fisheries: S1=bottom pollock, S2=turbot in 91 and pelagic pollock in 92 and 93, S3= arrowtooth in 91 and Pacific cod in 92 and 93, S4=rock sole, S5=yellowfin sole, S6=other flatfish, S7=other fishes.





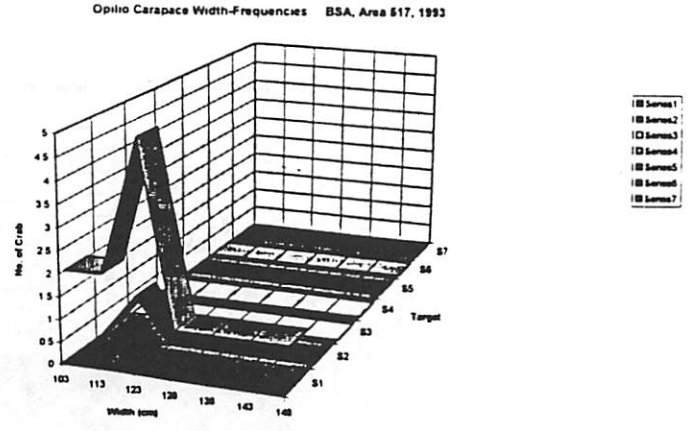
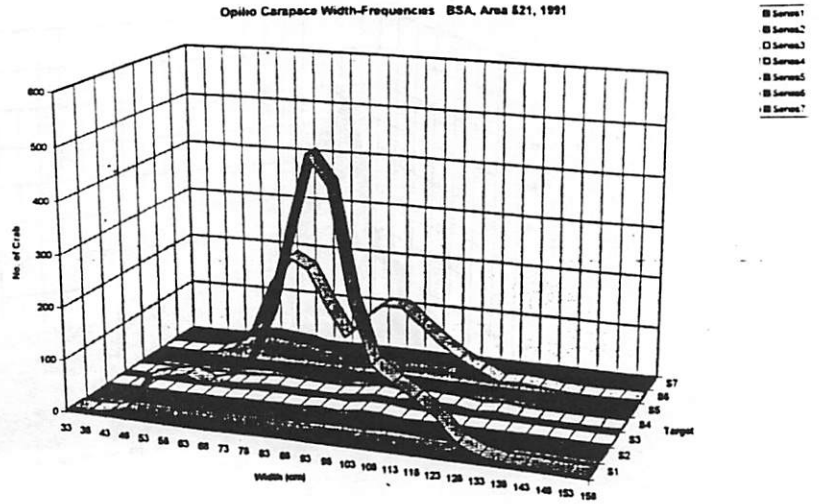
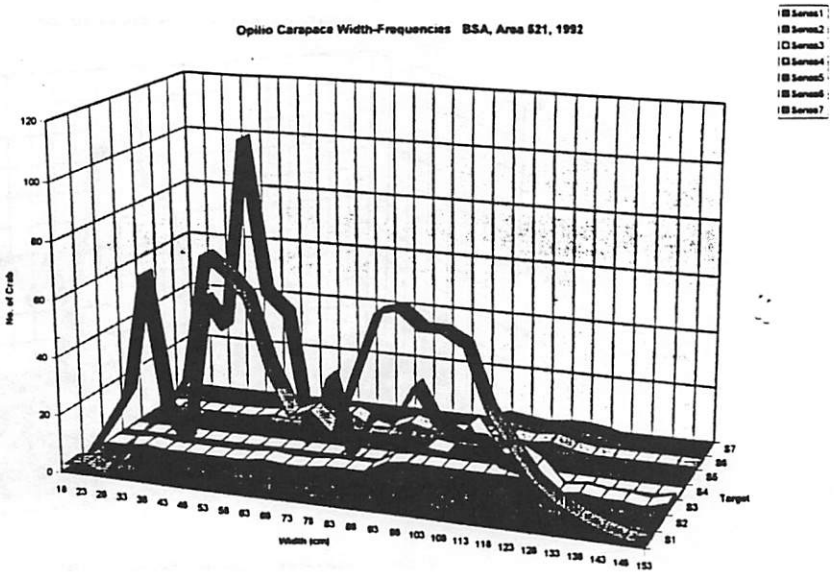


Figure 8. Length Frequencies (carapace width, mm) of snow crab bycatch taken in 1991, 1992, and 1993 trawl fisheries in BSAI Regulatory Area 521. KEY to target fisheries: S1=bottom pollock, S2=turbot in 91 and pelagic pollock in 92 and 93, S3= arrowtooth in 91 and Pacific cod in 92 and 93, S4=rock sole, S5=yellowfin sole, S6=other flatfish, S7=other fishes.





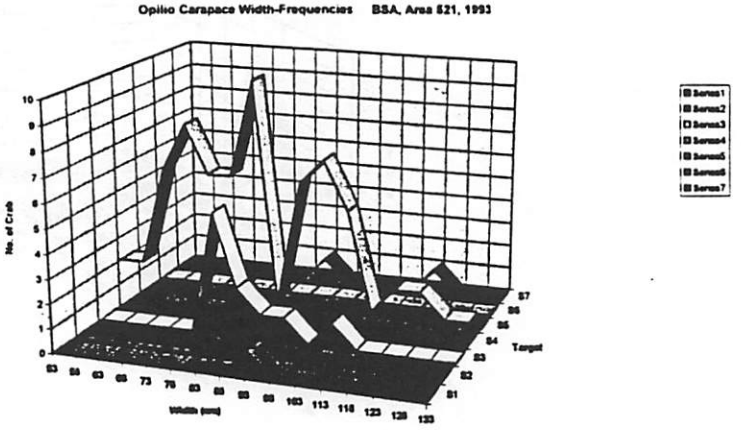
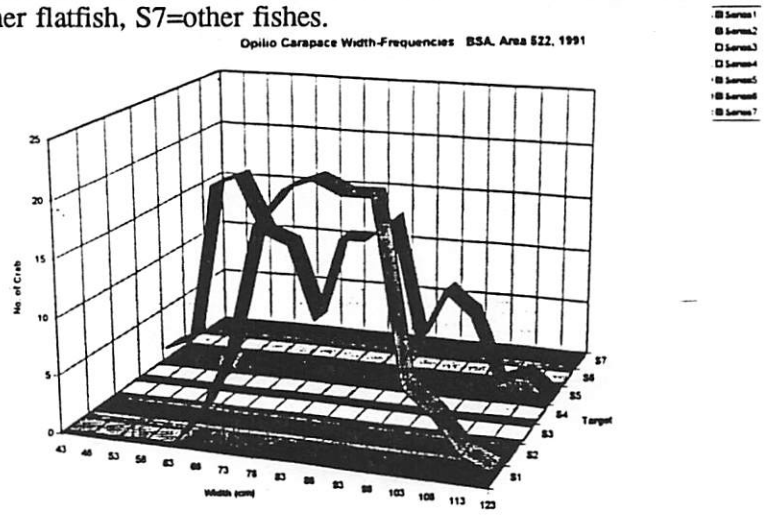
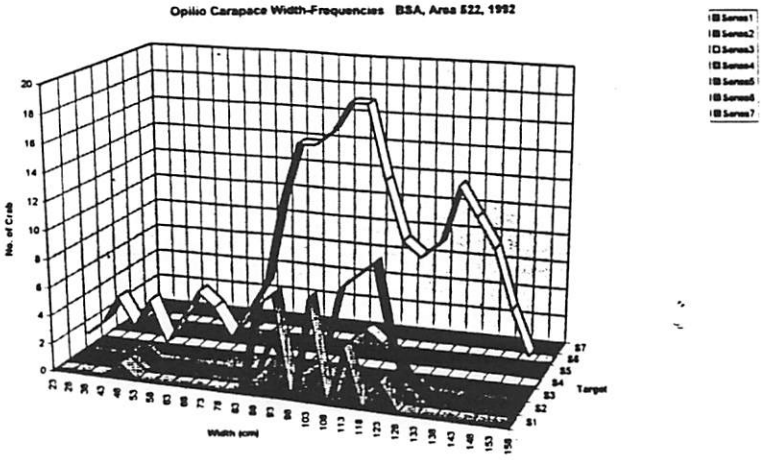


Figure 9. Length Frequencies (carapace width, mm) of snow crab bycatch taken in 1991, 1992, and 1993 trawl fisheries in BSAI Regulatory Area 522. KEY to target fisheries: S1=bottom pollock, S2=turbot in 91 and pelagic pollock in 92 and 93, S3= arrowtooth in 91 and Pacific cod in 92 and 93, S4=rock sole, S5=yellowfin sole, S6=other flatfish, S7=other fishes.





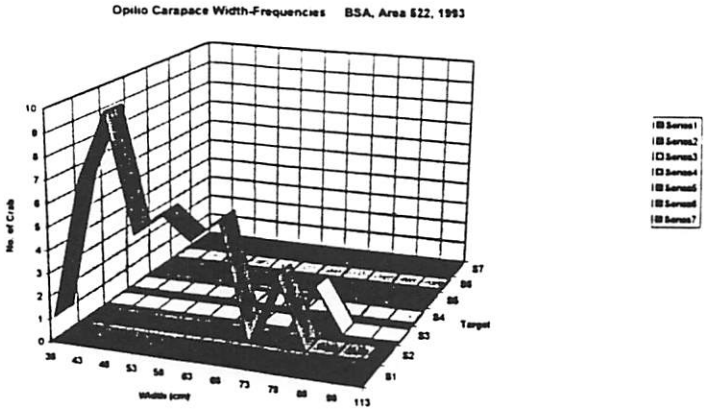


Table 33. Catch per pot of commercially important species from the 1992 Bristol Bay red king crab fishery.

Species	Total pot[a] sample catch	Catch per unit effort	Estimated total[b] fishery catch
red king crab			
legal male	1,520	5.2	1,070,472
sub-legal male	3,235	11.2	2,305,632
female	3,203	11.7	2,408,562
C. bairdi			
legal male	1,213	4.2	864,614
sub-legal male	832	2.9	596,994
female	107	.4	82,344
C. opilio			
legal male	18	.1	20,586
sub-legal male	0	-	-
female	0	-	-
pacific cod[c]	121	.4	82,344
yellowfin sole	216	.7	144,102
halibut	7	<.1	4,986

[a] Total pot contents derived from 289 random samples taken on catcher processors during the fishery.
[b] Estimated catch derived from pot sample CPUE x 205,860 total reported pot pulls during the fishery.
[c] All fish species mixed size and sex.

Table 35. Catch per pot of selected species from the 1993 Bristol Bay red king crab fishery.

Species	Total pot sample catch[a]	Catch per unit effort	Estimated total fishery catch[b]
red king crab			
legal male	4,446	8.0	2,022,165
sub-legal male	5,910	10.6	2,688,033
female	6,188	11.1	2,814,475
C. bairdi			
legal male	4,772	8.6	2,170,439
sub-legal male	2,707	4.9	1,231,219
female	1,246	2.2	566,716
C. opilio			
legal male	34	.1	15,464
sub-legal male	6	<.1	2,729
female	4	<.1	1,819
pacific cod[c]	404	.7	183,750
yellowfin sole	442	.8	201,034
halibut	7	<.1	3,184

[a]Total pot contents derived from 558 random samples taken on catcher processors during the fishery.

[b]Estimated catch derived from pot sample CPUE x 253,794 total reported pot pulls during the fishery.

[c]All fish species mixed size and sex.

Table 50. Catch per pot of commercially important species from the 1992 Bering Sea *C. bairdi* crab fishery between November 15th to December 31st, 1992.

Species	Total pot[a] sample catch	Catch per unit effort	Estimated total[b] fishery catch
C. bairdi			
legal male	15,365	29.7	14,629,181
sub-legal male	21,917	42.3	20,835,500
female	5,354	10.4	5,122,676
C. opilio			
legal male	2,754	5.3	2,610,595
sub-legal male	86	.2	98,513
female	66	.1	49,257
hybrid Tanner crab			
mixed size/sex	946	1.8	886,617
red king crab			
legal male	101	.2	98,513
sub-legal male	309	.6	295,539
female	1,115	2.2	1,083,643
blue king crab			
legal male	6	<.1	5,716
sub-legal male	28	<.1	26,677
female	48	.1	49,257
yellowfin sole	147	.3	147,770
halibut	23	<.1	21,913
pacific cod	754	1.5	738,848

[a] Total pot contents derived from 517 random samples taken on catcher processors between November 15th and December 31st, 1992.

[b] Estimated catch derived from pot sample CPUE x 492,565 total reported pot pulls between November 15th and December 31st, 1992.

Table 57. Catch per pot of selected species from the 1993 Bering Sea *C. bairdi* fishery.

Species	Total pot[a] sample catch	Catch per unit effort	Estimated total[b] fishery catch
C. bairdi			
legal male	17,426	17.2	7,209,948
sub-legal male	31,135	30.9	12,952,755
female	12,497	12.4	5,197,869
C. opilio			
legal male	3,388	3.4	1,425,222
sub-legal male	105	.1	41,918
female	45	<.1	18,695
hybrid Tanner crab			
mixed size/sex	680	.7	293,428
red king crab			
legal male	57	<.1	23,680
sub-legal male	176	.2	83,837
female	311	.3	125,755
blue king crab			
legal male	0	-	-
sub-legal male	99	<.1	48,129
female	123	.1	41,918
Korean hair crab	70	<.1	29,081
halibut	41	<.1	17,033
pacific cod	1,728	1.7	712,611

[a]Total pot contents derived from 1,009 random samples taken on catcher processors during the fishery.

[b]Estimated catch derived from pot sample CPUE x 419,183 total reported pot pulls between the dates of Nov. 21 and Dec. 31, 1993.

Table 5. Catch per pot of commercially important species from the 1992 Bering Sea *C. opilio* fishery.

Species	Total pot[a] sample catch	Catch per unit effort	Estimated total[b] fishery catch
C. opilio			
legal male	253,995	208.9	267,767,184
sub-legal male	1,857	1.5	1,922,694
female	3,855	3.2	4,101,747
C. bairdi			
legal male	3,194	2.6	3,332,670
sub-legal male	9,886	8.1	10,382,548
female	958	.8	1,025,437
hybrid Tanner crab			
mixed size/sex	8,083	6.6	8,459,854
red king crab			
legal male	20	<.1	21,082
sub-legal male	2	<.1	2,108
female	10	<.1	10,541
blue king crab			
legal male	9	<.1	9,487
sub-legal male	19	<.1	20,028
female	3	<.1	3,162
brown king crab[c] (legal males only)	6	<.1	6,325
halibut	15	<.1	15,812
pacific cod	1,119	.9	1,179,547

[a] Total pot contents derived from 1,216 random samples taken on catcher processors during the fishery.

[b] Estimated catch derived from pot sample CPUE x 1,281,796 total reported pot pulls during the fishery.

[c] Only legal males were observed in pot samples.

Table 5. Catch per pot of selected species from the 1993 Bering Sea *C. opilio* fishery.

Species	Total pot[a] sample catch	Catch per unit effort	Estimated total[b] fishery catch
C. opilio			
legal male	270,783	235.3	228,447,219
sub-legal male	2,568	2.2	2,166,504
female	2,927	2.5	2,469,376
C. bairdi			
legal male	876	.8	739,041
sub-legal male	6,029	5.2	5,086,391
female	1,049	.9	884,993
hybrid Tanner crab			
mixed size/sex	11,451	9.9	9,660,684
red king crab			
legal male	11	<.1	9280
sub-legal male	6	<.1	5062
female	12	<.1	10,124
blue king crab			
legal male	1	<.1	844
sub-legal male	33	<.1	27,841
female	7	<.1	5906
brown king crab	0	0	0
halibut	8	<.1	6749
pacific cod	1,292	1.1	1,090,001

[a]Total pot contents derived from 1,151 random samples taken on catcher processors during the fishery.

[b]Estimated catch derived from pot sample CPUE x 971,046 total reported pot pulls during the fishery.

AGENDA D-2(b)
JANUARY 1995
SUPPLEMENTAL

ALASKA MARINE CONSERVATION COUNCIL

Box 101145 Anchorage, Alaska 99510
(907) 277-5357 (kelp); 277-5975 (fax)

December 9, 1994

Rick Lauber, Chair
North Pacific Management Council
P.O. Box 103136
Anchorage, AK 99510

RE: Crab Bycatch: Actions to Protect Red King Crab in Bristol Bay (Agenda Item D-2(a))

Dear Chairman Lauber:

The recent depletions of the red king crab population in the Bristol Bay area are yet another example of the need for a comprehensive approach to bycatch and discards such as Harvest Priority. Lacking that overall approach at this time, the Council must take stopgap measures after the problem has reached a crisis.

The Alaska Marine Conservation Council supports the emergency action recommended by the Council at its recent teleconference. The Council voted to promulgate an emergency regulation which, in part, closed an area of Bristol Bay to trawling. From listening to the teleconference and reviewing the information presented by Dave Ackley of the Alaska Department of Fish and Game at the meeting, the Council's action was amply supported by the record. Mr. Ackley's charts showed that the area closed, including the area added by the State's amendment to the motion, is an area of high king crab bycatch in the rock sole fishery and is an area important to red king crab populations. This is made even more clear in the supplement Mr. Ackley prepared for this meeting. If the Council had not extended the closure to this area, the rock sole trawl fleet would likely have clustered its effort just on the southern border of the originally proposed closure area, in the heart of this important red king crab area.

At this meeting, AMCC recommends the Council take the following actions to further protect crab stocks in the Bristol Bay area:

- Convert the Council's emergency recommendation for a no trawl zone into a permanent rule change
- Establish a fixed PSC cap for opilio crab
- Reduce the bairdi cap from 4 million to 1.5 million
- Increase observer coverage to all tows in flatfish fisheries in the area
- Tightly enforce the red king crab cap and shut the fishery down promptly when the cap is reached
- Deduct the amount of crab cap exceeded in 1994 from the 1995 cap.

Thank you for your attention.

Sincerely,

Scott Highleyman
Executive Director

APPENDIX F

IMPACTS OF TRAWLING ON THE SEABED AND BENTHIC COMMUNITY

Prepared by
Grant Thompson

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center
Resource Ecology and Fisheries Management Division
7600 Sand Point Way NE., Seattle, WA 98115-0070

shoes penetrated up to 6 cm in hard sand. At the extreme, Jones (1992) noted in a review article that trawl door penetration up to 30 cm had been observed in at least one study. Since the substrate in the eastern Bering Sea is mostly of the hard sand variety, such extreme impacts should be unlikely.

Temporal duration of trawl tracks can vary greatly. Jones' (1992) review showed an upper limit of five years for the duration of tracks in sandy mud, whereas the tracks observed in hard sand by Bergman and Hup (1992) lasted for about 16 hours, and the tracks observed in hard sand by de Groot (1984) had a lifespan of only 75 minutes. Again, the fact that most of the substrate in the eastern Bering Sea is of the hard sand variety indicates that track duration should be minimal.

In heavily fished areas, a patch of ground might be impacted by trawl gear several times during a year. Churchill (1989) found an average of 20 tracks per 100 m^2 on the southern New England continental shelf. Rauck (1985, cited in ICES 1988 and Bergman and Hup 1992) calculated that each m^2 in some parts of the North Sea was trawled an average of 3-5 times per year, while Welleman (1989, cited in Bergman and Hup 1992) calculated a rate of 7 times per year for the same locations (but different year). However, it should be remembered that trawl effort in the eastern Bering Sea is generally considered to be much less than in New England or the North Sea.

Sediment Resuspension

Churchill (1989) found that trawling can be a primary source of suspended sediment over the outer continental shelf. Possible adverse impacts resulting from increased suspension of sediments include a reduction of light levels on the seabed, smothering of benthos following resettlement, creation of anaerobic conditions near the seabed, and reintroduction of toxins that may have settled out of the water column (ICES 1988, Jones 1992). It does not appear that organic material resuspended as a result of fishing activity improves nutrient availability to filter feeders (Anderson and Meyer 1986).

Adverse effects from resuspension of sediments are probably minimal in areas with significant current or tidal transport, since organisms in these areas are presumably adapted to such events (ICES 1988, Jones 1992). In the deep ocean, however, the effects would likely be greater (Jones 1992).

Destruction of Benthos

It is generally believed that trawling reduces the biomass of benthic organisms. Because crab bycatch is considered elsewhere in this document (Section 2.2.6) the discussion here will concentrate on other species, most of which are not of direct commercial importance.

Trawl-induced mortality stems both from damage inflicted by the gear itself as it passes over the seabed and from capture- and handling-related mortality of organisms taken in the net. In terms of the former, the abundance of benthic organisms may be decreased by 40% or more within the trawl tracks immediately after trawling (ICES 1988, Bergman

and Hup 1992). However, some of this decrease may be due simply to dislocation, as opposed to destruction (Rumohr and Krost 1991). In either case, at least some recolonization from outside the tracks would be expected shortly thereafter. In one study, most epibenthic organisms regained their original density after about 24 hours (Rumohr and Krost 1991).

Capture- and handling-related mortality can also have substantial impacts on organisms that actually make it into the net. In one study, molluscs and crabs showed at least 40% mortality due to capture and handling, starfish 70-80%, and whelks and hermit crabs approximately 100% (Fonds 1991).

The amount of trawl-induced mortality is a function of species morphology, size, and depth of occurrence in the substrate. For example, in a study conducted in Kiel Bay (Baltic Sea), Rumohr and Krost (1991) found that thin-shelled bivalves such as *Syndosmya (Abra) alba*, *Mya* sp., and *Macoma calcarea*, as well as the starfish *Asterias rubens* were substantially damaged by the passage of trawl gear, while thick-shelled bivalves such as *Astarte borealis* and *Corbula gibba* were fairly resistant, and impacts on *Arctica islandica*, *Macoma baltica*, and *Macoma calcarea* were related to body size. Large specimens of *Arctica islandica* were more affected than smaller specimens due to the unfavorable relationship between shell surface area and shell thickness. The size distribution of *A. islandica* in heavily trawled areas showed reductions in the upper size class in these areas, which Rumohr and Krost (1991) viewed as corroboration of their finding that trawl-induced mortality was size specific.

Community Structure

Some writers have suggested that trawling can lead to long-term shifts in the species composition of the benthic community. Most studies seem to conclude that trawling tends to cause an increase in the relative abundance of fast-growing and fast-reproducing species such as polychaetes at the expense of slow-growing and slow-reproducing species such as molluscs and crustaceans (Reise 1982, Riesen and Reise 1982, de Groot 1984, Pearson et al. 1985, ICES 1988). However, it is difficult to demonstrate rigorously that trawling was actually the cause of the species shifts observed in those studies (Jones 1992). Graham (1955) concluded that there was no clear difference between the benthic communities of trawled and untrawled areas in the North Sea. Likewise, a Dutch study was unable to draw a clear causal relationship between differences in species composition and beam trawling (Bergman 1991).

Forage Availability

Although most studies indicate that trawling at least carries the potential to damage benthic organisms (see "Destruction of Benthos" section), this does not necessarily translate into a decrease in forage availability for those species that feed upon benthic prey. For example, Graham (1955) concluded, "Damage to fish food species trawled over in the main area of the North Sea plaice, cannot be serious...." Other studies (reviewed by ICES 1988 and Jones 1992) have suggested that the effect was actually (or at least could be) positive.

Arntz and Weber (1970, cited in de Groot 1984, Rumohr and Krost 1991, Bergman and Hup 1992, and Jones 1992) observed that the stomach contents of cod in Kiel Bay (Baltic Sea) began to contain an extraordinary amount of the bivalve *Arctica (Cyprina) islandica* once trawling commenced in the area. Their conclusion was that the fish were feeding on animals crushed by the trawl doors. Brey et al. (1990) calculated the annual production of *A. islandica* in Kiel Bay and concluded that it could support 40% of the annual cod production.

In another study, Caddy (1973) found that fish and crabs were attracted to the trawl path within 1 hour after fishing and were observed in the tracks at densities up to 30 times greater than the densities observed outside the tracks.

Grounds Preemption

In areas which are trawled by vessels of greatly different horsepower, it is sometimes possible for the larger vessels to render the grounds untrawlable by the smaller vessels. De Groot (1984) described a complaint brought by small trawlers from Corsica, in which it was alleged that large trawlers were uncovering boulders buried in the seabed which then made the grounds inaccessible to the small trawlers. Bridger (1970) substantiated this complaint.

Conclusions

In conclusion, it is clear that trawling can impact both the seabed and the benthic community. The extent of these impacts depends on the weight of the gear, the towing speed, the nature of the bottom sediments, and the strengths of tides and currents. Bottom trawl doors leave scars on the seabed that can last for minutes, hours, or years. Trawls can damage benthic organisms, thereby causing changes in community species composition and population age structure, but perhaps also leading to an increase in the availability of forage for commercial species. Whether changes in community species composition would tend to come at the expense of commercially important species such as crab is difficult to determine. In any case, it is important to remember that the impacts described here become relevant only if any of the alternatives examined in this amendment result in a change in the *total amount* of trawling in an area, as opposed simply to a change in the amount of trawling for Pacific cod which is offset by an increase in the amount of trawling for other species in the same area.

References

Anderson, F. E., and L. M. Meyer. 1986. The interaction of tidal currents on a disturbed intertidal bottom with a resulting change in particulate matter quantity, texture and food quality. Estuarine Coastal and Shelf Science 22:19-29.

Bergman, M. (ed.). 1991. Long term effects of beamtrawl fishing on the benthic ecosystem in the North Sea. *In* Effects of beamtrawl fishery on the bottom fauna in the North Sea, II: the 1990 studies. BEON-report 13:69-85.

Bergman, M. J. N., and M. Hup. 1992. Direct effects of beamtrawling on macrofauna in a sandy sediment in the southern North Sea. ICES Journal of Marine Science 49:5-11.

Brey, T., W. E. Arntz, D. Pauly, and H. Rumohr. 1990. *Arctica (Cyprina) islandica* in Kiel Bay (Western Baltic): growth, production and ecological significance. Journal of Experimental Marine Biology and Ecology 136:217-235.

Bridger, J. P. 1970. Some effects of the passage of a trawl over the sea bed. ICES C.M. 1970/B:10 Gear and Behaviour Comm.

Caddy, J. F. 1973. Underwater observations on tracks of dredges and trawls and some effects of dredging on a scallop ground. Journal of the Fisheries Research Board of Canada 30:173-180.

Churchill, J. H. 1989. The effect of commercial trawling on sediment resuspension and transport over the Middle Atlantic Bight continental shelf. Continental Shelf Res. 9:841-864.

De Groot, S. J. 1984. The impact of bottom trawling on benthic fauna of the North Sea. Ocean Management 9:177-190.

Fonds, M. (ed.). 1991. Measurements of catch composition and survival of benthic animals in beam trawl fishery for sole in the southern North Sea. *In* Effects of beamtrawl fishery on the bottom fauna in the North Sea, II: the 1990 studies. BEON-report 13:53-68.

Graham, M. 1955. Effect of trawling on animals of the sea bed. Deep Sea Research Supplement 3:1-6.

ICES. 1988. Report of the study group on the effects of bottom trawling. International Council for the Exploration of the Sea CM 1988/B:56.

Jones, J. B. 1992. Environmental impact of trawling on the seabed: A review. New Zealand Journal of Marine and Freshwater Research 26:59-67.

Pearson, T. H., A. B. Josefson, and R. Rosenberg. 1985. Petersen's benthic stations revisited. I. Is the Kattegatt becoming eutrophic? Jounral of Experimental Marine Biology and Ecology 92:157-206.

Reise, K. 1982. Long-term changes in the macrobenthic invertebrate fauna of the Wadden Sea: are polychaetes about to take over? Netherlands Journal of Sea Research 16:29-36.

Riesen, W., and K. Reise. 1982. Macrobenthos of the subtidal Wadden Sea: Revisited after 55 years. Helgolander Meeresunters. 35:409-423.

Rumohr, H., and P. Krost. 1991. Experimental evidence of damage to benthos by bottom trawling with special reference to *Arctica islandica*. Meeresforsch. 33:340-345.

nt C. Paine
...utive Director

UNITED CATCHER BOATS
U C B
Washington · Oregon · California · Alaska

Steve Hughes
Technical Director

January 9, 1995

Mr. Richard B. Lauber, Chairman
Council Members
North Pacific Fishery Management Council
P.O. Box 103136
Anchorage, Alaska 99510

Re: Crab Bycatch/Crab Management

Dear Mr. Chairman and Council Members:

United Catcher Boats is comprised of 52 vessels, all of which conduct Bering Sea pollock and/or cod trawl fisheries for deliveries to shoreplants and motherships. Additionally, about one-half of our vessels participate in Bering Sea crab fisheries especially *bairdi* Tanner crab and Bristol Bay red king crab.

WE ARE EXTREMELY CONCERNED ABOUT THE PRESENT MANAGEMENT OF BERING SEA CRAB STOCKS, CRAB DISCARDS AND CRAB PREDATION. REAL AND EFFECTIVE MEASURES ARE PARTICULARLY NEEDED TO PROTECT RED KING CRAB AND *BAIRDI* TANNER CRAB STOCKS. REAL AND EFFECTIVE MEASURES NEED TO BE COMPREHENSIVE, NOT PIECEMEAL AND NOT MISDIRECTED.

Lets look a the facts. This presentation utilizes 1993 data collected by the ADF&G observer program during the commercial crab fisheries for *bairdi* and *opilio* Tanner crab, and Bristol Bay red king crab. Trawl crab bycatches are reported by NMFS and crab bycatch caps are those currently under NMFS regulation.

1. Based upon 901 random pot samplings during the 1993 commercial *bairdi* season, the 1993 directed *bairdi* crab fishery is estimated to have captured 17,620,654 crab as

identified by species and size/sex categories in Exhibit 1. Just over five million crab or 28.4% were retained as legal sized male *bairdi* and the balance were discarded.

2. Based upon 558 random pot hauls during the 1993 Bristol Bay red king crab fishery, the 1993 directed Bristol Bay red king crab fishery is estimated to have captured 11,513,059 crab. As noted in Exhibit 2, about 2.0 million legal male red king crab plus 2.2 million legal male *bairdi* crab were retained, equaling 36.4% of the catch. The balance were discarded, including 2.8 million female red king crab.

3. Based upon 1,151 random pot hauls during the 1993 *opilio* Tanner crab fishery, the 1993 directed *opilio* fishery is estimated to have captured about 250 million crab of which 91.6% were retained as legal *opilio* males. An unreported portion of the 9.6 million hybrid Tanners were presumably also retained (legal males), but discards included 6.7 million *bairdi* crab (Exhibit 3).

4. As a result of the combined *bairdi* Tanner crab, *opilio* Tanner crab and Bristol Bay red king crab fisheries during 1993, about 27.8 million *bairdi* crab were harvested, of which about 7.2 million crab were retained and about 20.6 million were discarded; and about 7.7 million red king crab were harvested, of which about 2.0 million crab were retained and 5.7 million crab were discarded.

5. In comparison to the 7.2 million retained *bairdi* and the 20.6 million discarded *bairdi* from the crab fishery, the *bairdi* cap in all trawl fisheries equals 4.0 million crab. Also in 1993, cod trawl discards of *bairdi* reportedly totaled 218,592 crab, and pollock bottom trawl discards totaled 1,662,332 crab.

6. By further comparison to the 2.0 million retained red king crab and 5.7 million discarded red king crab, the red king crab cap for all trawl fisheries equals 200,000 crab. For 1993, red king crab discards from cod trawl fisheries totaled 501 crab and pollock bottom trawl discards totaled 43,671 red king crab (Exhibit 6).

7. *Bairdi* Tanner and Bristol Bay red king crab discards as a percent of crab biomass are shown for crab pot fisheries, the trawl cap, and for the two bottom trawl fisheries which are particularly important to UCB--cod and bottom trawl pollock. Pot discards account for 8.09% of the *bairdi* biomass and 11.98% of the Bristol Bay red king crab biomass. The trawl caps equal 1.57% of *bairdi* biomass and 0.42% of the red king crab biomass. Cod trawl discards account for 0.09% of the *bairdi* biomass and less than 0.01% of the red king crab biomass. Pollock bottom trawl discards account for 0.65% of the *bairdi* biomass and 0.09% of the red king crab biomass.

From UCB's perspective, the Bering Sea crab stocks are indeed in trouble--particularly Bristol Bay red king crab and *bairdi* Tanner crab. Their management needs an overhaul. Re-visiting the trawl crab caps for Bristol Bay red king crab and *Bairdi* Tanner crab as a sole action, will not even begin to meaningfully address the problems. This does not imply that some trawl fishery specific actions are not warranted but clearly the adverse effects of trawl cod and pollock fisheries are minuscule.

Crab management re-evaluations must be initiated, they are urgently needed, and they must be comprehensive. Items we believe important to consider are:

1. Crab discard mortalities in crab pot fisheries.

2. Below freezing air temperature effects on crab discard mortalities (reference to Cook Inlet crab management and studies by Carls and O'Clair, 1989).

3. Crab mortalities in derelict crab pots.

4. Crab predation by a variety of groundfish species and salmon.

5. Crab discard mortalities in trawl fisheries.

6. IFQ's for crab and multi species retention.

UCB has specific action recommendations and we are anxious to work with the NPFMC and the State of Alaska in support of constructive changes. We thank you for considering our concerns.

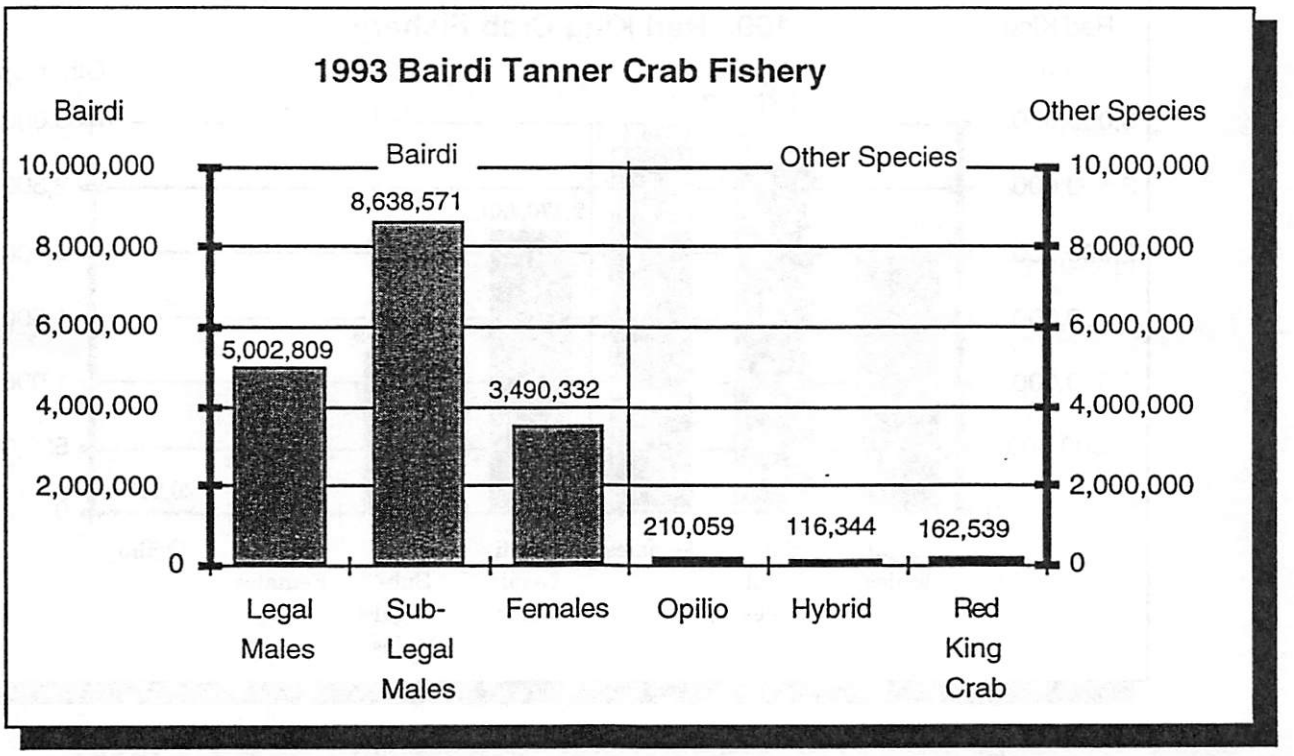
Sincerely,

UNITED CATCHER BOATS

Steven E. Hughes
Technical Advisor

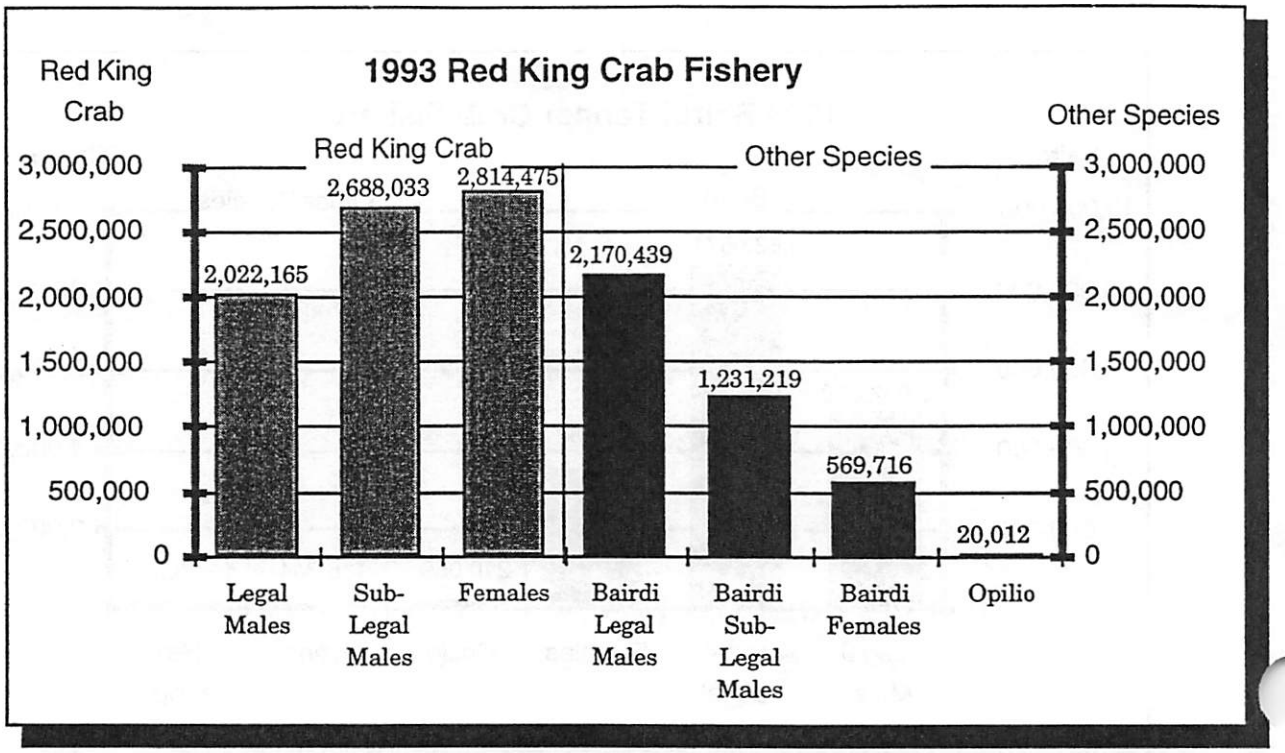
SEH:sjp

Exhibit 1. Estimated total crab catch (numbers of crab) from the 1993 *bairdi* Tanner crab fishery based upon 901 random pot samplings taken on catcher processors during the fishery. Source: ADF&G.



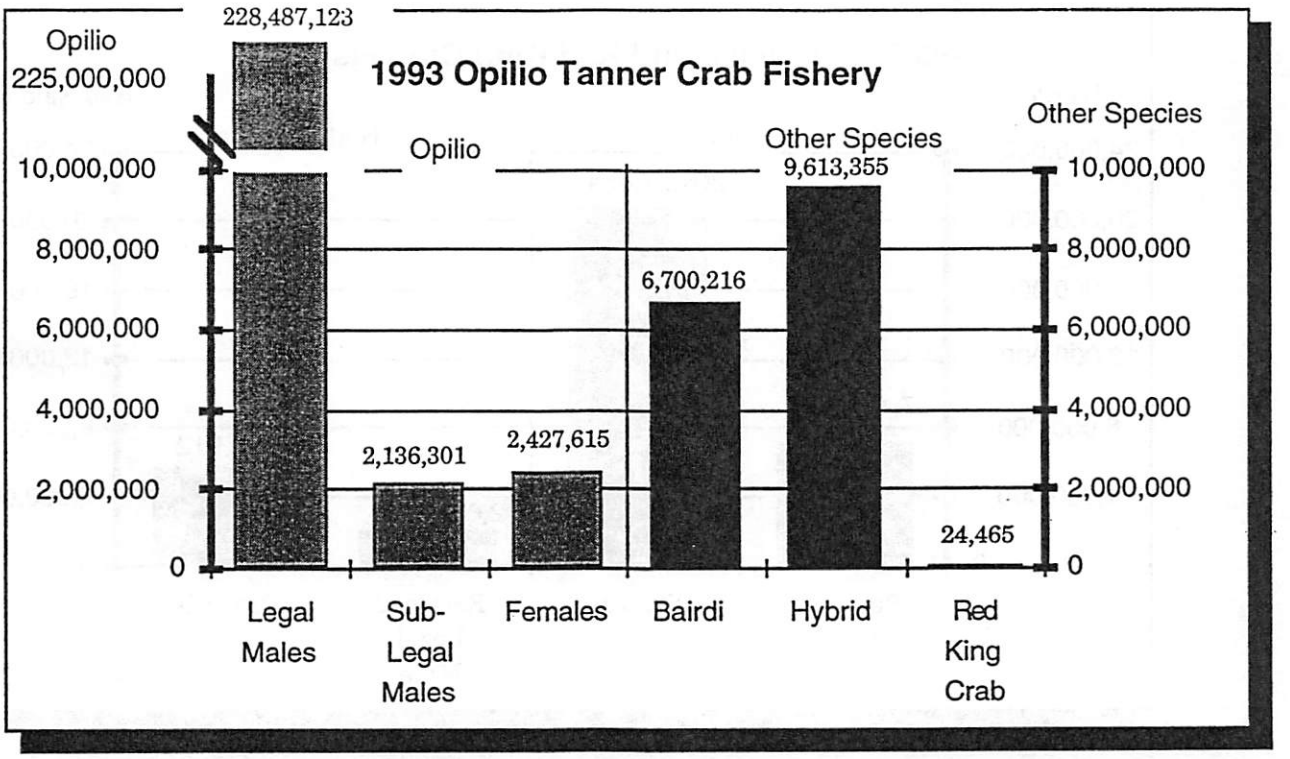
Type of Crab	Numbers of Crab
Bairdi	
Legal Males	5,002,809
Sub-Legal Males	8,638,571
Females	3,490,332
Opilio	210,059
Hybrid	116,344
Red King Crab	162,539

Exhibit 2. Estimated total crab catch (numbers of crab) from the 1993 Bristol Bay red king crab fishery based upon 558 random pot samplings taken on catcher processors during the fishery. Source: ADF&G.



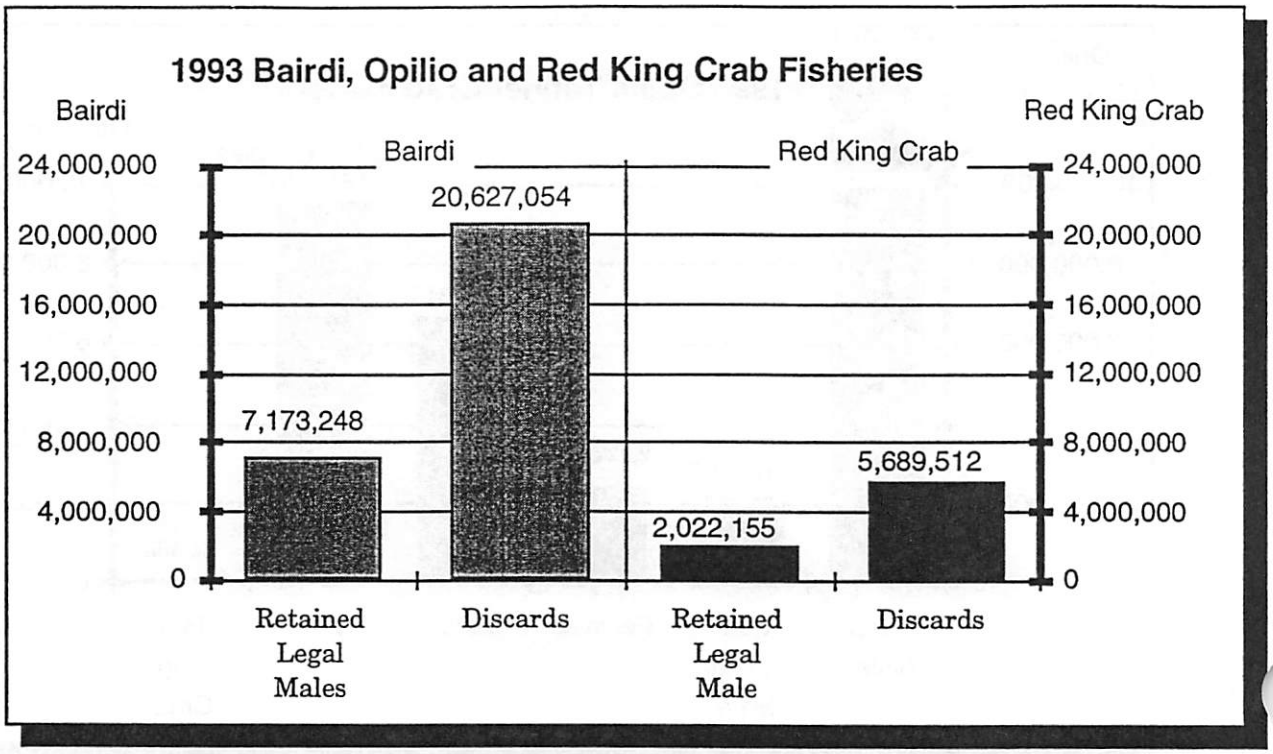
Type of Crab	Numbers of Crab
Red King Crab	
Legal Males	2,022,165
Sub-Legal Males	2,688,033
Females	2,814,475
Bairdi	
Legal Males	2,170,439
Sub-Legal Males	1,231,219
Females	566,716
Opilio	20,012

Exhibit 3. Estimated total crab catch (numbers of crab) from the 1993 *opilio* Tanner crab fishery based upon 1,151 random pot samplings taken on catcher processors during the fishery. Source: ADF&G.



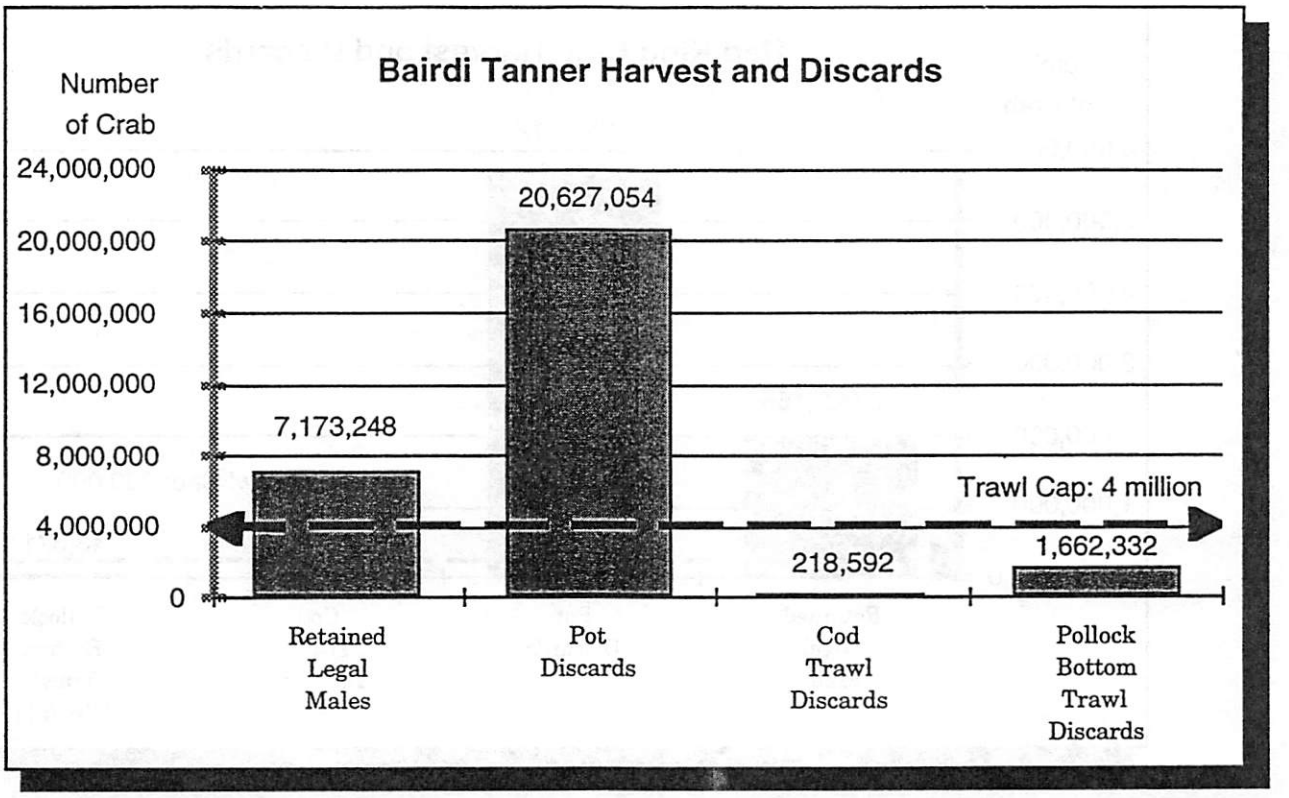
Type of Crab	Numbers of Crab
Opilio	
Legal Males	228,487,123
Sub-Legal Males	2,136,301
Females	2,427,615
Bairdi	6,700,216
Hybrid	9,613,355
Red King Crab	24,465

Exhibit 4. *Bairdi* Tanner and red king crab retained catch and discards (numbers of crab) estimated from the 1993 directed crab fisheries for *bairdi* and *opilio* Tanner crab and Bristol Bay red king crab. Source: ADF&G.



Type of Crab	Numbers of Crab
Bairdi	
Retained Legal Males	7,173,248
Discards	20,627,054
Red King Crab	
Retained Legal Males	2,022,155
Discards	5,689,512

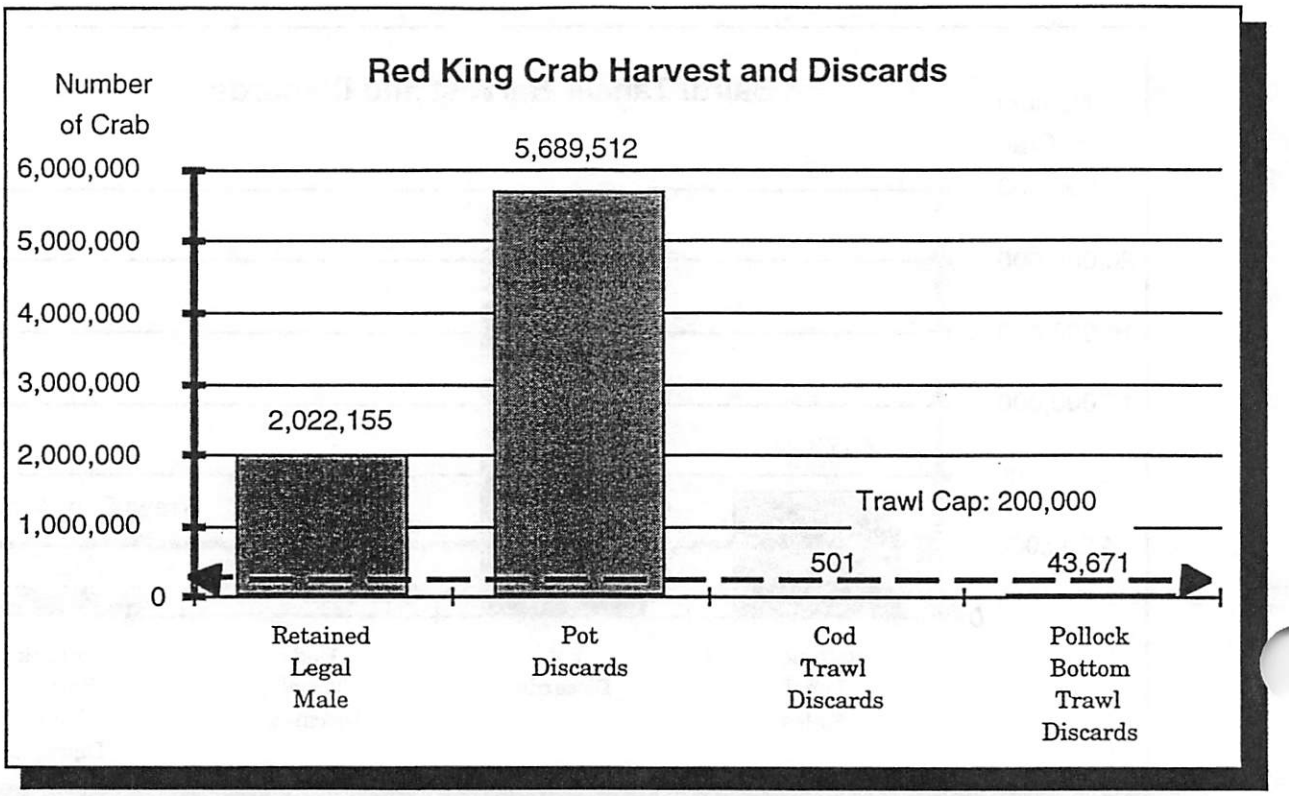
Exhibit 5. *Bairdi* Tanner crab retained catch and discards (numbers of crab) estimated from the 1993 directed crab fisheries for *bairdi* and *opilio* Tanner crab and Bristol Bay red king crab and from the 1993 cod and pollock bottom trawl fisheries. Source: ADF&G and NMFS.



Bairdi Tanner

Fishery	Numbers of Crab
Crab Fisheries	
Retained Legal Males	7,173,248
Pot Discards	20,627,054
Trawl Fisheries	
Cod Trawl Discards	218,592
Pollock Bottom Trawl Discards	1,662,332

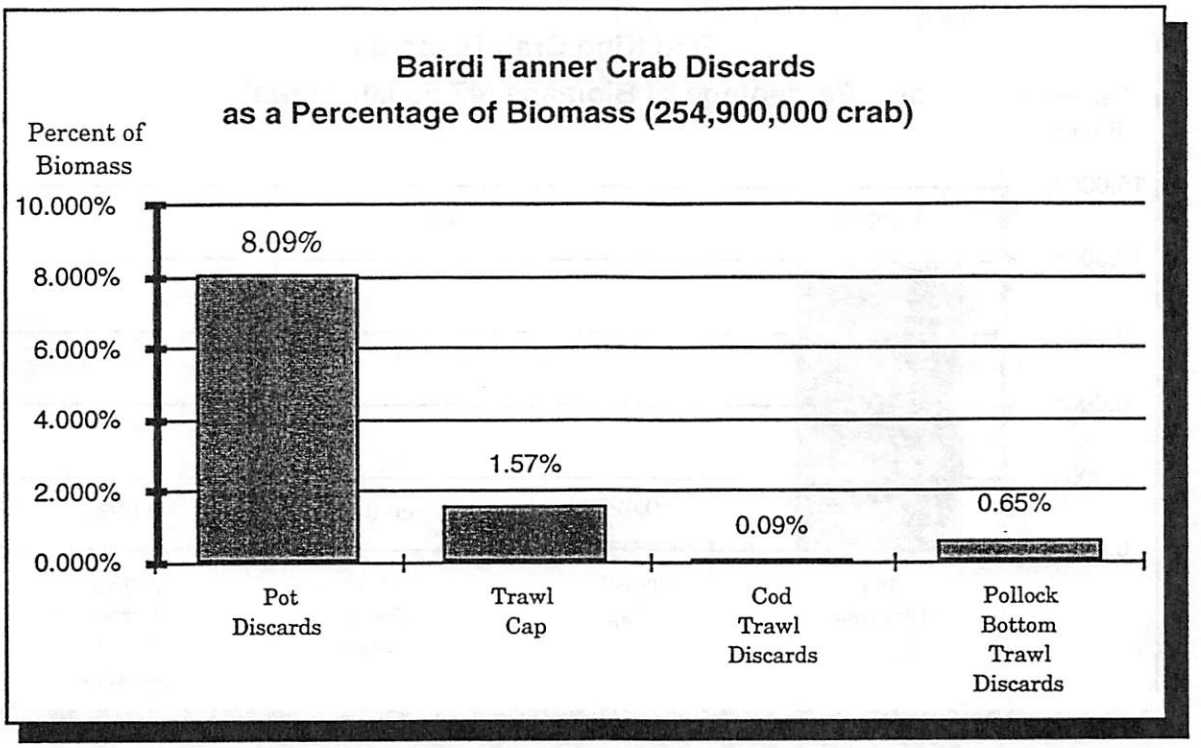
Exhibit 6. Red king crab retained catch and discards (numbers of crab) estimated from the 1993 directed crab fisheries for *bairdi* and *opilio* Tanner crab and Bristol Bay red king crab and from the 1993 cod and pollock bottom trawl fisheries. Source: ADF&G and NMFS.



Red King Crab

Fishery	Numbers of Crab
Crab Fisheries	
Retained Legal Males	2,022,155
Pot Discards	5,689,512
Trawl Fisheries	
Cod Trawl Discards	501
Pollock Bottom Trawl Discards	43,671

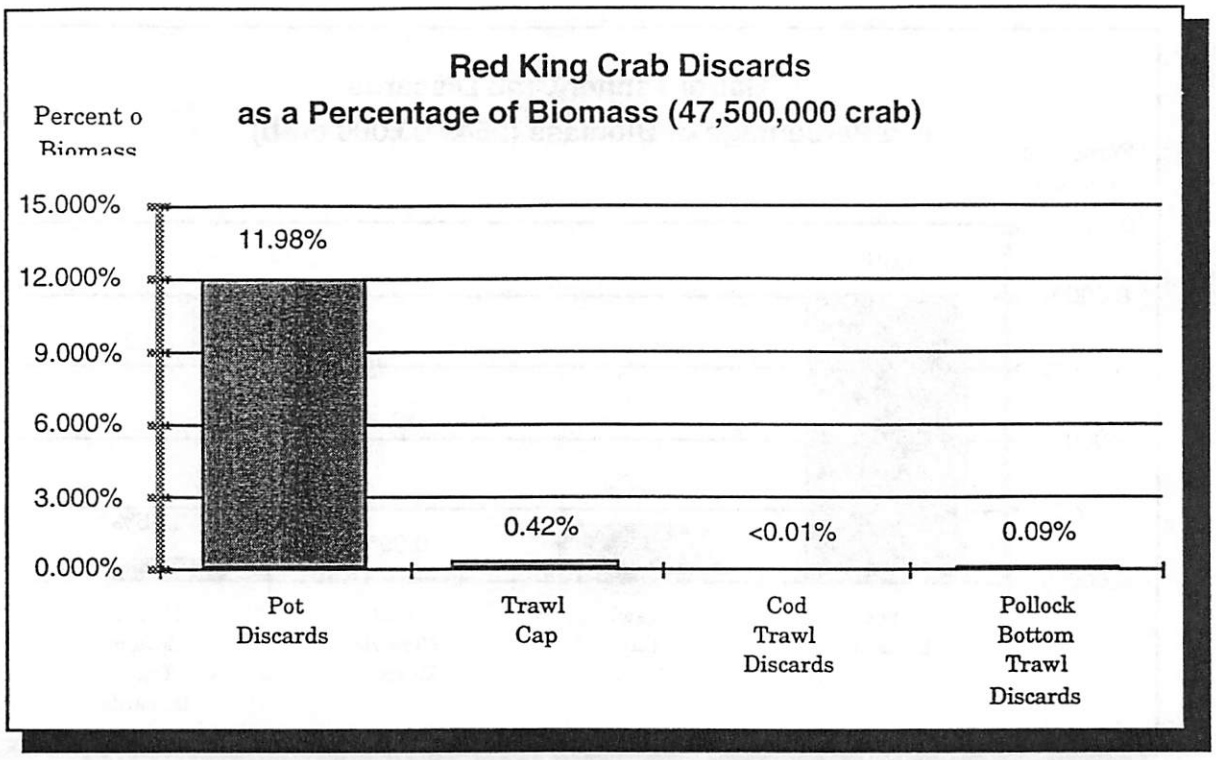
Exhibit 7. *Bairdi* Tanner crab discards as a percentage of *bairdi* Tanner crab biomass (numbers of crab). Source: ADF&G and NMFS.



Bairdi Tanner

Fishery	Discards Numbers of Crab	Discards Percent of Biomass
Crab Fisheries		
Pot Discards	20,627,054	8.09%
Trawl Fisheries		
Trawl Cap	4,000,000	1.57%
Cod Trawl Discards	218,592	0.09%
Pollock Bottom Trawl Discards	1,662,332	0.65%

Exhibit 8. Bristol Bay red king crab discards as a percentage of red king crab biomass (numbers of crab). Source: ADF&G and NMFS.



Red King Crab

1993 Biomass estimated at 47,500,000 crab

Discards

Fishery	Numbers of Crab	Percent of Biomass
Crab Fisheries		
Pot Discards	5,689,512	11.978%
Trawl Fisheries		
Trawl Cap	200,000	0.421%
Cod Trawl Discards	501	0.001%
Pollock Bottom Trawl Discards	43,671	0.092%