Joint Meeting
Alaska Board of Fisheries
and
North Pacific Fishery Management Council
January 30, 1996

TAB 5: COUNCIL ACTIONS TO PROTECT BSAI CRAB

a. **Overview of Crab Protection Measures**

Attachments:

1. **Charts with Protection Areas**
2. **Crab Rebuilding Committee Report**
3. **Outline for Proposed Northern Bristol Bay Closure**
4. **Outline for Proposed Crab Bycatch Modifications**
5. **Discussion Paper by Witherell and Harrington**

b. **Additional Crab Bycatch Proposals**

c. **Written Comments Received**

MEMORANDUM

TO: Council and Board of Fisheries Members

FROM: Clarence G. Pautzke
Executive Director

DATE: January 23, 1996

SUBJECT: Council Actions to Protect BSAI Crab

(a) Bering Sea Trawl Closures to Protect Crab

Pribilofs. Beginning in 1995, a year-round trawl closure area, named the Pribilof Islands Habitat Conservation Area (shown in Item 1), was implemented around the Pribilof Islands to protect stocks of blue king crab and hair crab so they may rebuild to exploitable levels. The Council adopted the closure area that provided the most benefit to crab populations and habitat, while least affecting trawl fisheries. Presently, the State is closing state waters by emergency order, and will submit a proposal for permanent closure on the next Board cycle.

Bristol Bay. In September 1995, the Council took final action on the Bristol Bay trawl closure area designed to protect red king crabs. The Council adopted a Red King Crab Savings Area (see Item 1) from 162° to 164°W longitude, 56° to 57°N latitude to be closed from January 1 to March 31 each year to all non-pelagic trawling. The area bounded by 56°00' to 56°10'N latitude will be opened during the years when a guideline harvest level for Bristol Bay red king crab is established. For 1996, this closure is being implemented to all trawling by the NMFS Regional Director using hot spot authority.

Crab Protection Areas. As shown in Item 1, the area between 160°W and 162°W, south of 58°N, Crab Protection Zone A, is closed to trawling year-round, except that cod trawling may be allowed in a narrow band of shallow water along the Alaska Peninsula. Crab Protection Zone B (an extension of Zone A west to 163°W) closes to trawling March 15-June 15, again except that cod trawling may be allowed in the southern portion. The cod trawling that is allowed in the southern reaches of the two zones is closed upon reaching a red king crab bycatch cap of 12,000 crabs.

Prohibited Species Bycatch Limitation Zones. These larger Zones 1 and 2, first implemented in 1987, are shown in the second figure in Item 1. Zone 1 has a *C. bairdi* bycatch cap of 1 million crabs and a red king crab bycatch cap of 200,000 crabs. Zone 2 has a 3 million crab bairdi cap. A halibut bycatch cap also controls groundfish fishing in these areas. In 1995, crab bycatch closures occurred in the Pacific cod trawl fishery on March 20, and in the yellowfin sole fishery on April 4; both were Zone 1 closures.

(b) Additional Crab Bycatch Proposals and Management Issues

In January 1995, the Council formed a committee to examine ways to rebuild red king, Tanner, and snow crab stocks in the Bering Sea. The committee met in March and synthesized available information on sources and magnitude of crab mortality and identified alternative management strategies the Council might use to enhance the survival of crab stocks and thus promote rebuilding. Minutes from that meeting are attached (Item 2). In addition to establishing the rebuilding committee, the Council has initiated three additional proposals to further control crab bycatch:

(1) Proposed Tanner Crab Bycatch Cap Transfers between Zones. During the June 1995 meeting, the Council directed staff to examine impacts of allowing greater flexibility in management of *C. bairdi* Tanner crab bycatch limits in prohibited species bycatch limitation Zones 1 and 2. Attainment of a trawl fishery allowance in Zone 1 may force fishing operations into Zone 2. Because Zone 2 typically has higher bycatch rates of halibut, there is increased potential for the halibut cap to close the entire BSAI to that fishery. Bairdi-related closures occurred in the yellowfin sole fishery in 1994 and the Pacific cod fishery in 1995, and may have been avoided with increased flexibility in the management of bairdi PSC limits between zones. An analysis has been drafted by NMFS that examines alternatives such as allowing transfers of the bairdi caps between zones, or combining the zones and creating a single annual limit of 4 million bairdi crab. The Council will review the analysis this week and may release it for public review.

(2) Proposed Northern Bristol Bay Closure. This analysis examines the effects of instituting a trawl closure area in the northeast section of Bristol Bay (north of 58°N and east of 162°W, as shown in the first figure in Item 1) to protect juvenile crab, seabirds, marine mammals, and spawning herring stocks. The alternatives and analytical outline are described in Item 3. The analysis is due for initial review in April.

(3) Proposed Crab PSC Modifications. This analysis examines the impacts of reducing the existing crab bycatch limits for groundfish trawl fisheries, and instituting a new bycatch limit for snow crab (*C. opilio*). The alternatives and analytical outline are described in Item 4. The analysis is due for initial review in April.

Dave Witherell of our staff, and Gretchen Harrington (NPFMC summer intern), prepared a discussion paper that makes a preliminary evaluation of these proposals from a crab rebuilding perspective (Item 5).

(c) Written Comments Received

These are batched in Item 6 under this tab and include the following:

1. January 19, 1996 letter from Deputy Commissioner David Benton requesting the Bristol Bay crab closure be extended to year-round.

2. November 7, 1995 letter from ABOF Chairman Larry Engel regarding the Bristol Bay closure.

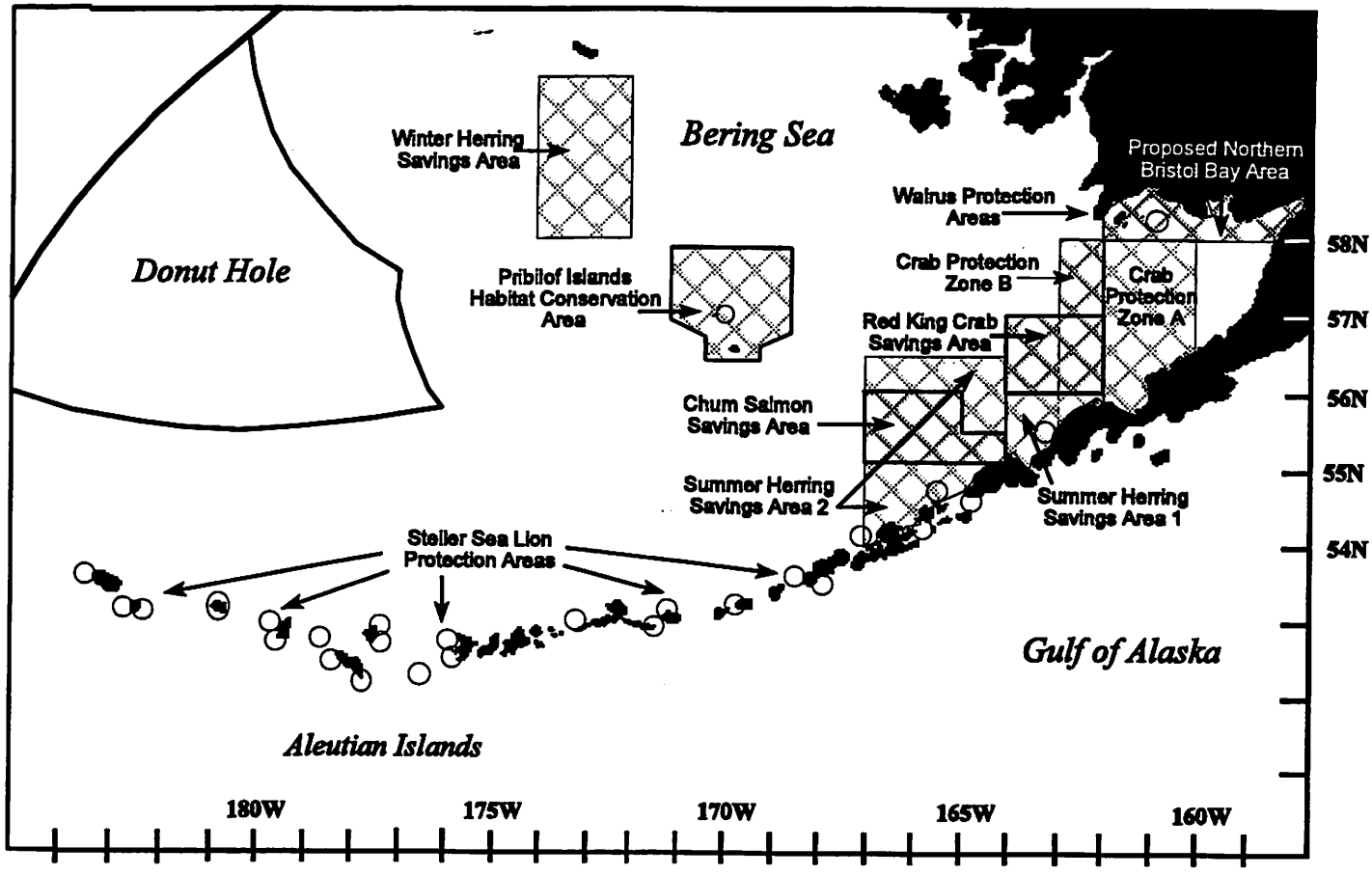
3. January 21, 1996 letter from Gordon Kristjanson regarding the Bristol Bay closure.

4. October 20, 1995 letter from PNCIAC regarding the Bristol Bay closure.

5. January 9, 1996 letter from United Catcher Boats (UCB) regarding crab protection and sources of mortality.

6. January 16, 1996 letter from American Factory Trawlers, Tyson Seafoods, and UCB regarding crab protection and sources of mortality.

Bering Sea Species Protection Areas



Proposed Northern Bristol Bay Area: closed year-round to all trawling (proposed).

Chum Salmon Savings Area: closed to all trawling August 1-31 with provisional extention to October 5.

Bristol Bay Red King Crab Area: closed seasonally to non-pelagic trawling.

Pribilof Islands Habitat Conservation Area: closed year-round to all trawling.

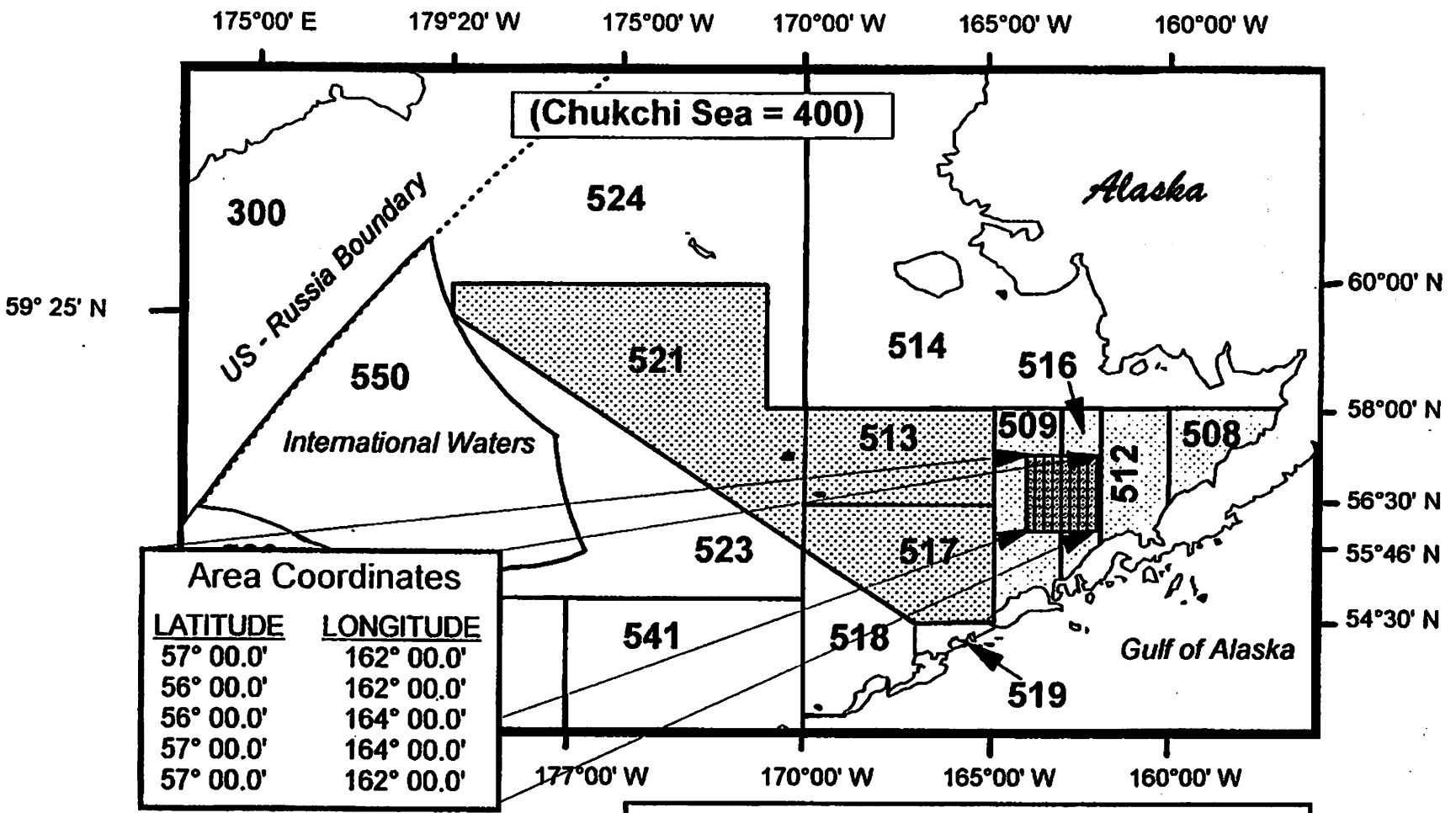
Crab Protection Zones: Zone A closed to trawling year-round.
Zone B closed to trawling March 15 - June 15.

Walrus Protection Areas: closed to all fishing April 1 - September 30.

Steller Sea Lion Protection Areas: closed to all trawling year-round with some extended seasonally on January 20.

Herring Savings Areas: closed to all trawling when trigger reached.
Summer Area 1 closed June 15 - July 1
Summer Area 2 closed July 1 - August 15.
Winter Area closed September 1 - March 1.

RED KING CRAB SAVINGS AREA



Area Coordinates

LATITUDE	LONGITUDE
57° 00.0'	162° 00.0'
56° 00.0'	162° 00.0'
56° 00.0'	164° 00.0'
57° 00.0'	164° 00.0'
57° 00.0'	162° 00.0'

BYCATCH PROTECTION AREAS

Zone 1 = 508 + 509 + 512 +516
Zone 2 = 513 + 517 + 521

Area 512 (160° - 162° W. long.) = No trawling year round
Area 516 (162° - 163° W. long.) = No trawling March 15 - June 15

1/96

Crab Rebuilding Committee Report:

Minutes of the BSAI Groundfish and Crab Plan Team Meeting March 21-22, 1995

Prepared by:
David Witherell

North Pacific Fishery Management Council
605 West 4th Avenue
P.O Box 103136
Anchorage, Alaska 99510

Note: *The Committee invites suggestions from the public regarding strategies the Council might use to enhance crab stock rebuilding. An informal feedback session is scheduled for Wednesday, April 19, at 7 p.m. Formal presentations are scheduled for April 20 to the SSC and AP, and April 22 to the Council.*

Draft Agenda

Joint Meeting of the BSAI Crab and Groundfish Plan Teams

8:30 a.m. - 5:00 p.m., March 21 - 22, 1995
Building 9, Rooms A&B, Alaska Fisheries Science Center
7600 Sand Point Way NE, Seattle, WA

I. Introduction

Dave Fluharty - proposed direction and focus of meeting

II. Status and Management of Bering Sea Crab Stocks

III. Bycatch Management in Groundfish Fisheries

current strategies, accounting, and observer methodology

IV. Sources and Magnitude of Crab Mortality

A. Direct sources
   crab fishery
B. Indirect sources
   bycatch in crab, groundfish, and scallop fisheries
      number of crabs bycaught by species
      size (age) of crab bycatch
      mortality rate of bycatch
C. Other sources
   unobserved mortality due to fisheries
      ghost fishing
      unobserved mortality by trawls, dredges, and pots
   predation
      e.g. sockeye salmon, yellowfin sole, rock sole, Pacific cod

V. Habitat Considerations

A. Critical habitat for crab stocks
B. Potential impacts of trawls, dredges, pots on habitat
C. Competition with fish for food
D. Physical environment effects on recruitment and mortality

VI. Alternative Management Strategies

strategies not otherwise presented through informal discussion

VII. Public Testimony

VIII. Plan Team Discussion

Information synthesis and recommendations
   determine how to structure the report
   determine the process and timing to complete work

Joint Meeting of the Bering Sea/Aleutian Islands Groundfish and Crab Plan Team

March 21-22, 1995

Members Present:

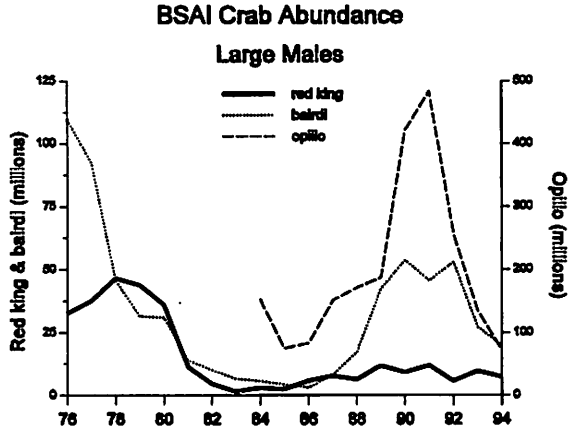
Groundfish Plan Team
Dave Ackley (ADF&G-Juneau)
David Colpo (NMFS-AFSC)
Loh-lee Low (NMFS-AFSC)
Richard Merrick (NMFS-AFSC)
Grant Thompson (NMFS-AFSC)
Farron Wallace (WDF)
Dave Witherell (NPFMC)

Crab Plan Team
Rance Morrison (ADF&G-Dutch)
Peggy Murphy (ADF&G-Juneau)
Bob Otto (NMFS-Kodiak)
Doug Pengilly (ADF&G-Kodiak)
Jerry Reeves (NMFS-AFSC)
Dave Witherell (NPFMC)
Gordon Kruse (ADF&G-Juneau, substitute)

The Bering Sea/Aleutian Islands (BSAI) Groundfish and Crab Plan Teams met jointly in Seattle beginning at 8:30 a.m. Tuesday, March 21, 1995. Council member Dave Fluharty chaired the meeting. The goal was to synthesize available information on sources and magnitude of crab mortality and ecosystem relationships and to identify alternative strategies the Council might use to enhance the survival of crab stocks and thus promote rebuilding. Discussion focused on Bristol Bay red king crab (*Paralithodes camtschaticus*), and Bering Sea Tanner crab (*Chionoecetes bairdi*) and snow crab (*C. opilio*) stocks. An information packet containing pertinent data and research reports was distributed to team members and industry representatives prior to the meeting. Active public participation and feedback were encouraged. The meeting format was to hear staff reports on each item, followed by questions and discussion. These minutes provide a synopsis of each staff report and a summary of the discussion that followed.

Status and Management of Bering Sea Crab Stocks

Bob Otto characterized the Bristol Bay red king crab, and Bering Sea Tanner and snow crab stocks as being in poor shape and declining based on the 1994 survey. Survey abundance estimates of large males in each of the three crab stocks are shown in the accompanying figure (note that Bristol Bay and Pribilof red king crab stocks are combined). The Bristol Bay red king crab fishery was canceled in 1994 due to low female abundance, which was below a threshold of 8.4 million females > 90 mm (3.5", the size at 50% maturity). Very few pre-recruit red king crab were detected in the survey. The survey also indicated low abundance of pre-recruit Tanner crab, as a high proportion of sublegal males (<140 mm) had reached terminal molt, and consequently most would never be harvested. [Jerry Reeves cited a laboratory study by A.J. Paul that showed 74% of pre-recruit sized Tanner crabs molted within 27 months. Bob and Gordon Kruse felt that AJ's results were non-representative, and Gordon indicated that his modeling studies showed a 20% molting rate for functionally mature males]. Although snow crab stocks were declining, a fair amount of pre-recruits was observed in the northern area.



Bob speculated that the crash in Tanner and red king crab abundances observed in the late 1970's and early

80's and subsequent poor recruitment may have resulted from large scale changes in the Bering Sea ecosystem. He noted population changes for crab in the eastern Bering sea that were much different than stable crab stocks observed in areas to the north. He also noted the dramatic increase in flatfish biomass and other changes that have occurred in groundfish populations. The teams discussed this at length the following day.

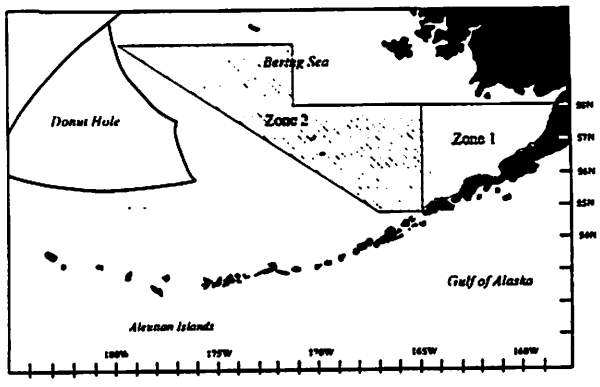
Rance Morrison provided a summary of crab fisheries management. The fishery management plan (FMP) for BSAI king and Tanner crab fisheries essentially defers crab management to the State of Alaska. The FMP establishes three categories of management measures: 1) fixed measures that require amendment to change, 2) frameworked measures that the State may implement and amend subject to FMP criteria, and 3) measures the State can implement and amend not subject to FMP criteria. To manage the BSAI crab fisheries, the State requires vessels to register with the state by obtaining licenses and permits, and register for each fishery and each area. Observers are required on all vessels processing crab in the BSAI. Pre-season guideline harvest levels (GHL) are established based on surveys or historical landings. GHLs correspond to exploitation rates of 20% for red king crabs > 120 mm, 40% for Tanner crabs, and 58% for snow crabs. Season opening dates are set through the Board of Fisheries to maximize yield per recruit and minimize handling of softshell crabs. Pot limits, based on vessel size, are currently 250 for vessels > 125 feet, and 200 for vessels < 125 feet. Minimum size limits (as measured by carapace width) in the Bering Sea are 6.5" for red king crab, 5.5" for Tanner crab, and 3.1" for snow crab. Only males are harvested.

Rance also reported on recent crab landings. The 1994 Bristol Bay red king crab fishery, which was scheduled to open on November 1, did not due to the low abundance observed by the NMFS bottom trawl survey. The survey indicated little prospect for increased recruitment of mature males or females, and female threshold (8.4 million mature females) was not reached. The fishery was also closed in 1983 due to low stock abundance. After re-opening in 1984, catches gradually increased to 20 million pounds in 1990, well below the record catch of 129.9 million pounds in 1980. The 1993 catch of red king crabs was 14.6 million pounds and worth $55 million. The 1994 Bering Sea Tanner crab fishery opened on November 1. The area east of 163 W was closed to minimize handling of red king crabs. Consequently, the GHL for Tanner crabs was set at 7.5 million pounds. A total of 7.6 million pounds were harvested during the 20 day fishery. Landings were down substantially from 1990, when 39.7 million pounds worth $45 million were landed. At an exvessel price of $3.75 per pound, the 1994 Tanner fishery was worth over $28 million. The 1995 snow crab fishery opened on January 15 with a preseason GHL of 55.7 million pounds of crab over 4". Although the legal size for opilio snow crab is 3.1" cw, current markets and processor prefer 4" crab. Over 255 vessels registered and caught 73.6 million pounds in the 32 day fishery. This fishery produced over 325 million pounds in 1991, but due to poor recruitment both GHL and landings have been reduced. Ex-vessel price, on the other hand, has sharply increased such that the 1995 fishery was worth over $191 million.

Bycatch Management in the Groundfish Fisheries

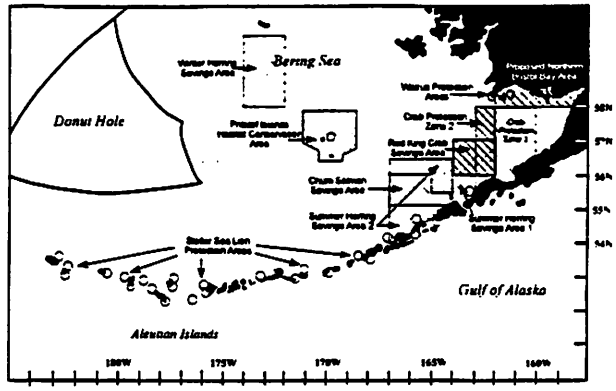
Dave Witherell described how crab bycatch is managed in groundfish fisheries. Among the objectives of the Bering Sea/Aleutian Islands (BSAI) groundfish fishery management plan is minimizing the impact of groundfish fisheries on crab and other prohibited species, while providing for rational and optimal use of the region's fishery resources. Prohibited species (all king crab and Tanner crab, halibut, herring, salmon, and steelhead) must be returned to sea as soon as possible. Prohibited species bycatch limitation zones and limits were set to control the number of red king crabs and *C. bairdi* crabs taken as bycatch each year. Bycatch limits for

Prohibited Species Bycatch Limitation Zones



trawl fisheries are set for each bycatch limitation zone, which are then apportioned among the various directed fisheries. Prohibited species catch (PSC) limits are 1,000,000 *C. bairdi* crab and 200,000 red king crab in Zone 1 and 3,000,000 *C. bairdi* crab in Zone 2. To optimize total groundfish harvest under established PSC limits, PSC is apportioned to directed trawl fisheries during the annual specification process. When a target fishery attains a PSC apportionment or seasonal allocation specified in regulations, the bycatch zone to which the allocation applies closes to that target fishery for the remainder of the season.

Bering Sea Species Protection Areas



Closed areas have been established to protect prohibited species and their habitat in the BSAI. The adjacent figure shows these areas, some of which are seasonal so that not all are closed simultaneously. Some of these areas were specifically closed to protect crab resources. Crab protection zones were implemented in 1987 to prevent the incidental catch of crabs in trawl fisheries. The Pribilof Islands Habitat Conservation Area was implemented in 1995 to protect blue king crabs and their habitat. The Bristol Bay Red King Crab Savings Area was closed by emergency order in 1995 to protect red king crab populations and habitat, and the Council is considering making this closure permanent. Another closure area in Northern Bristol Bay has been proposed to protect juvenile red king crabs.

Several other measures have been taken to reduce the incidental capture of crabs in groundfish fisheries including a vessel incentive program (VIP) and gear restrictions. The intended effect of the VIP program is to increase the opportunity to harvest groundfish TACs (quotas) before established PSC limits are reached. The VIP program is based on specification of bycatch rate standards that, when exceeded, constitute a violation of the regulations implementing the VIP. In the BSAI, bycatch rate standards were 2.5 red king crabs per ton of groundfish in the yellowfin sole and non-pollock trawl fisheries in Zone 1. It was noted that very few cases have been prosecuted for VIP violations, however. Gear restrictions have been implemented in the groundfish pot fishery to reduce the potential for ghost fishing by lost pots by requiring a biodegradable panel constructed of # 30 or less cotton thread that is a minimum of 18" long, parallel to and within 6" of the bottom of each pot. In the trawl fisheries, minimum mesh sizes regulations, that were recently adopted by the Council, may reduce the bycatch of juvenile crabs.

Bycatch Estimation Procedures

Martin Loefflad (NMFS-AFSC) reported on how data are collected by the observer program, and detailed the steps taken to produce estimates of crabs bycaught in groundfish fisheries. Observer coverage depends on vessel length: 100% observers on vessels > 125 feet, 30% coverage on vessels 60-125 feet, and 0% coverage on vessels <60 feet. Shoreside processors have 100% coverage. 100% coverage means that an observer is always onboard; it does not mean that every haul or landing is observed.

On trawl vessels, observers sample about 3 to 4 tows per 24 hour period, which equate to about 50-60% of the hauls observed on at sea processing vessels, which have 100% observer coverage. The tows to be sampled are pre-selected based on a random sequence. The two primary goals of biological sampling for the observer is to estimate total catch size and to determine species composition of the catch. Catch size is generally estimated volumetrically based on codend size and fullness. Species composition is estimated from basket samples or by whole haul samples. For basket samples, a 300 kg sample (about 8 baskets) is randomly taken from the catch (usually from holding bin below deck). The observer weighs each component of the sample. Crabs are counted and a portion of these sexed and weighed. Sampling for crab length frequency has not been a priority item for observers, and consequently data are sparse. Catch data are reported on a haul by haul basis to the NMFS-AFSC

Observer Program in Seattle, where the sampled haul data are extrapolated to the entire catch. From there, the information is forwarded to NMFS in-season management division, where it is run through the BLEND program to estimate total catch. The PSC bycatch rate observed is then applied to total catch to get the number of PSC bycaught that is reported on the Bulletin Board and used for bycatch management.

Estimates of crabs taken as bycatch assume that basket samples are representative of entire hauls. Dr. Pennington (NMFS) is comparing the accuracy of basket sampling versus whole haul sampling at the Alaska Fisheries Science Center.

Rance Morrison briefed the teams on the State observer program for directed crab fisheries. The State observer program was promulgated in 1988 to enforce minimum size limits, and has since expanded to include biological sampling. The observer program operates on a third party contract like the groundfish program, and observers are briefed and debriefed in Dutch Harbor. Catcher/processors and floating processors require 100% observer coverage. Observers randomly sample 4-10 pots per day. The entire catch is counted and sexed, and a subsample is measured. Bycatch is estimated from the CPUE of observed pots and the number of pots lifted.

Bycatch Estimates

Rance Morrison summarized information on crab bycatch in directed crab fisheries. Length frequency data are available by species, sex, and shell condition. Crab bycatch includes females of target species, sublegal males of target species, and non target crab species. Beginning in 1993, the Tanner crab season opened on November 1 to coincide with the red king crab fishery, This allowed retention of legal males of both species, thereby reducing bycatch. Prior to 1993, the Tanner crab fishery opened 7 days after the Bristol Bay red king crab fishery closed. Additionally, some legal size male Tanner and snow crabs were retained when fishing seasons overlapped (prior to 1994/95). A regulation instituted in 1993 to restrict tunnel openings to a 3" maximum has reduced the bycatch of red king crab in both Tanner and snow crab fisheries. For example, king crab bycatch in the Tanner crab fishery showed a 84% reduction from 1992 to 1993.

Crab bycatch in the 1992 and 1993 directed crab fisheries is summarized in the tables below. Note that the snow crab fishery catches few non-target crabs, in part because snow crab females do not grow very large. The snow crab fishery also concentrates further to the north than other crab fisheries. Bob Otto noted that research is being conducted on escape vents (rings) that would further filter out sublegal male and female Tanner crab, as well as reduce bycatch of non-target species. Gordon noted that ADF&G is supporting a study by UA on red king crab behavior in relation to pot design. Significant progress has been made to reduce bycatch and results are expected within the year. A regulation scheduled to be implemented in September 1995 will require all king crab pots in Bristol Bay to have at least one-third of one vertical surface of the pot composed of not less than 7.75" stretched mesh webbing.

Crab Catch and Bycatch in Directed Fisheries, 1992

	Red king crab fishery	Tanner crab fishery	Snow crab fishery
legal males*	1,070,472	14,629,181	267,767,184
non-legals	4,714,194	25,958,176	6,024,441
red king crab	--	1,477,695	33,731
Tanner crab	1,543,952	--	14,740,655
snow crab	20,586	2,758,365	--
hybrid**	NR	886,617	8,459,854

Crab Catch and Bycatch in Directed Fisheries, 1993

	Red king crab fishery	Tanner crab fishery	Snow crab fishery
legal males*	2,022,165	7,209,948	228,487,123
non-legals	5,502,508	18,150,624	4,563,916
red king crab	--	233,272	24,465
Tanner crab	3,968,374	--	6,700,215
snow crab	20,012	1,485,835	--
hybrid**	NR	293,428	9,613,355

*refers to commercial size (>4") males for snow crab.
**hybrid = opilio X bairdi crab

Dave Witherell provided a summary of red king crab, Tanner crab, snow crab bycatch in the Bering Sea and Aleutian Islands area (BSAI) groundfish trawl, pot, and hook and line fisheries. Although length frequency data have been collected by observers when time permits, data are limited. Therefore, bycatch of crabs from various fisheries could not be compared on the same scale (such as adult equivalents). Bycatch of crabs in the 1992-1994 BSAI groundfish fisheries is shown in the table below.

Crab Bycatch in Groundfish Fisheries

Year	Red king crab	Tanner crab	Snow crab
1992	179,348	4,292,033	17,662,549
1993	248,550	3,421,826	14,760,722
1994	281,023	2,544,982	12,482,127

Dave compared the number of crabs taken as bycatch to the total population size as determined from the trawl survey. Bycatch accounted for a low percentage of crab abundance: red king crab 0.5 - 0.8%; Tanner crab 1.0-1.3%, and snow crab 0.1-0.2%. Bob noted that the survey was not designed to estimate abundance indices for immature crabs, and indices for small crab are probably the least reliable. The total survey estimate is simply the sum of indices for each size group and is not representative of the total population. Bob further noted that bycatch limits were not derived based on survey estimates.

In January, the Council's Scientific and Statistical Committee (SSC) recommended that estimating mortality in terms of adult equivalents would provide better estimates of bycatch impacts across fisheries. The difficulty, of course, is the limited amount of length frequency data that are available. It was noted that although length frequency data were sparse, some information has been gleaned from the observer program. For example, based on crab distribution and trawling effort, one would predict that red king crab bycatch consisted primarily of legal sized males. Average size of red king crab males bycaught in 1989 JV groundfish fisheries was 132 mm carapace length, as reported by Armstrong. Dave Ackley's preliminary analysis of red king crabs taken in recent trawl fisheries agrees with these results. The team agreed that all red king crab bycaught in trawl fisheries could thus be considered adult equivalents, as every indication is that bycatch consists of large mature crab. For snow crabs,

preliminary analysis of observer data indicated that bycatch consisted of small (40-80 mm) individuals, although a good proportion of these would be mature (50% maturity = 65mm (♂) and 50 mm (♀)). Length frequency information for Tanner crabs taken as bycatch in the groundfish fisheries has not been examined.

Doug Pengilly summarized crab bycatch management in the BSAI weathervane scallop fishery. Crab bycatch caps were instituted for the scallop fishery beginning in 1993, along with a mandatory observer program (100% coverage). In areas other than the Bering Sea, crab bycatch caps were set at 1% of the population if the crab fishery was open, and 1/2% the population if the crab fishery was not open. In the Bering Sea, caps were not set based on crab biomass because the numbers would be astronomical relative to other caps. Instead, the caps were set at a rate that ADF&G determined could be accommodated, and extrapolated out based on the projected number of vessels and length of season. For 1994, Bering Sea crab caps were 260,000 Tanner crab (all species) and 17,000 red king crab.

Bycatch in the 1993 Bering Sea scallop fishery totaled 276,500 Tanner crabs, 15,000 snow crabs, and one king crab. The original report contained an estimate of 212 red king crab, but when Doug re-edited the data last week, he discovered that there was only one king crab actually observed. The fishery occurred south and west of the red king crab population. Scallop dredges apparently catch all sizes of Tanner crabs > 20 mm; in the Bering sea, most crab taken were > 60 mm in carapace width. About 11.3 % of the Tanner crabs were observed to be dead and about 26% had new injuries. The largest and smallest crab had the highest mortality rates. For large Tanners, mortality was related to number of injuries which were dependent on size. Bycatch of snow crabs consisted of very large crabs (most 100 mm - 140 mm). About 19% were moribund when observed. Of the 20 red king crabs bycaught in scallop fisheries throughout Alaska, 2 were moribund.

Bycatch Mortality

Gordon Kruse briefed the teams on crab bycatch mortality studies. Gordon and Peggy Murphy are publishing a bibliography on handling mortality studies of crabs and lobsters done around the world. There are a variety of effects from sublethal (reduced growth rates, molting probabilities, visual acuity from bright lights, and vigor) to lethal effects. Studies have shown a range of mortality due to handling based on gear type, species, molting stage, number of times handled, temperature, and exposure time.

Several studies have been done on Dungeness crabs. One study showed that handling mortality was 20-30% for softshell crabs held over a 4-6 day period; mortality of hard shell crabs was only 1-9% over the same period. Softshell crabs handled 3 times had a 41% mortality, whereas those handled only once had a 23% mortality rate. A study on discard mortality of Dungeness crab done in Alaska by Tom Shirley showed that crabs handled 4 times had 100% mortality over a 4 month period. The control crabs had a 10% mortality. Tag studies also have shown higher mortality for softshell and injured crabs.

Studies on red king crabs indicate that bycatch mortality in pot fisheries may be low. A study by Shijie Zhou and Tom Shirley simulated the catching and discard of red king crabs held over a 3 month period. Controls were also held over the same period. No significant difference in mortality was found across treatments and no difference in feeding rates, righting times (time for crabs to turn over), or bacterial counts was observed. Injury rates were directly related to the number of times handled. Doug Pengilly and Leslie Watson tagged 4,000 crabs during a test fish project to compare mortality of crabs returned to the sea in the most careful manner (control) versus those thrown off the deck while the vessel was moving (treatment). Return rates (27%) were nearly equal indicating that the discarding did not affect recovery rates, and hence no bycatch mortality due to discard procedure.

Other work has been done with Tanner crabs. Bob Otto described NMFS experiments in which Tanner crab were dropped either once or four times from about 2.5 m, as well as crabs that weren't dropped (controls), and held them for two months. No significant difference in mortality among treatments was observed. Another test was

conducted to measure the impact of injuries (leg loss, cracked carapace) on subsequent mortality, and again found no significant difference in mortality among treatments, including controls. Preliminary results from another experiment underway indicates that crabs do not suffer additional mortality from being brought to the surface multiple times. Bob noted that in all these studies, mortalities are similar to the rates estimated by natural mortality (M = 0.3).

A study of red king crabs and Tanner crabs found that mortality was related to air temperature and exposure duration. Exposed crabs exhibited reduced vigor and righting times, feeding rates (Tanner crabs), and growth (red king crabs). For surviving females, there was no impact on eggs or larvae. Cold air resulted in leg loss or immediate mortality for Tanner crabs, whereas red king crabs exhibited delayed mortality, which occurred during molting. A relationship was developed to predict mortality as the product of temperature and duration of exposure. It was noted that the temperatures used in the tests were not considered extreme cold for BSAI crab fisheries.

A study on the mortality of trawl caught red king crabs and Tanner crabs done by Brad Stevens found that on average, 21-22% of the bycaught crabs held in tanks over a 2 day period survived. One of the factors that determined survival was captivity time, which was the sum of towing time and processing time. At 3 hours captivity time, the mortality rate was zero; after 17 hours, mortality was 100%. Shell age was also a factor, with new shell crabs having lower survival. It was noted that other factors affecting bycatch mortality have not been tested. Other factors include predation on discarded crabs, discarding in unsuitable habitat, etc..

Unobserved Mortality

The team discussed the unobserved impact of trawling on crab stocks. One concern was that trawling could scatter crabs by breaking up pods and exposing crab to predation or leaving them in an unsuitable area. Another concern was the effects of trawls and dredges running over or filtering crabs and perhaps injuring or killing them. Studies done in other areas indicate that impacts on crabs may be none to major. In general, the heavier the gear, the larger the impact. There is hope that laser line technology may be the ticket to examining trawl impacts, and ADF&G is pursuing this research. These lasers have the precision to actually get measurements of crab even in turbid conditions.

Gordon Kruse reported on unobserved mortality and ghost fishing in the pot fisheries. Ghost fishing is the term used to describe mortality caused by lost or derelict gear. "Catching mortality" is ascribed to those crabs that enter a pot and are eaten by other pot inhabitants before the pot is retrieved. Gordon discussed how catching mortality may happen in some Dungeness crab fisheries that occur during the molting period, when crabs are more susceptible to cannibalism. Other crab fisheries are set to occur outside of the molting season, and catching mortality in these fisheries may be limited to octopus or large fish entering a pot. Because no evidence of crab is left in the pot, these mortalities remain un-assessed.

The impact of ghost fishing on crab stocks remains unknown. It is estimated that 10-20% of crab pots are lost each year. [About 10,000 pots were estimated lost in the 1992 Bristol Bay red king, and Bering Sea Tanner and snow crab fisheries combined.] Fewer pots are expected to be lost under pot limit regulations and shorter seasons. It was suggested that data on lost pots and their contents could be extracted from NMFS trawl survey logs and observer database. Some high resolution side-scan sonar work done by NMFS Kodiak mapped the distribution of lost pots in Chiniak Bay. A total of 284 crab pots were found in inner Chiniak Bay alone. NMFS plans to observe these pots directly with a submersible and ROVs this spring, and this study may yield information on ghost fishing by crab pots.

Since 1993, the State has required crab pots be fitted with degradable escape mechanisms consisting of #30 cotton thread or 30-day galvanic timed release (GTR) mechanisms. A #30 cotton thread section is also required in groundfish pots. The average time for #30 cotton twine to degrade is 89 days, and the GTR about 30 days to

degrade. This is somewhat of a tradeoff between degradability and the amount of time required of fishermen to replace the biodegradable section. Biodegradable escape mechanisms have been required for some years, but prior to 1993, maximum allowable twine size was considerably larger.

Crabs captured in lost pots may die of starvation or predation. Gordon reported on two studies of Tanner crabs; one indicated that about 10% of the crabs died of starvation in 90 days and the other study observed 39% mortality after 119 days. In the first study, the 90% that had survived were subsequently fed, but all died anyway.

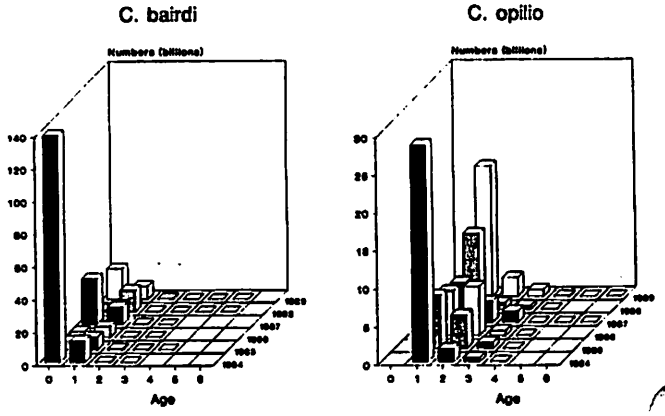
Bob Otto estimated that mortality of crabs caused by "pot bombing" was extremely minor, based on some earlier calculations of number of pots and area they occupy relative to the Bering Sea. Pot bombing is a term used to mean a pot landing on the ocean floor when it is being set, presumably impacting any crab on which it lands.

Predation and Competition

Pat Livingston (NMFS-AFSC) reported on predation and competition of crabs and groundfish. She noted how the total biomass of inshore benthic infauna consumers (starfish, crabs, flatfish) has increased about 40% from 1979-1993. Most of this increase is attributable to a growing rock sole biomass, and to a lesser extent starfish and flathead sole biomass. Of the crab species, only snow crab comprises a substantial portion of the infauna consumer guild (species that eat clams, polycheates, etc.). Yellowfin sole had dramatically increased in abundance in the early 1980's to become the largest component of this guild until the early 1990's when rock sole became co-dominant. Mean size at age has declined for yellowfin sole and rock sole, indicating stress caused by competition with rock sole, and to a lesser extent a decrease in average bottom temperature. Reduced mean size at age has also been observed for halibut. Unfortunately, a survey of infaunal biomass has not been conducted since the 1970's, so we don't know what or how much food is available. Crab eat small clams, marine worms, brittle stars, sand dollars, and other echinoderms.

Several studies have examined the relationship of crab abundance with predators and competitors. Pat found a significant inverse relationship in red king crab recruitment and the exploitable biomass of yellowfin sole. Vidar Wespestad and others found a significant inverse relationship between the abundance of sockeye salmon smolts and subsequent red king crab recruitment. One team member recalled that Don Rogers (U.WA) has sockeye smolt samples collected off Port Moller and is planning to examine stomach contents, which may provide additional information on predation of crabs by sockeye salmon.

Pat has also estimated the number of crabs eaten based on groundfish stomach samples from the 1984-1989 summer bottom trawl surveys. Annual consumption of snow crabs from May through September ranged from 11 billion to 31 billion crabs. Snow crabs consumed were primarily age 1, and to a lesser extent age 2 and 3 crabs. Impacts of predation on crab stocks were measured by examination of the instantaneous annual natural mortality coefficient by age, obtained from reconstructing population sizes of ages 0-2 using survey estimates of population size at age 3. Estimates range from 0.41 to 1.77 for Age 1 snow crabs, and 0.14 to 1.53 for age 2 snow crabs for the years 1984-1989. Pacific cod was the primary predator, particularly on older crabs. Flathead sole, yellowfin sole, and rock sole were also found to be predators on younger snow crabs.



Annual consumption of Tanner crabs by groundfish ranged from 10 billion to 153 billion crabs, consisting primarily of Age 0 and Age 1 crabs. Instantaneous

annual natural mortality coefficients ranged from 0.26-2.92 for age 0, 2.92-3.22 for age 1, and 0.93 to 2.69 for age 2. Yellowfin sole and flathead sole were found to be the primary consumers of Tanner crabs < 20 mm. Pacific cod also preyed on young crabs, and were responsible for all of the larger (20-35 mm) Tanner crabs consumed. The figure above shows the number of Tanner and snow crabs consumed by age, May through September. Consumption during other times of the year has not been estimated.

The little information concerning predation on red king crab suggests that mortality caused by groundfish predators may be low. Pat found red king crab in some Pacific cod stomach samples, but the numbers were low. It was noted, however, that sampling occurs in the summer, when king crabs have hard shells and less vulnerable to predation.

Habitat Considerations

Dave Ackley and Bob Otto summarized available information on crab habitat requirements. Juvenile red king crabs < 18 months old are solitary and cannibalistic, and require habitat that provides protection. Habitat is characterized as relatively shallow (20-60 m) with rocks, shell hash, and biological cover. In the Bering Sea, age 1 juveniles occur along the Alaska Peninsula, and around Kvichak and Togiak Bays as shown in the accompanying figure from Armstrong (1993), and likely in other areas not sampled. One study found small red king crabs exhibit a patchy distribution from the east end of Unimak Island to Port Moller, and are associated exclusively with stalked ascidians, bryozoans, and other living substrates. Age 2-4 red king crabs form pods and progressively move to deeper waters and away from protective nearshore habitat. Adult red king crabs occupy deeper waters with sand/silt bottom. Both adult and juvenile Tanner and snow crabs apparently utilize mud bottom habitat throughout the BSAI.

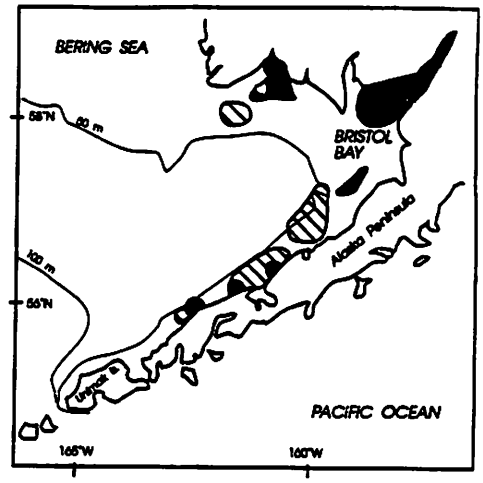


Fig. 5. Areas of the southeastern Bering Sea with substrate of more than 10% gravel (shading) during surveys in 1983 and distribution (cross-hatching) of early juvenile (age 0+ to 1+ yrs) RKC collected at the same time. Redrawn from McMurray et al. 1984, fig. 3.1–14 and 3.5–4, 5, 6a.

Red king crabs in Bristol Bay begin spawning as early as January and typically finish in June. It is thought that first time spawners spawn the earliest, and the older crabs later in the season. Males molt at least two weeks prior to female molting and egg extrusion. [Males do not have to molt to mate, however.] Peak hatching occurs in mid-May and the zoea and megalopae (glaucothoe) drift and swim in the currents. Zoea are nocturnally active and exhibit diel vertical migrations. Tidal currents move northward along the Alaska Peninsula and into Bristol Bay. Gordon suggested that dominant tidal currents may assist in retaining crab larvae in the Bristol Bay area; however, wind driven currents do move larvae and these currents may have shifted in the late 1970's due to a climatic phenomenon. Settling of larvae occurs in July and August. To survive, the juveniles need structure to avoid predation by fish and each other. Early juveniles have even been observed to hide between starfish arms during the day.

Dave Witherell and Gordon Kruse reviewed studies on the potential impacts of fishing gear on crab habitat. Studies indicated that all gear used to harvest aquatic resources may have some potential to adversely affect crabs and other organisms comprising benthic communities, and the magnitude of these effects are presumably linked to fishing effort, gear type, and substrate. The primary ways in which trawling and dredging can disrupt the habitat: 1) scraping and plowing the sea-floor, (2) sediment re-suspension and redistribution of sediment layers, (3) damaging or removing non-target benthic organisms, and (4) dumping of processing waste. Generally, the heavier the gear in contact with the seabed, the greater the damage. The effects vary greatly, depending on the amount of gear contact with the bottom, together with the depth, nature of the seabed, and the strengths of the

currents or tides. Overall, studies show that bottom trawling and dredging have an impact on the environment, but that the extent and duration of that impact varies from severe to minimal. Although no studies have been done on longline or pot gear, these gears may also impact habitat by sediment re-suspension and upending small rocks, shells, ascidians, bryozoans, and other bottom structure during the process of setting and retrieval. Submersible observations in the Gulf of Alaska showed that longlines snag on whatever objects are in its path, including rocks and corals, which may be dragged across the seafloor, upended or broken.

Alternative Management Strategies

Team members and participating public suggested some strategies the Council might consider pursuing to assist crab stock rebuilding.

It was generally agreed that minimum spawning stock sizes need to be maintained to provide a possibility of rebuilding, particularly for the Bristol Bay red king crab stock. A plan needs to be developed that would protect a strong year-class when one comes along. ADF&G is placing high emphasis on maintaining spawning stocks. A new analysis using stock reduction and a length-based model has indicated that perhaps threshold biomass for Bristol Bay red king crabs has been set too low. ADF&G is considering increasing the spawner threshold to 12 million females > 90 mm.

The team also discussed protecting areas of critical habitat. Areas to be closed may include those areas where crabs are congregated or nearshore habitat for juveniles. Other and perhaps less discrete areas could be closed during times when crabs are molting. One team member suggested that for adults, the time of year was a critical aspect for closures. For juveniles, it may be more important to close areas with appropriate habitat. Someone also suggested that perhaps instead of closing areas, we should designate open areas. Areas with historically low bycatch rates could be opened to bottom trawling to increase the harvest of flatfish stocks without impacting crab stocks. Outer Kuskokwim Bay was cited as one possible area that this might be able to occur (halibut bycatch may be a problem at times here, however). The possibility was raised that trawling was in part responsible for increasing the biomass of crab predators by mixing nutrients, exposing food, and providing food in the form of discards.

There was considerable discussion about reducing stocks of Pacific cod and flatfish that may prey on crabs. One person suggested that the 2 million mt optimum yield (OY) cap set for the Bering Sea be re-examined to allow increased harvesting of flatfish; the mechanism suggested would be to decouple pollock from the OY cap. Another team member pointed out that an increase in flatfish TAC could be made under the existing management system and OY cap; however, the Council may need to reduce pollock TAC and increase flatfish TAC. It was agreed that bycatch of halibut may be limiting, however.

All of these alternatives imply a fair amount of research and analysis. Plan team members and participating public identified areas of research to answer questions regarding factors affecting crab stock recovery. In other cases, we were left with questions. These research needs are listed in the order they were discussed, and have not been prioritized.

- What is the natural variation in crab population size; how would the population fluctuate in the absence of fishing? Also, how has fishing changed these dynamics? It was suggested that in the long term, environment plays the biggest role in population fluctuation. One team member suggested that core samples be analyzed to determine historical population sizes of fish and crab (Bob noted that this is probably not possible for crab). This work may be done by F.R.I.

- Define areas of critical habitat for crabs, so that they can be protected. The group recommended literature and survey data be compiled to identify known areas of critical habitat in the Bering Sea. Additional and specialized surveys would be needed.

- Examine potential habitat alterations and impacts caused by trawl and dredge gear. Laser line technology may provide some answers here.

- Examine larval transport to see where they are being carried. Some type of seasonal collector system was suggested.

- Would a comprehensive rationalization program or other program resolve bycatch problem?

- Develop or modify gear and fishing behavior to reduce bycatch or impacts. It was suggested by industry that bigger discs on the footrope with wider spacing would catch less crabs. Shorter tows and pre-sorting were suggested to reduce mortality of those discarded.

- Examine changing seasons to reduce bycatch rates. For example, industry suggested that rock sole roe can be processed in December when they may be in areas with low crab bycatch.

- Examine the effects of existing area closures, which result in crowding the fleet and chumming, on crab bycatch rates. The new closed areas in 1995 may provide a comparison. Also, see what effect the pot sanctuary and 12 mile closure area had on foreign fisheries.

- Examine time area closures relative to crab molting periods.

- Repeat the survey of benthic infauna that was conducted in the 1970's. See if there was a change in standing stock of infaunal invertebrates.

- Collect information on bycatch and incorporate into models in the same units, such as adult equivalents. Information on crab length frequency by sex needs to be collected and examined.

- Urge the observer program to examine existing length frequency data to provide some information we can use now.

- Conduct food habit studies year-round. Current predation studies are limited by data collected only in the summer on research surveys. Current estimates may not be accurate depending on when crabs molt. For example, predation on red king crabs may be underestimated because their shells are hard in the summer. Perhaps collections by observers could be made, or have biologists collects samples from trawlers.

- Determine how heavily predators would need to be fished to increase crab recruitment.

- Compare BSAI ecosystem and management with other systems. Has the closed area in Kamchatka prevented crab population declines? What factors allowed transplants in the Barents Sea to establish a viable population? How about comparing the Bristol Bay stocks to those around Kodiak and Southeast Alaska? Even within SE Alaska, certain bays have high crab populations, whereas others nearby are at all time lows; why?

- The disproportional harvest rates of groundfish may have had some impact on crabs. It would be helpful to construct a history of exploitation rates relative to groundfish ABCs. How many crabs would have been consumed each year if groundfish had been harvested at ABC levels?

- Measure the precision of crab bycatch estimates from the observer program. How precise are estimates obtained from basket samples?

- Determine the proportion of crabs encountered by trawls that are actually captured. What happens to crabs not retained by the net?

- Examine the entire issue of bycatch caps. Where did they originate and what do they mean relative to crab stocks and groundfish catch? If bycatch caps are needed, what should they be? Should caps fluctuate with biomass?

- Examine market solutions to bycatch. Would IFQs or individual bycatch quotas (IBQs) reduce crab bycatch?

- Consider that Bristol Bay is not a closed system. Do stocks in the Gulf of Alaska contribute to recruitment in the Bering Sea.

- Have observers examine pots caught in trawl gear. How many pots encountered? For those brought aboard, how many had biodegradable panels and were they still fishing? How many crabs were in the pots? How did the vessel get rid of the pot; was it full of fish and set back baited? Was the pot discarded in a fishable condition? Also check NMFS survey for lost pot data.

- Determine crab bycatch mortality rate and examine ways to improve survival of discarded crabs.

- Examine the potential of sonar (Roxanne device?) to map substrate in the BSAI to define areas of critical habitat.

- Investigate potential changes to crab management strategies, such as gear modifications or changes to the sex and size restrictions.

- Add observers to crab catcher vessels to compare data with catcher-processors. The vessels likely fish quite differently in terms of areas fished, soak times, and may thus have different bycatch.

- Examine effects of a Sea State type program on reducing crab bycatch in the groundfish fleet, so that areas with high bycatch rates can be voluntarily avoided.

Recommendation and Information Synthesis

The teams were asked to comment on the proposed area closure in Bristol Bay designed to protect red king crabs. A 90 day emergency rule (ER) closing this area to trawling is scheduled to expire April 28. The ER can be extended for an additional 90 days. Although the teams did not make a recommendation regarding extension of the ER, it was noted during the discussions that some molting and spawning would occur during this time period, and that crabs in the closure area were primarily mature crabs. At the April meeting, the Council will review an analysis of making this closure permanent. The teams recommended that if the Council needs to take action, that they don't make the closure permanent until other options for crab rebuilding are examined. A closure with a sunset after 1 year (and the possibility of extension) could be considered until a more comprehensive program is developed.

The team discussed how this information would be synthesized and presented to the Council. It was agreed that Dave Witherell would prepare meeting minutes for presentation at the April Council meeting. Dave Fluharty suggested that we have an informal meeting with the public during a night at the April Council meeting as a means of getting additional feedback and suggestions. If the Council wants the teams to flesh out more details of potential rebuilding options, then an additional meeting of the group would be required, and a full report from the group would be finalized and presented to the Council in September.

The meeting adjourned at about 5 p.m. on Wednesday, March 22.

Others in attendance were:

Bill Karp
Martin Loefflad
Sue Salveson
Chris Blackburn
Gretchen Harrington
Laure Jansen
Brent Paine
Pat Livingston
Ken Tippett
Gordon Blue
Arni Thompson
Tom Casey
Garry Loncon
Joe Terry
Rich White
Mark Kandianis
Teressa Kandianis
Vince Curry
Dave Benson
Wally Pereyra
Seth Macinko

Literature Review

Copies of the following reports were distributed before and during the meeting. Papers distributed before the meeting are identified by Agenda Item and reference number.

Agenda Item II

(1) ADF&G. 1995. Report to the crab and groundfish plan teams, March 21-22, 1995. 7p.

(2) NPFMC. 1994. Description of crab FMP.

(3) B.G. Stevens, J.A. Haaga and R.A. MacIntosh. 1994. Report to industry on the 1994 eastern Bering Sea crab survey. NMFS, Kodiak. 29p.

(4) Otto, R.S. 1990. An overview of eastern Bering Sea king and Tanner crab fisheries. Proceedings of the International Symposium of King and Tanner Crabs. Alaska Sea Grant College Program, UAF. p. 9-26.

Agenda Item III

(1) NPFMC. 1995. Exerpts from: Fishery management plan for the Bering Sea/Aleutian Islands groundfish. Chapter 14.

(2) NPFMC. 1995. Draft regulatory and closure areas for the groundfish fisheries in the Bering Sea and Aleutian Islands. 14p.

(3) Kruse, G.H. 1991. Issues paper: the application of basket sampling methods to estimate bycatch rates of prohibited species aboard domestic fishing vessels. ADF&G, Juneau, AK. 7p.

(4) Smith, T.P. 1993. Allocating the incidental catch of crab, halibut, herring, and salmon in the groundfish fisheries off Alaska. Proc. of Int. Symp on Mgmt. Strategies for Exploited Fish Populations. 93: 745-760.

Witherell, D.B. 1995. Management of crab bycatch in the BSAI groundfish fisheries. March 1995. 4 p.

Thompson, A. 1989. An industry perspective on problems facing the rebuilding of king and Tanner (bairdi) crab stocks of the eastern Bering Sea. Proceedings of the International King and Tanner Crab Symposium. 533-545.

Hughes, S. 1995. Testimony of United Catcher Boats on crab bycatch and crab management to the North Pacific Fishery Management Council, January 1995. 12 p.

Agenda IV (A)

(1) Morrison, R., R. Gish. 1994. Bering Sea/Aleutian Islnads crab fishery reports by management area: Bristol Bay red king crab (Statistical Area T), Bering Sea Tanner crab (Statistical Area J). ADF&G. 34p.

Agenda Item IV (B)

(1) Armstrong, D.A., T.C. Wainwright, G.C. Jensen, P.A. Dinnel, and H.B. Andersen. 1993. Taking refuge from bycatch issues: red king crab (Paralithodes camtschaticus) and trawl fisheries in the eastern Bering Sea. Can. J. Fish. Aquat. 50: 1993-1999.

(2) Murphy, M.C., G.H. Kruse. 1995. Excerpts from: an annotated bibliography of capture and handling effects on crabs and lobsters. ADF&G, Juneau, AK. 13p.

(3a) Pengilly, D., L. Watson. 1994. Summary and review of Bristol Bay red king crab tagging studies, 1990-1994. ADF&G, Kodiak, AK. 1p.

(3b) Zhou, S., T.C. Shirley. 1994. Abstract - Effects of handling on feeding, activity and survival of red king crabs. Juneau Center, School of Fisheries & Oceans, UAF, Juneau, AK. 1p.

(3c) Stevens, B.G., R.A. MacIntosh. 1993. Preliminary results of the 1992 survival experiment for crabs discarded from commercial pot fisheries. NMFS, Kodiak, AK. 2p.

(3d) Carls, M.G., C.E. O'Clair. 1989. Abstract - Influence of cold air exposures on ovigerous red king crabs (Paralithodes camtschatica) and Tanner crabs (Chionoecetes bairdi) and their offspring. Proc. Int. Symp. King and Tanner Crabs. p. 329.

(4) Kruse, G.H. 1994. Excerpts from: Fishery management plan for commercial scallop fisheries in Alaska. ADF&G, Juneau, AK. 12p.

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

(6) Carls, M.G., C.E. O'Clair. 1994. Responses of Tanner crabs, Chionoecetes bairdi, exposed to cold air. Fishery Bulletin 93:44-56.

(7) Tracy, D.A. 1994. Excerpts from: Alaska Department of Fish and Game Biological Summary of the 1992 Mandatory Shellfish Observer Program Database. ADF&G, Kodiak, AK. 44 p.

(8) ADF&G, NMFS Staff. 1994. Draft Discussion Paper - An analysis of red king crab bycatch in the Bering Sea with alternatives for trawl closures. ADF&G, NMFS. 48p.

(9) ADF&G Staff. 1994. Addendum to the draft discussion paper: An analysis of red king crab bycatch in the Bering Sea with alternatives for trawl closures. ADF&G. 22p.

Witherell, D.B. 1995. Bycatch of Red King Crab, Tanner crab, and snow crab in the BSAI groundfish fisheries. March 1995. 9 p.

Agenda Item IV (C)

(1) Kruse, G.H., A. Kimker. 1993. Excerpts from: Degradable escape mechanisms for pot gear: A summary report to the Alaska Board of Fisheries. ADF&G, Juneau, AK.

(2) Urban, D., D. Pengilly, and I. Vinning. 1994. Excerpts from: The scallop observer program and statewide data analysis summary to the Board of Fisheries. ADF&G: 4K94-28.

(3) Livingston, P.A. 1989. Interannual trends in Pacific cod, Gadus macrocephalus, predation on three commercially important crab species in the eastern Bering Sea. Fishery Bulletin 87:807-827.

(4) Westpestad, V.G., P.A. Livingston, and J.E. Reeves. 1994. Juvenile sockeye salmon, (Oncorhynchus nerka) predation on Bering Sea red king crab (Paralithodes camtschaticus) larvae as a cause of recruitment variation. ICES C.M. 1994/R: 10.

(5) McLellan, G.L., J.K. Leong. 1981. Summer food of Pacific cod, Gadus macrocephalus, in coastal waters of Southeastern Alaska. Fishery Bulletin 78(4): 968-973.

(6) Haflinger, K.E., C.P. McRoy. 1983. Summary - Yellowfin sole (Limanda Aspera) predation on three commercial crab species (Chionoecetes Opilio, C. Bairdi, and Paralithodes Camtschatica) in the Southeastern Bering Sea. Institute of Marine Science, UAF, Fairbanks, AK. 1p.

(7) Livingston, P.A., A. Ward, G.M. Lang, and M-S. Yang. 1993. Groundfish food habits and predation on commercially important prey species in the Eastern Bering Sea from 1987 to 1989. NOAA-NMFS-AFSC-11.

(8) Livingston, P.A., G.M. Lang, R. Pacunski, J. Parkhurst., M-S. Yang. 1991. Executive Summary - Groundfish food habits and predation on commercially important prey species in the Eastern Bering Sea from 1984-1986. NOAA/NMFS-F/NWC-207.

(9) Wainwright, T.C., D.A. Armstrong, H.B. Andersen, P.A. Dinnel, D.W. Herren, G.C. Jensen, J.M. Orensanz, and J.A. Shaffer. In collaboration with J.E. Edinger, J.E. Buchak, and J.E. Edinger Assoc., Inc. 1992. Abstract - Coastal fisheries oceanography of the Southern Bering Sea and North Aleutian Basin: Port Moller king crab studies. OSC Study MMS 92-0040.

Witherell, D.B. 1995. Literature review on the potential impacts of fishing gear on crab habitat. March 1995. 3 p.

Agenda Item V (A)

(1a) Walters, G.E., M.J. McPhail. 1982. Abstract - An atlas of demersal fish and invertebrate community structure in the Eastern Bering Sea: Part 1, 1978-81. NOAA/NMFS.

(1b) Walters, G.E. 1983. Abstract - An atlas of demersal fish and invertebrate community structure in the Eastern Bering Sea: Part 2, 1971-77.

(2) MCMurray, G., A.H. Vogel, P.A. Fishman, D.A. Armstrong, S.C. Jewett. 1984. Abstract - Distributional of larval and juvenile red king crabs (Paralithodes Camtschatica) in Bristol Bay. VTN, ARCS, NPR.

Agenda Item V (B)

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

(2) Messieh, S.N., T.W. Rowell, D.L. Peer, P.J. Cranford. 1991. Abstract - The effectrs of trawling, dredging and ocean dumping on the eastern Canadian continental shelf seabed. Continental Shelf Research II: 1237-1263.

(3) Eleftheriou, A., M.R. Robertson. 1992. The effects of experimental scallop dredging on the fauna and physical environment of a shallow sandy community. Netherlands Journal of Sea Research 30: 289-299.

(4) Study Group of the International Council. 1992. On ecosystem effects of fishing activities, Copenhagen, 7-14, April.

(5) Thompson, G. 1991. BSAI Amendment 26, Appendix F - Impacts of trawling on the seabed and benthic community. AFSC, NOAA/NMFS, Seattle, WA. 7p.

Agenda Item V (C)

(1) Harrison, R.C., R.C. Francis. Fisheries and biological interactions between Pacific cod and red king crab in the Eastern Bering Sea. Fisheries Research Institute.

(2) Ilinskii, E.N. 1991. Longstanding changes in the composition of bottom fish caught at the continental slope of the Sea of Okhotsk and Sea of Japan.

Agenda Item V (D)

(1) Tyler, A. L., G.H. Kruse. 1995. Report of the modeling workshop on year-class strength formation of red king crab. ADF&G, Juneau, AK. 20p.

(2) Taylor, D.M., P.G. O'Keef, C. Fitzpatrick. 1993. A snow crab, Chionoecetes opilio (Decapaoda, Majidae), fishery collapse in Newfoundland. Fishery Bulletin 92:412-419.

Agenda VI

(1) Kruse, G.H. 1993. Biological perspectives on crab management in Alaska. Proc. Int.Symp. on Mgmt. Strategies for Exploited Poplulations. 1993: 357-384.

(2) Kruse, G.H. King and Tanner Crab Research in Alaska: Executive Summary of Work Completed by the State of Alaska during 7/1/93-6/30/94 and Work Planned for 7/1/94-6/30/95. 5p.

Kuzmin, S., and S. Olsen. 1994. Barents Sea king crab (Paralithodes camtschatica) The transplantation experiments were successful. ICES C.M. 1994/K:12.

Loch, J.S., M. Moriyasu, and J.B. Jones. 1994. An improved link between industry, management and science: a case history - the southern Gulf of St. Lawrence snow crab fishery. ICES report. 22 p.

Alternatives and Analytical Outline

for analysis:

A Trawl Closure Area in the Nearshore Waters of Bristol Bay

In January 1995, the Council initiated an analysis to examine impacts of a proposal to establish a trawl closure area in the northeast EEZ section of Bristol Bay (north of 58°N and east of 162°W) to protect juvenile red king crab. The area within 3 miles of shore within Bristol Bay are closed to trawling year-round under State regulations (5 AAC 39.165). This document examined the impacts of prohibiting trawling in areas of Bristol Bay. In addition to the status quo, two alternative area closures were examined:

Alternative 1: Status quo, no action.

Alternative 2: Establish a Northern Bristol Bay Closure Area, which would prohibit all trawling, on a year-round basis, in the area east of 162° W longitude and north of 58° N latitude.

Alternative 3: Prohibit all trawling in Bristol Bay, on a year-round basis, in the area east of 162° W longitude.

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  - 1.3.2 Biological and Physical Environment .....
  - 1.3.3. Subsistence Fisheries of Bristol Bay .....
  - 1.3.4 Commercial Fisheries of Bristol Bay .....
  - 1.3.5 Red King Crab Biology .....
  - 1.3.6 Pacific Herring Biology .....
  - 1.3.7 Pacific Halibut Biology .....
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2.2 Impacts on Endangered, Threatened or Candidate Species .....
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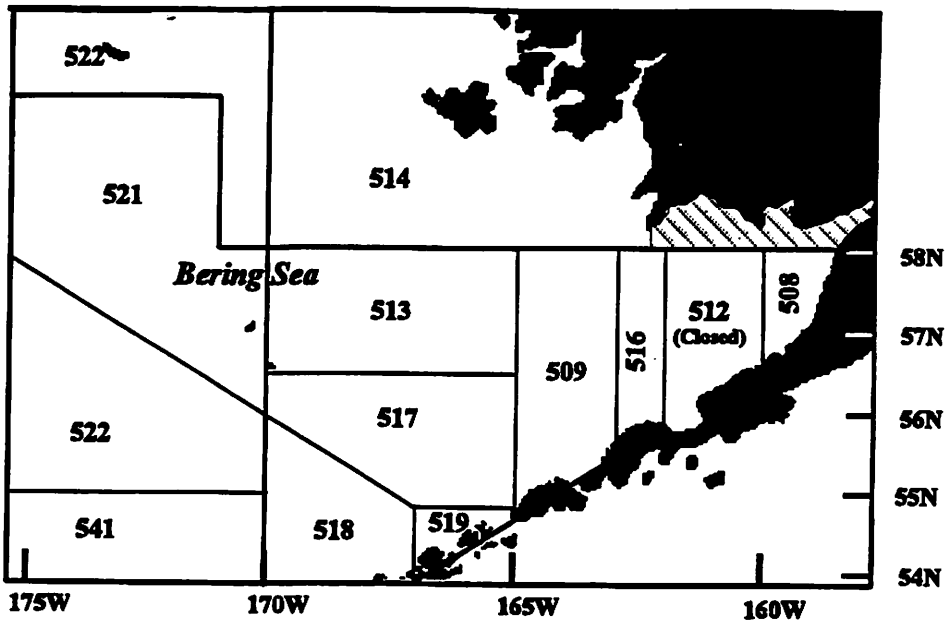
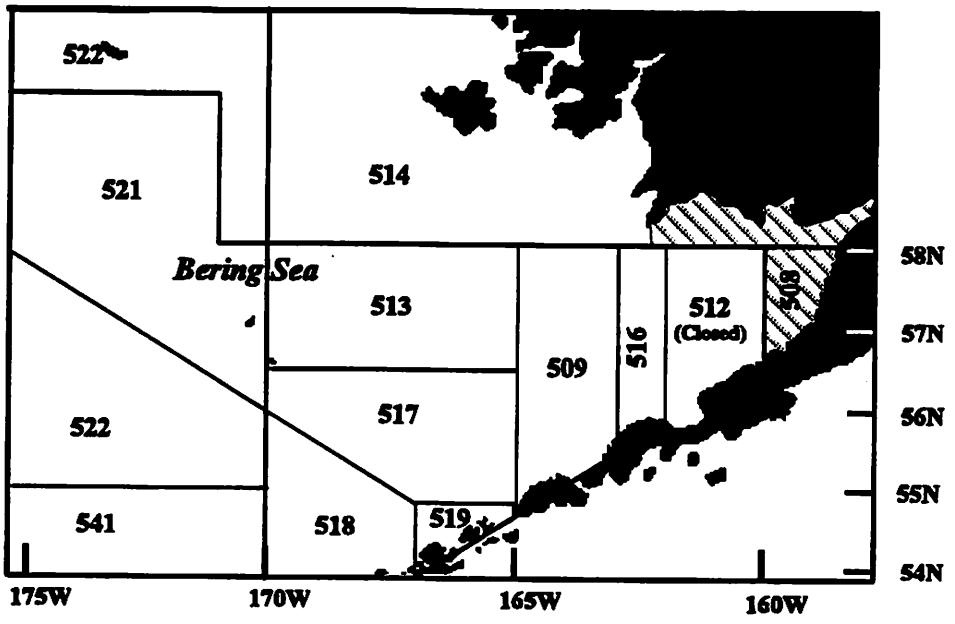
3.4 Administrative, Enforcement and Information Costs .....

4.0 INITIAL REGULATORY FLEXIBILITY ANALYSIS .....
4.1 Economic Impact on Small Entities .....

Alternative 2



Alternative 3



Alternative trawl closure areas examined by this analysis (shaded areas), relative to statistical areas of the Bering Sea. Note that statistical area 512 is closed to all trawling on a year-round basis.

Alternatives and Analytical Outline

for analysis:

Management of Red King Crab (*P. camtschaticus*), Tanner Crab (*C. bairdi*), and Snow Crab (*C. opilio*) Bycatch in Bering Sea Groundfish Trawl Fisheries

In January 1995, the Council initiated an analysis to examine impacts of a proposal to modify management of crab Prohibited Species Catch (PSC) limits. Three main alternatives, developed by the Council's Advisory Panel and the State of Alaska, were examined. The alternatives to the status quo included a reduced bycatch limit for crab and a crab PSC limit that fluctuates with crab abundance. Potential impacts of instituting a new bycatch limit for snow crab were also examined as an option. The alternatives and options were as follows:

Alternative 1: Status quo, no action. PSC limits would remain at 200,000 red king crab and 1,000,000 Tanner crab in Zone 1, and 3,000,000 Tanner crab in Zone 2.

Alternative 2: Reduce PSC limits of red king crab and Tanner crab. Based on a three year average (1992-1994), PSC limits would be reduced to a fixed level at 180,000 red king crab and 900,000 Tanner crab in Zone 1, and 2,100,000 Tanner crab in Zone 2.

Option A: Further reduce the red king crab PSC limit in Zone 1 to 35,000 crab, which was the number of red king crab bycaught in 1995 within Zone 1.

Option B: Establish a PSC limit for snow crab. Based on a three year average (1992-1994), a PSC limit would be established at a fixed level of 11,000,000 snow crab in Zone 2. No snow crab PSC limit would be established for Zone 1, as bycatch in this area has been minuscule by comparison.

Alternative 3: Establish PSC limits for crab that fluctuate with crab abundance. Annual PSC limits would be set as a percentage of the total population indexed by the NMFS bottom trawl survey. Limits would be established based on a rate specified, within the range 0.25-1.0% of red king crab in the Bristol Bay District, and 0.25-2.0% of Tanner crab in the Eastern District, as indexed by the survey. For Tanner crab, 25% of the total limit would be set as the limit for Zone 1, and 75% of the total for the Zone 2 limit.

Option A: Set a fixed upper limit for PSC at 200,000 red king crab and 1,000,000 Tanner crab in Zone 1, and 3,000,000 Tanner crab in Zone 2.

Option B: Establish a PSC limit for snow crab as a percentage of the eastern Bering Sea total population indexed by the NMFS bottom trawl survey. Limits for Zone 2 would be set at a percentage within the range 0.005 to 0.25% of the snow crab population index (all districts combined). No snow crab PSC limit would be established for Zone 1.

Suboption b-1: Set fixed upper limit for PSC at 12 million snow crab in Zone 1.

Analytical Outline

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- 1.1 Purpose of and Need for the Action .....
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  - 1.2.2 Alternative 2: Reduce PSC limits of red king crab and Tanner crab .....
    - Option A: Further reduce the red king crab PSC limit in Zone 1 to 35,000 crab .....
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  - 1.2.3 Alternative 3: Establish PSC limits for crab that fluctuate with crab abundance. ....
    - Option A: Set a fixed upper limit for crab PSC .....
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- 1.3 Background .....
  - 1.3.1 Bycatch Management .....
  - 1.3.2 Biology of Major Bering Sea Crab Resources .....
    - 1.3.2.1 Red King Crab .....
    - 1.3.2.2 Tanner Crab .....
    - 1.3.2.3 Snow Crab .....
  - 1.3.3 Status and Management of Bering Sea Crab Stocks .....
    - 1.3.3.1 Red King Crab .....
    - 1.3.3.2 Tanner Crab .....
    - 1.3.3.3 Snow Crab .....
  - 1.3.4 Bycatch of Crab in Groundfish Trawl Fisheries .....
    - 1.3.4.1 Bycatch Numbers by Fishery and Zone .....
    - 1.3.4.2 Bycatch Mortality .....
    - 1.3.4.3 Unobserved Mortality .....
  - 1.3.5 Impacts of Fishing Gear on Benthic Habitat .....
    - 1.3.5.1 Trawl Gear .....
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    - 1.3.5.3 Longline Gear .....
    - 1.3.5.4 Pot Gear .....
  - 1.3.6 Other Sources of Crab Mortality .....
    - 1.3.6.1 Bycatch Mortality in Other Groundfish Fisheries. .....
    - 1.3.6.2 Bycatch Mortality in the Scallop Fishery .....
    - 1.3.6.3 Crab Harvests .....
    - 1.3.6.4 Bycatch Mortality in Crab Fisheries .....
    - 1.3.6.5 Catching Mortality .....
    - 1.3.6.6 Ghost Fishing .....
    - 1.3.6.7 Pot Bombing .....

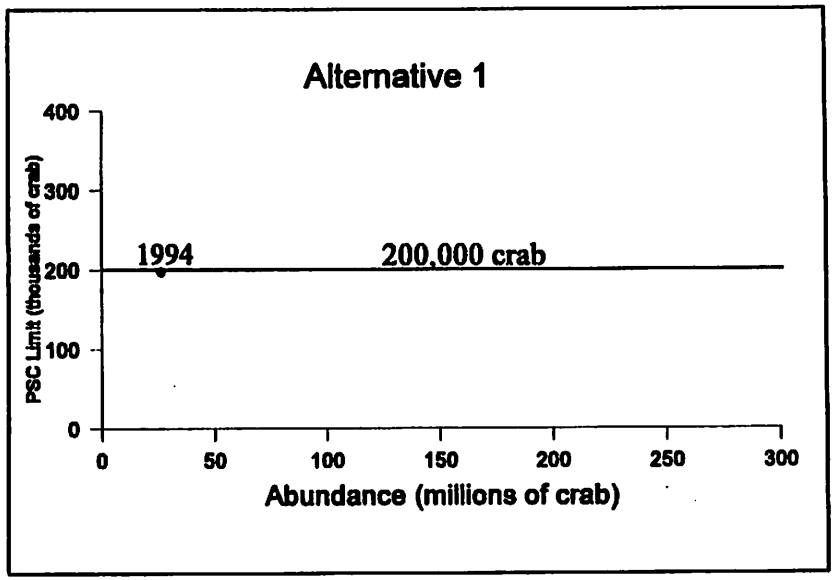
2.0 NEPA REQUIREMENTS: ENVIRONMENTAL IMPACTS OF THE ALTERNATIVES .....
- 2.1 Environmental Impacts of the Alternatives .....
  - 2.1.1 Potential Impacts on Groundfish Stocks .....
  - 2.1.2 Potential Impacts on Crab Stocks .....
- 2.2 Impacts on Endangered, Threatened or Candidate Species .....
- 2.3 Impacts on Marine Mammals .....
- 2.4 Coastal Zone Management Act .....

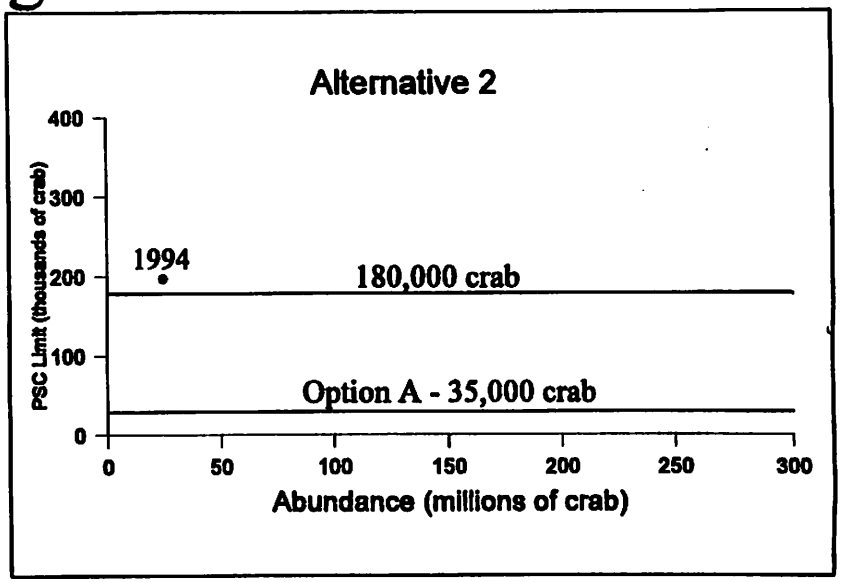
2.5 Conclusions or Finding of No Significant Impact .....

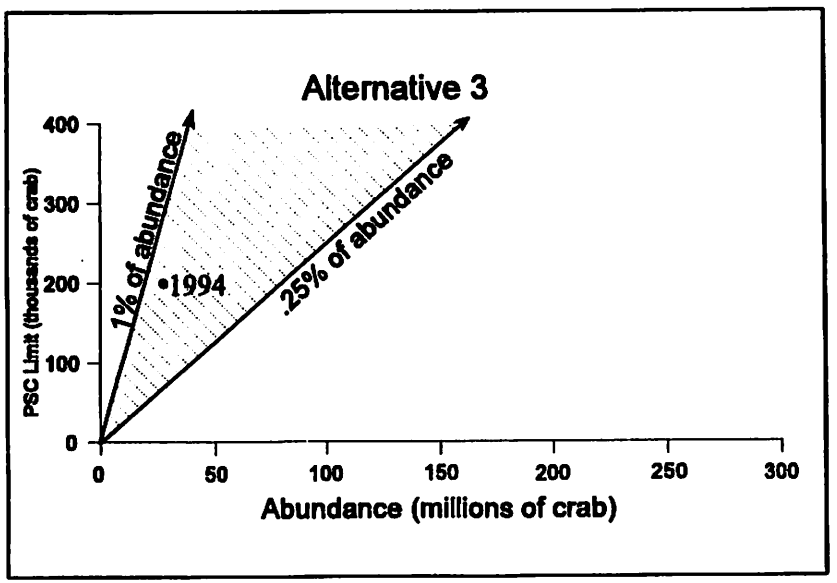
3.0 REGULATORY IMPACT REVIEW: ECONOMIC AND SOCIOECONOMIC IMPACTS OF THE ALTERNATIVES .....
3.1 Alternative 1: Status quo .....
3.2 Alternative 2: Reduce PSC limits of red king crab and Tanner crab .....
Option A: Further reduce the red king crab PSC limit in Zone 1 to 35,000 crab .....
Option B: Establish a fixed PSC limit for snow crab. .....
3.3 Alternative 3: Establish PSC limits for crab that fluctuate with crab abundance .....
Option A: Set a fixed upper limit for crab PSC .....
Option B: Establish a PSC limit for snow crab as a percentage .....
3.4 Administrative, Enforcement and Information Costs .....

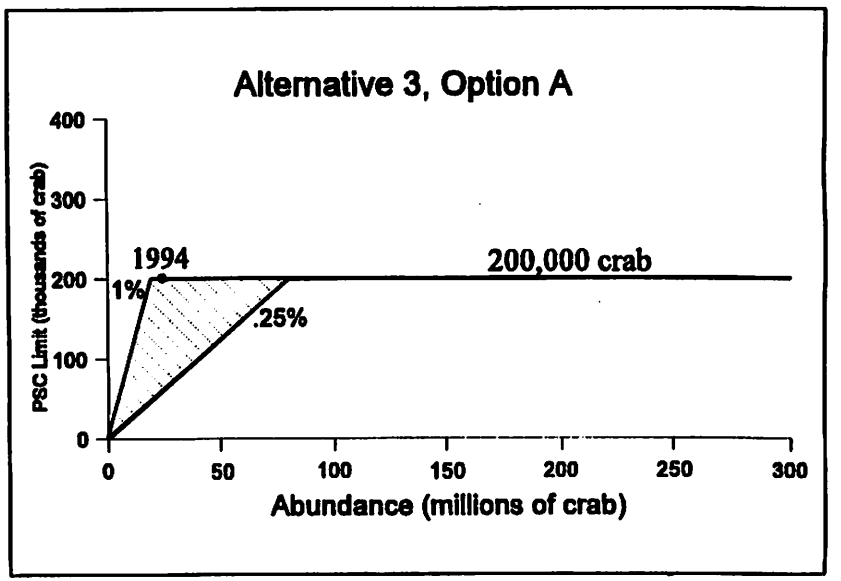
4.0 INITIAL REGULATORY FLEXIBILITY ANALYSIS .....
4.1 Economic Impact on Small Entities .....

Red King Crab

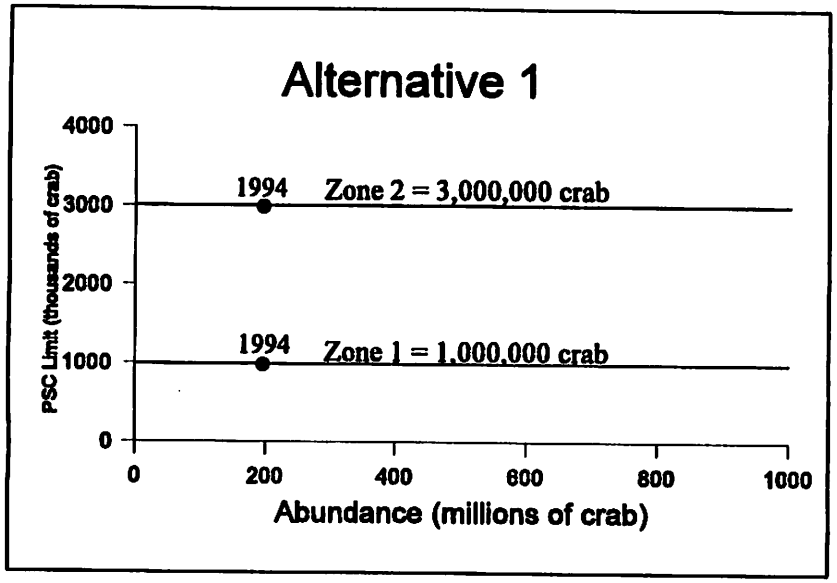


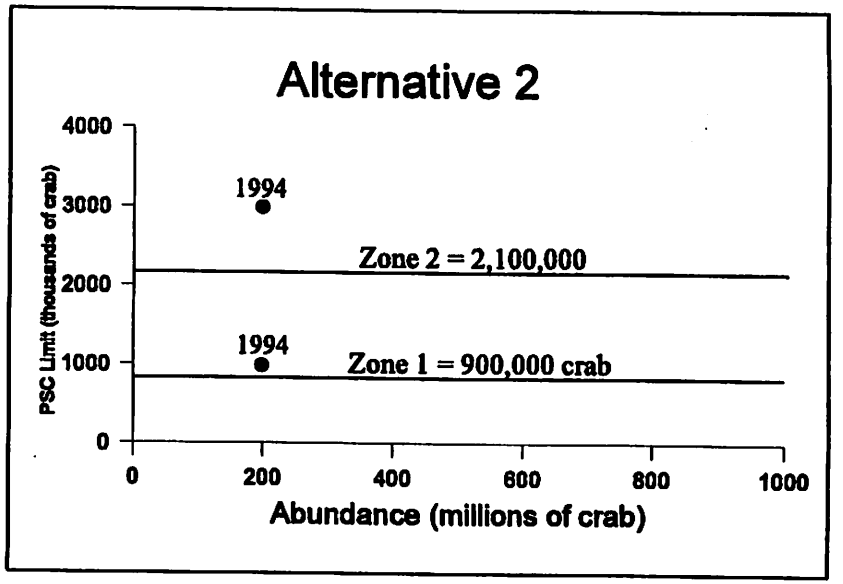


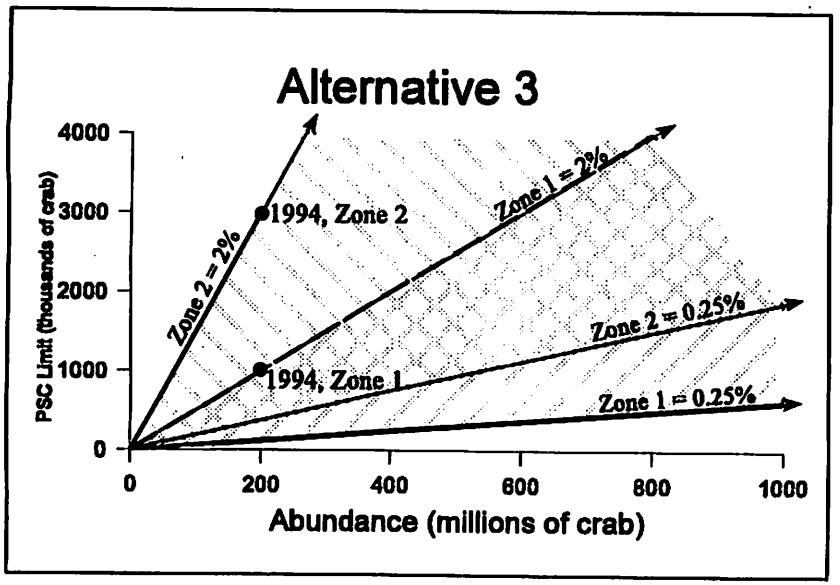


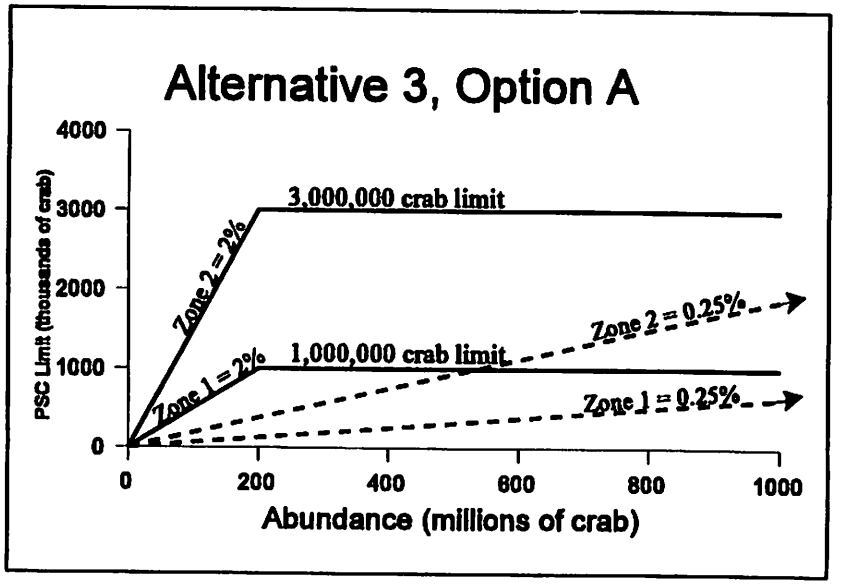


Tanner Crab

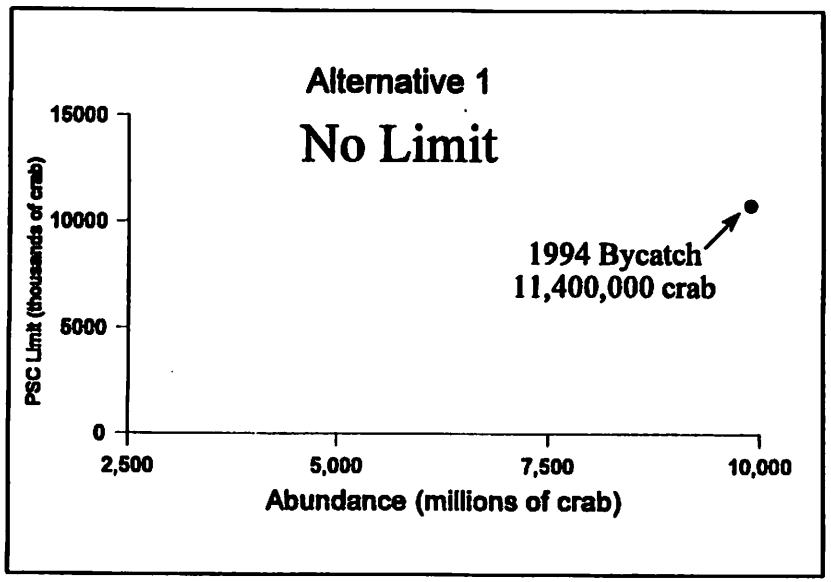

Alternative 1
PSC Limit (thousands of crab)
4000
3000
2000
1000
0
1994
Zone 2 = 3,000,000 crab
1994
Zone 1 = 1,000,000 crab
0
200
400
600
800
1000
Abundance (millions of crab)

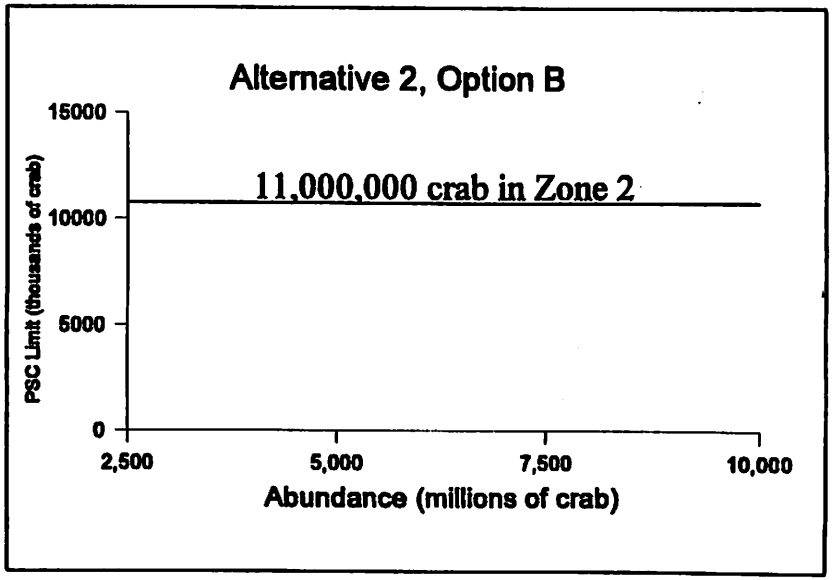

Alternative 2
PSC Limit (thousands of crab)
4000
3000
2000
1000
0
1994
Zone 2 = 2,100,000
1994
Zone 1 = 900,000 crab
0
200
400
600
800
1000
Abundance (millions of crab)

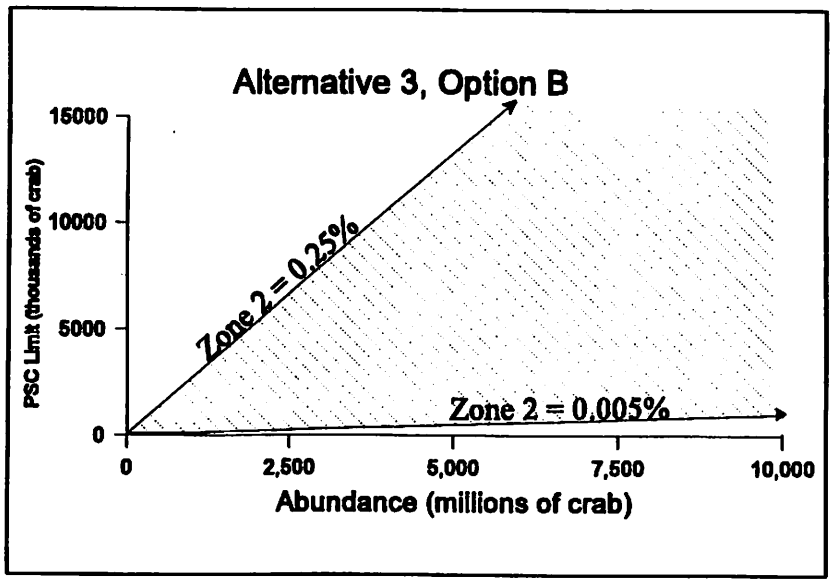

Alternative 3
PSC Limit (thousands of crab)
4000
3000
2000
1000
0
Zone 2 = 2%
1994, Zone 2
Zone 1 = 2%
Zone 2 = 0.25%
1994, Zone 1
Zone 1 = 0.25%
0
200
400
600
800
1000
Abundance (millions of crab)

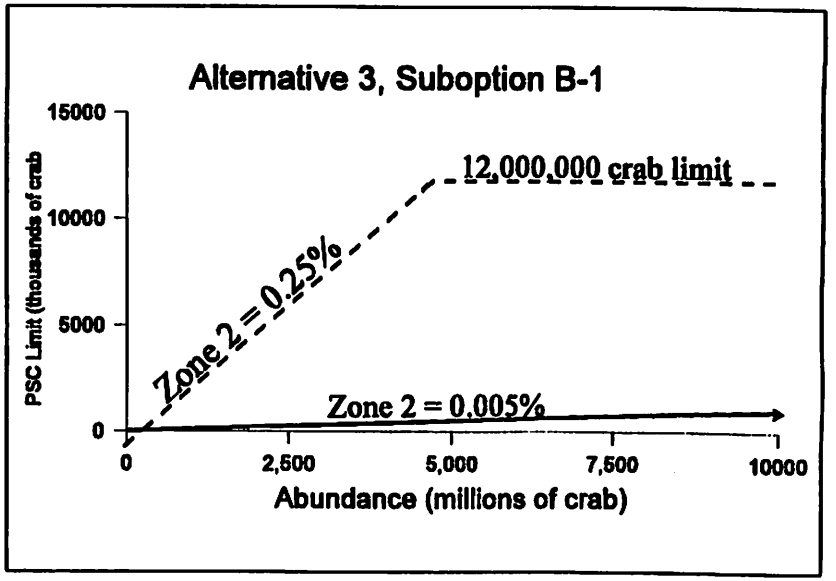

Alternative 3, Option A
PSC Limit (thousands of crab)
4000
3000
2000
1000
0
3,000,000 crab limit
Zone 2 = 2%
Zone 1 = 2%
1,000,000 crab limit
Zone 2 = 0.25%
Zone 1 = 0.25%
0
200
400
600
800
1000
Abundance (millions of crab)

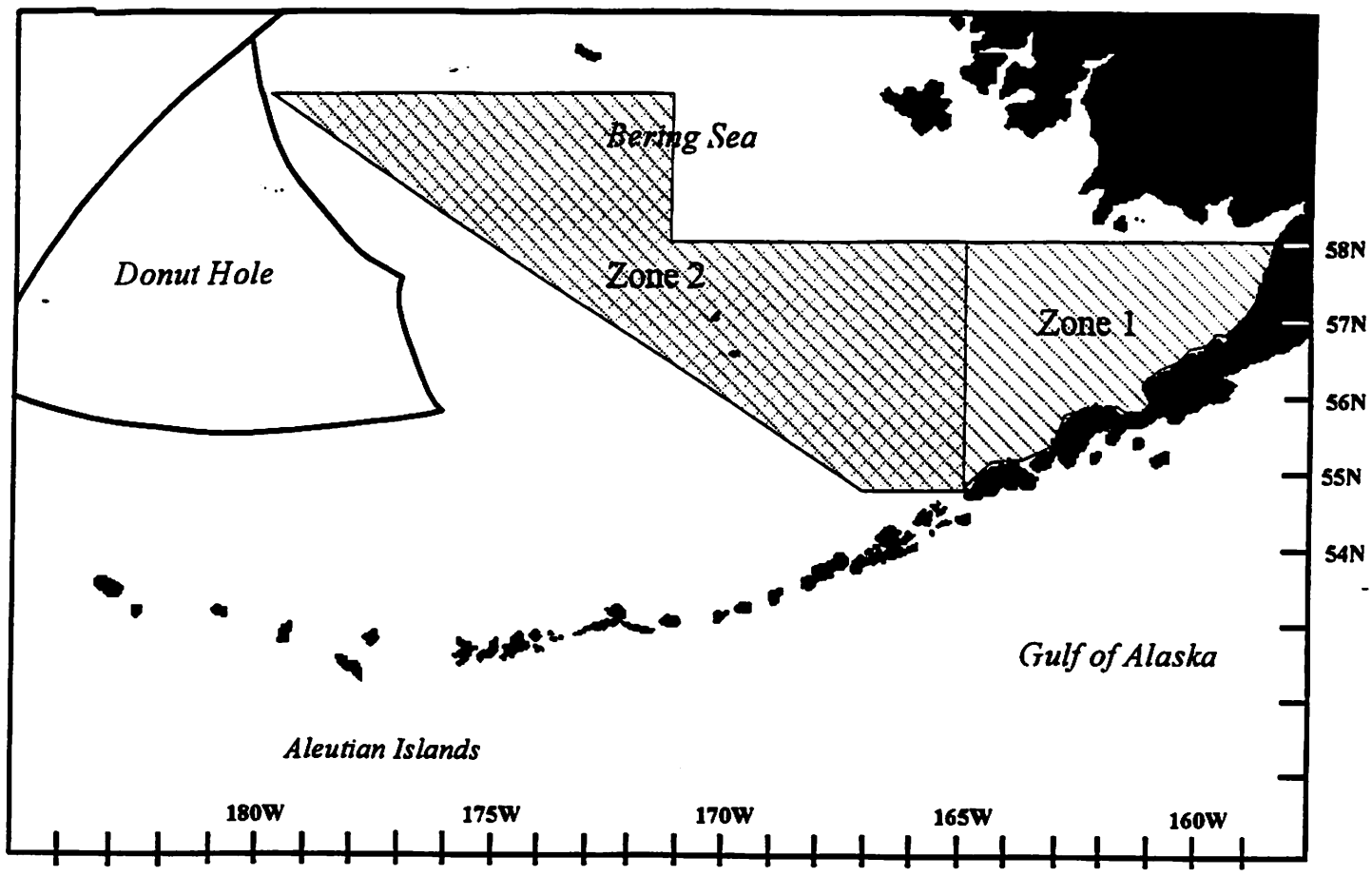
Snow Crab


Alternative 1
No Limit
1994 Bycatch
11,400,000 crab
PSC Limit (thousands of crab)
15000
10000
5000
0
2,500
5,000
7,500
10,000
Abundance (millions of crab)


Alternative 2, Option B
11,000,000 crab in Zone 2
PSC Limit (thousands of crab)
15000
10000
5000
0
2,500
5,000
7,500
10,000
Abundance (millions of crab)


Alternative 3, Option B
Zone 2 = 0.25%
Zone 2 = 0.005%
PSC Limit (thousands of crab)
15000
10000
5000
0
0
2,500
5,000
7,500
10,000
Abundance (millions of crab)


Alternative 3, Suboption B-1
12,000,000 crab limit
Zone 2 = 0.25%
Zone 2 = 0.005%
PSC Limit (thousands of crab
15000
10000
5000
0
0
2,500
5,000
7,500
10000
Abundance (millions of crab)



Prohibited Species Bycatch Limitation Zones

Rationale for Closure: To allow for control of red king crab and C. bairdi Tanner crab bycatch.

Origin: Implemented under Amendment 10 on March 16, 1987.

Description of Area: Areas close to directed fishing when crab bycatch caps are attained in specified fisheries. Bycatch Limitation Zone 1 means that part of the Bering Sea Subarea that is south of 58° 00' N. latitude and east of 165° 00' W. longitude. Bycatch Limitation Zone 2 means that part of the Bering Sea Subarea bounded by straight lines connecting the following coordinates in the order listed:

North latitude	West longitude
54° 30'	165° 00'
58° 00'	165° 00'
58° 00'	171° 00'
60° 00'	171° 00'
60° 00'	179° 20'
59° 25'	179° 20'
54° 30'	167° 00'
54° 30'	165° 00'

[Prepared as a Discussion Paper for the NPFMC meeting, September 1995]

Evaluation of Alternative Management Measures to Reduce the Impacts of Trawling and Dredging on Bering Sea Crab Stocks

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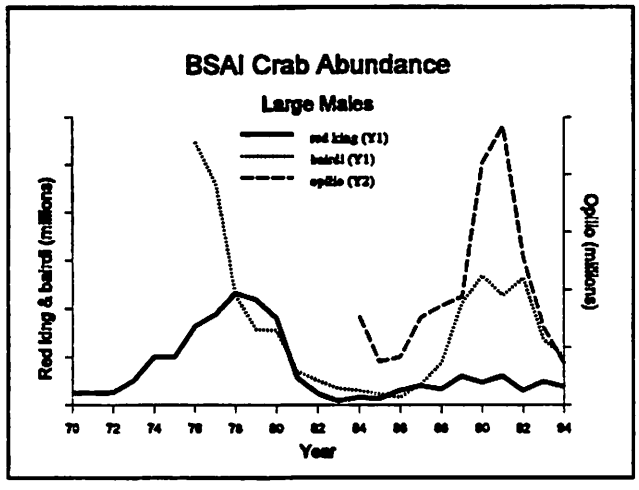
Abstract - The North Pacific Fishery Management Council is looking for ways to rebuild red king, Tanner, and snow crab stocks in the Bering Sea. The Council has delegated authority over crab management to the State of Alaska and is thus constrained to modifying it's management strategies for groundfish and scallop fisheries as a means to reduce the impacts on crab populations. In this paper, we examine several alternative management measures that the Council has proposed to reduce impacts of trawling and dredging on crab stocks. These measures include time/area closures, bycatch limits, and market solutions. Our analysis suggests that a comprehensive trawl/dredge closure area in the nearshore waters of Bristol Bay may allow increased red king crab recruitment by protecting juvenile crab and their habitat. Bycatch limits previously established for trawl and dredge fisheries could be reduced to conserve some crab, but would have little benefit to crab stocks. Similarly, bycatch management through individual vessel bycatch accountability may allow slightly larger harvests of crab predators and competitors such as yellowfin sole and Pacific cod, but the impact on crab rebuilding would be minor.

Bering Sea crab stocks are currently at relatively low levels based on National Marine Fisheries Service (NMFS) bottom trawl survey data. Data from the 1994 NMFS survey indicate that exploitable biomass of Bristol Bay red king crab (*Paralithodes camtschaticus*), and Bering Sea Tanner crab (*Chionoecetes bairdi*) and snow crab (*Chionoecetes opilio*) stocks are about one-fifth record levels (Stevens et al. 1994). The survey revealed that the female red king crab stock in Bristol Bay was below a threshold of 8.4 million females > 90 mm (3.5", the size at 50% maturity). The survey also detected low abundance of pre-recruit red king and Tanner crab, but a fair amount or pre-recruit snow crab were observed. These numbers suggest that declines in red king and Tanner crab abundance will continue, but that the snow crab stock may increase in coming years.



Crab fisheries have been impacted by these low stock sizes. Red king crab stocks are at their lowest since the fishery was closed after the first stock collapse in 1983. In 1994 Bristol Bay was closed to red king crab fishing because the annual trawl surveys indicated little prospect for increased recruitment of mature males or females, and the female threshold was not reached. The 1994 Tanner crab fishery in the Bering Sea opened as scheduled, but with a much reduced guideline harvest level of 7.5 million pounds. Additionally, the area east of 163°W was closed to Tanner crab fishing to minimize the bycatch of female red king crabs. The 1995 snow crab harvest was less than one-fourth of the record 1991 harvest (73.6 million pounds in 1995, 325 million pounds in 1991).

This situation has prompted the North Pacific Fishery Management Council to examine ways to rebuild red king, Tanner, and snow crab stocks in the Bering Sea. In January 1995, the Council formed a committee to develop a rebuilding plan for Bering Sea crab stocks. The committee was composed of Bering Sea/Aleutian Islands (BSAI) Crab Plan Team and Groundfish Plan Team members, and was chaired by Council member Dr. Dave Fluharty. The committee synthesized available information on sources and magnitude of crab mortality and

identified alternative management strategies the Council might use to enhance the survival of crab stocks and thus promote rebuilding (Witherell 1995). A rebuilding goal has yet to be specified, however. In addition to establishing the rebuilding committee, the Council initiated several analyses to examine impacts of proposals to control crab bycatch in the groundfish fisheries. The first analysis, which has been completed, examined impacts of a trawl closure area in central Bristol Bay to protect adult red king crabs. A second analysis examines the effects of instituting a trawl closure area in the northeast section of Bristol Bay (north of 58°N and east of 162°W) to protect juvenile crab, seabirds, marine mammals, and spawning herring stocks. A third analysis examines the impacts of reducing the existing crab bycatch limits for groundfish trawl fisheries. In addition, in June, the Council adopted for analysis an individual vessel bycatch accounting program for all BSAI non-pollock fisheries as part of a proposed ITQ program for the pollock fishery. Because these analyses were initiated before the committee could report to the Council, we make a preliminary examination of these alternative management measures from a rebuilding perspective, and suggest some options to be considered.

Proposals currently being analyzed by the Council to protect crab stocks.

1. Institute a trawl area closure in central Bristol Bay
2. Institute a trawl area closure in northern Bristol Bay
3. Reduce existing crab bycatch limits, and initiate bycatch limits for snow crab
4. Institute an individual vessel bycatch accounting program

Developing a rebuilding plan for crab stocks will be complex due to the existing management regime, sources of mortality, and life history. Crab year-class strength depends both on the number of spawners and on environmental condition such as temperature and currents (Tyler and Kruse 1995). Habitat availability for larval settlement and rearing is also likely to be important, particularly for red king crabs. Survival of juvenile crab after settlement until they reach maturity depends on a number of factors, which are listed in the accompanying table. Rebuilding crab stocks will hinge upon changing management strategies for crab, scallop, and groundfish fisheries to maintain adequate crab spawning stock and provide suitable habitat. However, abiotic factors (temperature, currents, etc.) may play a larger role in determining crab year-class strength.

Sources of mortality for adult and juvenile crab in the BSAI.

Crab Fishery	Groundfish/Scallop Fishery	Natural Mortality
✓ fishery removals	✓ habitat impacts	✓ predation
✓ bycatch	✓ bycatch	✓ competition
✓ ghost fishing	✓ ghost fishing by pots	✓ parasites/disease
	✓ unobserved mortality	✓ other sources

Alternatives and Options

Rebuilding options available to the Council are limited without major changes to the BSAI king and Tanner crab fishery management plan (FMP). Under the crab FMP, management measures fall into three categories: (1) those that are fixed in the FMP and under Council control, (2) those that are framework measures that the State can change following criteria outlined in the FMP, and (3) those measures under complete discretion of the State. Under this plan, conservation and rebuilding

Management measures used to manage king and Tanner crabs in the BS/AI management unit category.

Category 1 (Fixed in FMP)	Category 2 (Frameworked in FMP)	Category 3 (Discretion of State)
* Legal Gear	* Minimum Size Limits	* Reporting Requirements
* Permits Requirements	* Guideline Harvest Levels	* Gear Placement and Removal
* Federal Observer Requirements	* Inseason Adjustments	* Gear Storage
* Limited Access	* Districts, Subdistricts and Sections	* Gear Modifications
* Norton Sound Superexclusive Registration Area	* Fishing Seasons	* Vessel Tank Inspections
	* Sex Restrictions	* State Observer Requirements
	* Closed Waters	* Bycatch Limits (in crab fisheries)
	* Pot Limits	* Other
	* Registration Areas	

of crab is mainly at the State's discretion. For example, if the Council wanted to develop a crab rebuilding plan based on limiting crab harvest, the crab FMP would need to be amended to limit guideline harvest levels. Thus, without amending the crab FMP, the Council is constrained to managing groundfish and scallop fisheries that impact the crab resource.

The State of Alaska is also working to rebuild and maintain viable crab stocks. The State has been conducting research on crab stock dynamics (Zheng et al. 1994, Zheng et al. 1995, Tyler and Kruse 1995), as well as evaluating changes to crab fishery management (Kruse 1993, Schmidt and Pengilly 1993, Murphy et al. 1994, Kruse 1995, Zhou and Shirley 1995).. Modifications to crab harvesting strategies (based on size limits, sex restrictions, and seasons) and gear design that would reduce bycatch and handling mortality are currently being evaluated (Kruse 1995). Mortality caused by ghost fishing of lost crab pots and groundfish pots remains unquantified, but escape mechanisms have been required to reduce potential impacts (Kruse and Kimker 1993).

The State has instituted numerous regulatory changes in the past few years to reduce crab bycatch in the crab fishery. Crab bycatch in the directed fishery includes females of target species, sublegal males of target species, and non-target crab. Beginning in 1993, the Tanner crab season opened on November 1 to coincide with the opening of the red king crab fishery. This allowed retention of legal males of both species, thereby reducing bycatch (prior to 1993, the Tanner crab fishery opened 7 days after the Bristol Bay red king crab fishery closed, resulting in high bycatch of red king crab). A regulation instituted in 1993 to restrict tunnel openings on crab pots to a 3" maximum successfully reduced the bycatch of red king crab in both Tanner and snow crab fisheries. As shown in the following tables, bycatch of red king crab in the 1993 Tanner and show crab fisheries was reduced to 257,737 crab (Tracy 1994). Bycatch in the red king crab fishery increased to 5.5 million red king crab in 1993. However, to further reduce the bycatch of juveniles, females, and non-target crab, a regulation scheduled to be implemented in September 1995 will require all king crab pots in Bristol Bay to have at least one-third of one vertical surface of the pot composed of not less than 7.75" stretched mesh webbing.

Crab bycatch in the 1992 crab fisheries.

	Red king fishery	Tanner fishery	Snow fishery
legal males	1,070,472	14,629,181	267,767,184
non-legals	4,714,194	25,958,176	6,024,441
red king crab	-	1,477,695	33,731
Tanner crab	1,543,952	-	14,740,655
snow crab	20,586	2,758,365	-
hybrid C. spp.	nr	886,617	8,459,854

Crab bycatch in the 1993 crab fisheries.

	Red king fishery	Tanner fishery	Snow fishery
legal males	2,022,165	7,209,948	228,487,123
non-legals	5,502,508	18,150,624	4,563,916
red king crab	-	233,272	24,465
Tanner crab	3,968,374	-	6,700,215
snow crab	20,012	1,485,835	-
hybrid C. spp.	nr	293,428	9,613,355

Although the Council delegates management authority of the crab fishery to the State, the Council does have direct control over the groundfish and scallop fisheries in the EEZ. In harvesting groundfish and scallops, mobile gear fisheries take crab as bycatch and possibly damage crab habitat. Among the objectives of the BSAI groundfish FMP is minimizing the impact of groundfish fisheries on crab and other prohibited species, while providing for rational and optimal use of the region's fishery resources. Although all gear types used to catch groundfish have some potential to catch crab incidentally and impact habitat, managers have been primarily concerned with reducing the impacts of dredge and trawl fisheries.

Fishery managers and crab fishing representatives have been concerned with mortality of crab captured incidentally in scallop dredge and groundfish trawl fisheries and its impact on crab stocks (NPFMC 1986, Thomson 1989, NPFMC 1995). Together, these fisheries bycaught about 248,500 red king crab, 3,700,000 Tanner crab, and 14,800,000 snow crab in 1993. Although these numbers appear large, the impact of crab bycatch from trawl and dredge fisheries on Bering Sea crab populations may be relatively minor because (1) bycatch in trawl/dredge fisheries accounts for a very small percentage of the crab population in most years, (2)

Crab bycatch in the 1993 BSAI groundfish and scallop fisheries, by gear type.

	Red king	Tanner	Snow
Trawl	248,121	3,412,342	14,631,617
Hook and Line	417	7,949	127,966
Groundfish pot	11	1,535	1,138
Scallop dredge	6	276,000	15,000

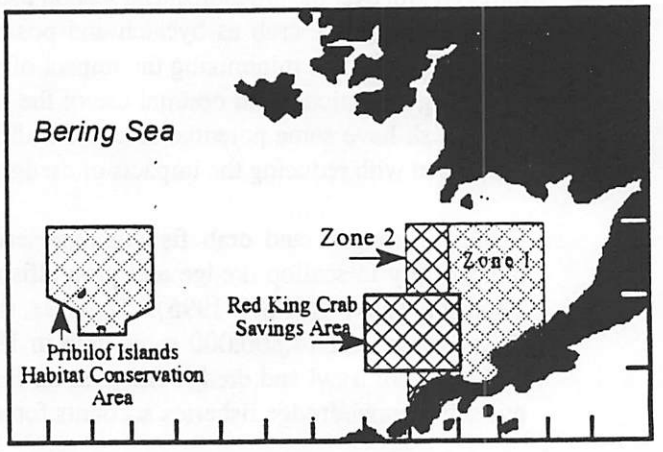
not all crabs taken are mature and (3) some bycatch survives. Total crab bycatch by groundfish fisheries has accounted for about 0.6% of the red king crab stock, 1.2% of the Tanner crab stock, and 0.1% of the snow crab stock in the Bering Sea as indexed by the 1992-94 NMFS surveys. Examination of crab bycatch length frequency suggests that most bycatch is smaller than market size, but larger than the size of 50% maturity for females. Bycatch of red king crab has averaged about 106 mm for females and 132 mm for males (Guttormson et al. 1990, NPFMC 1995) and bycatch of snow crab consisted of small (40-80 mm) individuals (NPFMC 1994); data for Tanner crab are limited and have not been examined. When survival is factored into the equation, impacts of bycatch become smaller. Stevens (1990) found that 21% of the king crabs and 22% of the Tanner crabs captured incidentally in BSAI trawl fisheries survived at least 2 days following capture. Observations of the 1993 BSAI scallop fishery indicated immediate survival of bycaught crabs was about 80-90% (Urban et al. 1994). Potential impacts of dredging and trawling on crabs that come into contact with the gear but are not captured, has proven difficult to quantify because they occur on the ocean floor and cannot be directly observed.

Trawling and dredging may negatively impact crab habitat, particularly living substrate on which young red king crab depend for food and protection from predators. Juvenile red king crab in the Bering Sea depend on both physical substrate and biogenic assemblages for settlement, food, and protection from predators (McMurray et al. 1984, Stevens et al. 1992). Both the physical substrate (cobble, shell) and biogenic assemblages (such as ascidians and tube-building polychaete worms) are vulnerable to trawling. Studies have shown that trawling and dredging impacts the seabed through scraping and ploughing, sediment re-suspension, and physical destruction, removal, or scattering of non-target benthos (Messieh et al. 1991, Jones 1992). In the Wadden Sea, scientists have observed destruction and elimination of erect epifaunal species (Reise 1982). If habitat is impacted by trawling and dredging, crab settlement and survival could be reduced, thereby lowering recruitment.

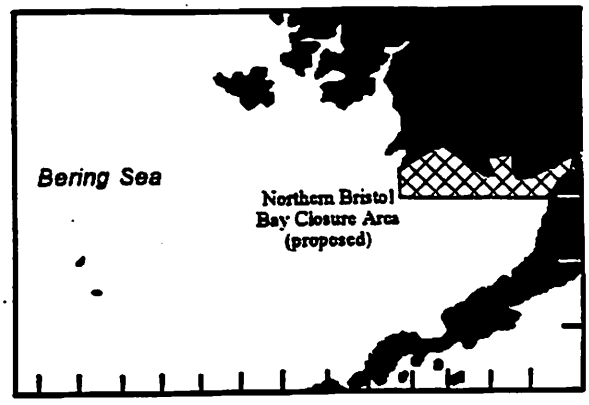
The focus of this paper is on what the Council can do to lessen the impacts of trawling and dredging as an aid to rebuilding crab stocks. Three alternatives (time/area closures, bycatch limits, and vessel bycatch accounts), which have been proposed by the Council as potential measures to reduce the impact of groundfish fishing on crab resources, were examined.

Time/Area Closures

Large portions of the Bering Sea have been closed to trawling to protect adult king crab and crab habitat. Crab protection zones were implemented in 1987 to prevent the incidental catch of adult male and female red king crabs in the domestic trawl fisheries. Protection Zone 1 is closed to trawling year-round and covers a substantial portion of the red king crab mating area. Protection Zone 2 extends the Zone 1 closure west to 163°W from March 15 to June 15. The Pribilof Islands Habitat Conservation Area was implemented in 1995 to protect blue king crabs and their habitat. Due to the continued decline in the red king crab population, NMFS (at the Council's request) issued an emergency order in January 1995 to close to trawling the red king crab savings area. In September, the Council will consider making this a permanent time/area closure to reduce bycatch of adult red king crab.



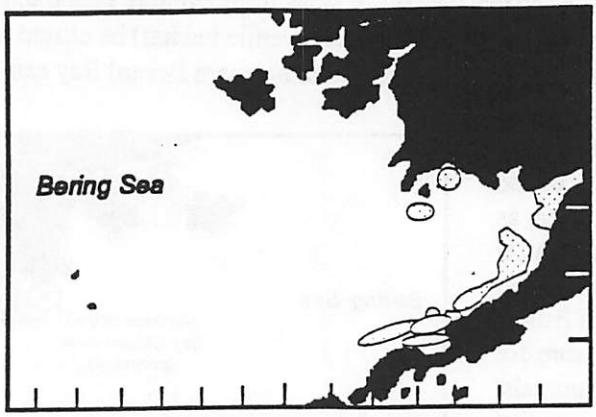
Closure areas have also been proposed to protect juvenile crab and their habitat from negative impacts associated with bottom trawling. Armstrong et al. (1993) suggested that nearshore areas from Unimak Island to east of Port Moller, which are important breeding and hatching grounds (and contain juvenile habitat) be closed to trawling. In January 1995, the Council initiated an analysis of a trawl area closure in northern Bristol Bay east of 162°W longitude and north of 58°N latitude. The objective of the proposed closure is to increase crab recruitment into the adult populations, rebuilding the population of red king crab to their relative historical level. This area, as well as other nearshore (<50 m) areas in Bristol Bay, is known to contain juvenile red king crab habitat. In addition to protecting red king crabs, the northern Bristol Bay closure was proposed as a protection measure for migrating herring, seabirds, and marine mammals. Portions of the northern area are already closed to protect walrus. Since 1992, the areas within a 12 mile radius of Round Island, the Twins, and Cape Pierce have been closed to all fishing from April 1 through September 30.



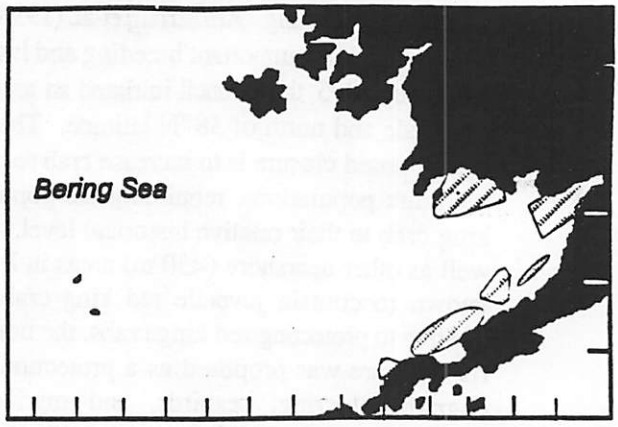
The effectiveness of any trawl/dredge closure designed to protect juvenile red king crab hinges on our understanding of recruitment dynamics and the distribution of juveniles and their habitat. It has been hypothesized that red king crab encounter a critical intersection at the settlement and juvenile stage, when the availability of appropriate habitat constrains the abundance of juveniles, in turn affecting the year class strength and recruitment (Cassano et al. 1995). Larval crab drift with the current before they settle on the sea floor to begin life on the benthos. Larval settlement and survival patterns vary according to ocean currents and availability of appropriate substrate. If the current transports the larvae to an area without suitable habitat, the chances of survival are slim (McMurray et al. 1984, Jewett & Onuf 1988). Larval crab settle in late July and August in areas with biotic assemblages and rocky substrate, where they stay as juvenile crab for the first two years before they move to deeper waters. Juvenile red king crab are solitary, cannibalistic, and require habitat that provides protection. Therefore, during this time they are mainly found among biogenic assemblages, such as tube building polychaete worms, sea onion, erect bryozoans, mussels, kelp, and ascidians (McMurray et al. 1984, Armstrong et al. 1993, NOAA 1991). If no epifauna community exists, juveniles can be found on rocky or gravel substrate, but it is considered to be inferior habitat (McMurray et al. 1984).

In the Bering Sea, juvenile red king crab inhabit depths less than 50 m, and have been found along the Alaska Peninsula, and around Kvichak and Togiak Bays (McMurray et al. 1984). Within this area juveniles live among epifaunal communities, which are associated with gravel/cobble substrate. Juvenile distribution in Bristol Bay can be interpreted from published maps showing the distribution of associated substrate (gravel and cobble) and areas sampled for young crab (McMurray et al. 1984, NOAA 1991, Armstrong et al. 1993). Suitable juvenile habitat is "extremely patchy" in Bristol Bay (McMurray et al. 1984, Jewett & Onuf 1988). Areas shown by surveys to contain age 0-2 juvenile crab likely underestimate their actual distribution because: (1) the entire area has not been sampled, and (2) young crab are difficult to catch with sampling gear, particularly in cobble habitats (Stevens et al. 1992). Furthermore, distribution of juvenile red king crab may be affected by year class strength. Juvenile surveys were conducted in years of low stock abundance, 1984 and 1991. The abundance and distribution of juveniles might have been more encompassing and conclusive had the surveys occurred in the early 1970s. Sample areas with low abundance could be viable habitat in times of high abundance. From the existing survey data it is not possible to determine the exact distribution of juveniles in any given year. However, by combining the survey data of where juveniles have been sampled with substrate information, a general map of juvenile red king crab habitat can be constructed.

Distribution of juvenile red king crab 0-2 years



Distribution of gravel sediment (> 10%)



Although the proposed closure area in northern Bristol Bay would protect some juvenile red king crab habitat, more comprehensive nearshore area closures may be considered. Due to the depressed state of the stock and the existing knowledge that trawling may potentially damage juvenile habitat, a modified trawl closure might be warranted. Both Armstrong et al. (1993) and Cassano et al. (1995) propose more extensive trawl closures to protect both spawning females and juvenile habitat from impacts of trawling. The lack of suitable habitat could be a population constraint, and habitat protection should be considered as a means to increase red king crab populations (Armstrong 1993, Cassano et al. 1995). Since there is uncertainty about the exact interactions between trawling and juvenile crab and its habitat, the ultimate trawl closure system would allow research trawling in designated areas to study the interactions between trawling, juveniles, and their habitat. Incorporated into this system is the ability to adapt to the new information gathered by research. As the effects of trawling and the juvenile habitat are better understood, modifications and adjustments could be made to evaluate existing management measures.

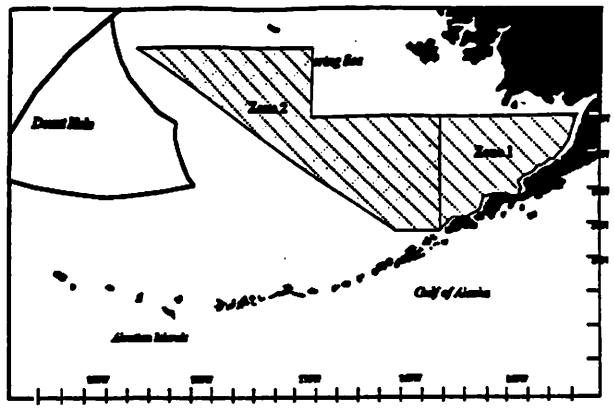
Another factor to consider when developing appropriate refugia for juvenile red king crab is their migration into deeper water as they get older. Cassano et al. (1995) propose closing migration corridors for juvenile crabs between the ages of 2-4 as they migrate into deeper waters and into the adult protection zone. After the age of 2 juvenile crabs begin podding, forming into large clusters of crab, for protection from predators as they move into deeper waters (>50 m) (Jewett & Onuf 1988, Dew 1990, Stone et al. 1993). These pods are vulnerable to trawling, which could cause direct mortality or break up pods and expose crabs to predation. Migration corridors may allow the juveniles to move safely from nearshore nursery areas into the existing adult protection areas.

If taken further, analysis of area closures should take into account costs to the affected fisheries, benefits to future crab fisheries and effects of the displaced trawl effort on other areas. To date, relatively little domestic trawling has occurred in the nearshore areas of Bristol Bay, so costs to affected fisheries may be minimal. However, combined with the closure of the Pribilof Islands Area to trawling, additional closures in Bristol Bay to bottom trawling could potentially shift trawling into Tanner and snow crab habitat. Potential benefits of a nearshore closure to future crab fisheries are difficult to quantify. However, if environmental conditions for spawning, settlement, and survival are favorable such that stocks rebuild to historic levels, benefits to crab fishermen would be substantial.

Bycatch Limits

Another management measure that has been proposed to rebuild crab is a reduction of the existing Prohibited Species Catch (PSC) limits for BSAI king crab and Tanner crab, and implementation of a new PSC limit for snow crab. Prohibited species bycatch limits and zones were designed to control the number of adult red king crabs and Tanner crabs taken as bycatch in trawl fisheries. Limits were not established as a crab conservation measure, but rather to allocate crab among the crab and groundfish fisheries. Current crab PSC limits, which were

negotiated by crab and groundfish industry representatives, are 1,000,000 Tanner crab and 200,000 red king crab in Zone 1 and 3,000,000 Tanner crab in Zone 2. To allocate total groundfish harvest under established PSC limits, PSC is apportioned among trawl fisheries during the annual specification process. When a target fishery attains a PSC apportionment or seasonal allocation specified in regulations, the bycatch zone to which the allocation applies closes to that target fishery for the remainder of the season.



Bycatch management has become increasingly complex over the past ten years. Bycatch limits for domestic fisheries were first adopted in 1986 under BSAI groundfish FMP Amendment 10, which specified red king crab and Tanner crab PSC limits for the yellowfin sole/other flatfish fishery only (NPFMC 1986). PSC limits of 135,000 red king crab and 80,000 Tanner crab in Zone 1, and 326,000 Tanner crab in Zone 2 were negotiated between representatives of crab and groundfish fishermen. In 1989, under FMP Amendment 12a, crab PSC limits were extended to the remaining trawl fisheries and crab PSC limits were increased to the current levels. These limits were further apportioned among joint-venture (JV) flatfish fisheries, other JV fisheries, domestic flatfish fisheries, and other domestic fisheries. FMP Amendment 16, adopted in 1990, authorized seasonal apportionment of PSC limits, and apportioned the trawl PSC limits for 1991 into allowances for domestic turbot, rock sole, yellowfin sole/other flatfish, other domestic groundfish, and JV flatfish. More recently, PSC limits for crab have been apportioned among the following trawl fisheries: yellowfin sole, rock sole/other flatfish, turbot/sablefish/arrowtooth, rockfish, Pacific cod, and pollock/Atka mackerel/other species. Crab PSC limits for the scallop fishery were implemented by the State in 1993, and were adopted by the Council as part of a federal scallop FMP amendment in June 1995.

By design, crab bycatch limits have constrained the scallop fishery in the Bering Sea. There have been no scallop TACs set for the Bering Sea; consequently, the fishing season ends once a bycatch limit is reached. The State set crab bycatch limits in the Bering Sea based on a preferred bycatch rate, extrapolated to a limit based on the projected number of vessels participating and limited season length. For 1993, PSC limits were set at 260,000 Tanner crab and 17,000 red king crab. The season closed when 276,500 Tanner crab were taken.

Crab PSC limits have not constrained most groundfish trawl fisheries. Rather, these fisheries close either upon reaching the total allowable catch quota (TAC) or attainment of halibut PSC limits. The one notable exception is the rock sole/other flatfish trawl fishery, which was limited in 1993 and 1994 despite relatively high levels of crab PSC apportioned to that fishery. For example, in 1994 Zone 1 was closed on February 28 due to attainment of red king crab PSC limit (110,000 crabs) and Zone 2 closed on May 7 due to the Tanner crab PSC limit (260,000 crabs). In 1995, the red king crab PSC was not reached, in part due to emergency implementation of the red king crab savings area (NPFMC 1995).

Recent data indicate that the current PSC limits for crab could be reduced from existing levels, yet not impact groundfish fisheries if the available PSC is optimally allocated among target fisheries and seasons. As shown by the adjacent table, the average bycatch taken each year has been less than the PSC limit. Hence, based on average bycatch needs, PSC limits could be reduced by about 20,000 red king crab and 1,000,000 Tanner crab (Zones 1 and 2 combined). Optimal allocation will be

Crab PSC bycatch in the 1992-1994 trawl fisheries.

	Red king (Zone 1)	Tanner (Zone 1)	Tanner (Zone 2)
1992	110,520	853,269	2,326,578
1993	183,713	1,031,985	2,337,884
1994	244,634	752,886	1,692,628
PSC Limit	200,000	1,000,000	3,000,000
Average	179,622	879,380	2,119,030

difficult to achieve because these apportionments are made pre-season. However, the Council will be considering a FMP amendment in September that would allow additional flexibility for in-season allocation of Tanner crab PSC among the bycatch limitation zones. More flexibility could be achieved with market solutions to bycatch, as discussed later in this paper.

The proposed PSC limit for opilio crab taken incidentally in BSAI trawl fisheries could be negotiated by industry representatives based on bycatch needs. Bycatch of "other crab"[1] (hereafter referred to as snow crab) in BSAI groundfish fisheries totaled 17.7 million in 1992, 14.8 million in 1993, and 12.5 million in 1994. This bycatch equates to about 0.2% of the snow crab stock as measured by the NMFS survey index of abundance (Stevens et al. 1994). Most snow crab bycatch is taken in the trawl fisheries (99%) and to a lesser extent in the longline (0.7%) and groundfish pot fisheries (0.3%). Although snow crabs are bycaught in nearly every trawl fishery, the yellowfin sole fishery takes the vast majority (70% on average 1992-1994). Bycatch is highest in the areas north and east of the Pribilof Islands, corresponding to NMFS statistical areas 513, 514, and 521 (NPFMC 1994). PSC caps for snow crab in Zone 1 make little sense due to the low numbers taken there. On the other hand, 60-86% of the snow crab bycatch comes from the area encompassed by the existing crab protection Zone 2. Average snow crab bycatch in Zone 2 was about 10.8 million crabs, which provides a reference point for industry representatives to negotiate the proposed snow crab PSC limit.

Snow crab bycatch in the 1992-1994 trawl fisheries, by zone.

	Zone 1	Zone 2	Other areas	Total
1992	104,844	11,996,347	5,561,358	17,662,549
1993	40,611	8,123,627	5,797,956	14,760,722
1994	25,334	11,424,057	1,032,736	12,482,127
Average	56,930	10,780,853	4,130,683	14,968,466

Crab PSC limits were designed as an allocative measure, not a conservation measure. Reducing the PSC limits will not do much to rebuild crab stocks. There are several reasons for this including: (1) bycatch appears to be a relatively minor source of crab mortality, (2) fleet-wide PSC limits provide vessels with no incentive to reduce bycatch rates, (3) halibut PSC limits already constrain most fisheries. Current bycatch limits amount to 0.7% of the red king crab and 2.0% of the eastern Bering Sea Tanner crab stocks based on NMFS survey index of abundance. It has been estimated that approximately 0.75% to 1.5% of the total mature red king crab stock in Bristol Bay is impacted by trawling each year (NPFMC 1995). For comparison, natural mortality annually removes about 20% to 25% of the red king crab stock (NPFMC 1990). Because bycatch mortality caused by trawl/dredge fisheries is probably very small relative to other sources of removals due to natural and fishing mortality, reductions in bycatch limits will not result in measurable improvements to crab stock abundance. Potential "savings" of crab through PSC reduction identified in this paper (20,000 red king crab and 1,000,000 Tanner crab) are not really savings because they would not be bycaught under the existing constraints of halibut PSC limits anyway. Also, reducing the existing crab PSC caps may cause lower groundfish harvests unless the limits are optimally allocated among target fisheries and seasons (Smith 1993). This may be impossible to achieve, and consequently, groundfish trawl fisheries may be negatively impacted. From a crab rebuilding perspective, a lower bycatch limit may result in fewer crab predators and competitors harvested, increasing mortality on juvenile crab.

Market Solutions

Individual bycatch quotas (IBQ's), also called individual bycatch accounts (IBA's), or vessel bycatch accounts (VBA's), have been proposed by the Council's Crab Rebuilding Committee and others as a means to reduce bycatch rates of halibut and crabs in trawl and scallop fisheries. In June 1995, the Council adopted for analysis an IBQ program for all BSAI non-pollock fisheries as part of a proposed individual transferrable quota (ITQ) program for the pollock fishery. Options for a VBA program analysis were proposed in August 1995 by the

[1]The NMFS observer data set groups crab bycatch into red king crab, other king crab, C. bairdi Tanner crab, and other Tanner crab. In the Bering Sea, other Tanner crab are almost entirely snow crab.

United Catcher Boats. Analysis of a VBA or other individual vessel bycatch program will require substantial time and consideration.

In theory, a VBA system would provide an incentive for each vessel to reduce its bycatch rate to maximize its catch of groundfish. Fishermen with high bycatch rates would be penalized by having to purchase additional bycatch allowances or by catching less groundfish. Fishermen with low bycatch rates would benefit by being able to catch additional groundfish without being shut down by vessels with higher bycatch rates, as they are under the current PSC system. In the current open access system, individual fishermen have no incentive to avoid bycatch; in fact just the opposite is true, because an individual fishermen who adopts bycatch reducing tactics will probably catch less target species (Huppert et al. 1992).

History has shown that individual vessels can reduce their bycatch with individual vessel incentives. In 1983, BSAI FMP Amendment 3 mandated a substantial reduction in foreign bycatch rates of halibut and crab, and total bycatch of salmon over a 5-year period. Foreign fleets successfully accomplished this goal. The Japanese fleet accomplished this by allocating its PSC share among participating vessels based on historical performance. If a vessel allocation was exceeded for any one species, that vessel had to stop fishing unless it purchased unused bycatch shares from other vessels. The result was an accumulated bycatch savings by the entire fleet (Hastings 1991).

One benefit of implementing a VBA program is that it would make reductions in crab PSC limits more acceptable to trawl fishermen. Even under an overall reduced PSC limit, trawl fishermen could potentially increase their groundfish catch under a VBA program. This would be especially true if VBAs were fully transferrable among target fisheries and seasons. As previously stated, however, reductions in crab bycatch will not have much impact on crab rebuilding.

From a crab rebuilding perspective, a VBA program could benefit crab stocks by allowing increased harvests of crab predators and competitors, which have increased in recent years. Biomass of crab competitors (inshore benthic infauna consumers such as starfish and flatfish) has increased about 40% from 1979-1993 (Livingston et al. 1993). Most of this increase is attributable to a growing rock sole biomass, and to a lesser extent starfish and flathead sole biomass. Of the crab species, only snow crab comprises a substantial portion of the infauna consumer guild (species that eat clams, polycheates, etc.). Yellowfin sole had dramatically increased in abundance in the early 1980s to become the largest component of this guild until the early 1990s when rock sole became co-dominant. Mean size at age has declined for yellowfin sole and rock sole, indicating stress caused by competition, and to a lesser extent a decrease in average bottom temperature (P. Livingston, personal communication, 3/20/95).

Predation by groundfish may be another factor affecting the recovery of crab stocks. For snow crabs, estimates of annual consumption by groundfish from May through September ranged from 9 billion to 31 billion crabs (Livingston et al. 1993). Snow crabs consumed were primarily age 1, and to a lesser extent age 2 and 3 crabs. Pacific cod is a primary predators of snow crab, particularly softshell female and juvenile crab (McLellan & Leong 1981, Livingston 1989, Livingston et al. 1991). Flathead sole, yellowfin sole, and rock sole have been found to prey on young snow crabs (Haflinger and Roy 1983, Livingston et al. 1993). Annual consumption of Tanner crabs by groundfish ranged from 10 billion to 153 billion crabs, consisting primarily of Age 0 and Age 1 crabs (Livingston et al. 1993). Yellowfin sole and flathead sole were found to be the primary consumers of small Tanner crabs, whereas Pacific cod preyed on the larger juveniles. Although yellowfin sole and Pacific cod are known predators of juvenile and molting red king crab (Haflinger and McRoy 1983, Livingston et al. 1991), data suggest that mortality caused by groundfish predators on adult red king crab may be low during summer months.

It should be noted that even under a VBA program, fisheries will be unable to harvest crab competitors and predators to the point where these stocks stabilize in abundance. Total annual BSAI groundfish harvest is

limited by an optimum yield cap of two million metric tons. This cap generally results in TAC allocations to higher valued species and fisheries with lower halibut bycatch that flatfish fisheries (Witherell 1994). It is unlikely that pollock TAC would be reduced by 580,000 mt in order to harvest yellowfin sole, rock sole, flathead sole, and other flatfish to their ABC levels. Additionally, populations of another predator of juvenile red king crab, sockeye salmon (Wespestad et al. 1994), remain high and will not be impacted by a groundfish VBA program.

One potential limitation of a VBA system is that there will still be a race for fish TAC. Unless an individual fishing quota system were implemented in concert with a VBA system, fishermen will still harvest fish as early in the season as possible, so as to catch some fish before TACs are reached by the fleet. Additionally, fishermen will tend to race for and use their VBA shares for higher valued species (such as Pacific cod and rock sole), potentially leaving less valuable species unharvested (such as flathead sole). From a crab rebuilding perspective, this may have positive or negative consequences depending on what species are harvested and where and when fishing occurs.

A critical factor that must be worked out before implementing a VBA system is monitoring of individual vessels bycatch. On vessels with 100% observer coverage, monitoring may be rather straightforward, using observer samples to extrapolate bycatch numbers. However, bycatch accounting on vessels with 30% coverage or no coverage requirement would require a different approach, and one not easily solved. There are also unresolved questions regarding enforcement of VBAs using observer data. These and other potential implementation issues are being examined by NMFS.

Other Options

Bycatch Penalties and Fees - Penalties and fees have been proposed as a disincentive for individual fishermen to catch bycatch. An evaluation by Marasco and Terry (1982) suggested that economic disincentives would be preferable to PSC limits, time/area closures, gear restrictions, and reduced groundfish quotas as a way to minimize the impact and control costs of incidental catch. The BSAI groundfish FMP Amendment 16 originally contained a "penalty box" system that would temporarily remove vessels with high PSC bycatch rates from the fishery on a real time basis. This system was disapproved by the Secretary of Commerce. In its place, the Council adopted a vessel incentive program (VIP) and gear restrictions. The intended effect of the VIP program is to increase the opportunity to harvest groundfish TACs before established PSC limits are reached. The VIP program is based on specification of bycatch rate standards that, when exceeded, constitute a violation of the regulations implementing the VIP, and monetary penalties are assessed. In 1994, bycatch rate standards were 2.5 red king crabs per ton of groundfish in the BSAI yellowfin sole and non-pollock trawl fisheries in Zone 1. Analysis indicates that the VIP may have helped reduce crab bycatch rates in the yellowfin sole fishery, but not in the rock sole fishery. Bycatch rates of red king crab in the at-sea processing yellowfin sole fishery were reduced from 0.31 in 1992 and 0.14 in 1993, to only 0.08 crab per metric ton of groundfish in 1994. Bycatch rates in the rock sole fishery increased from 1.12 in 1992 to 2.03 in 1993, and up to 2.77 crab per metric ton of groundfish in 1994 (NMFS 1994). Unfortunately, because the VIP program is based on rates of PSC per metric ton of groundfish, fishermen that use selective gear to reduce juvenile groundfish bycatch may actually be penalized for violating the VIP. Additionally, due to its cumbersome legal nature, very few cases have been prosecuted.

Gear and season modification - Gear restrictions have been used to reduce bycatch and ghost fishing. To reduce the potential for ghost fishing by lost pots, pots used in the groundfish fishery require a biodegradable panel constructed of # 30 or less cotton thread, that is a minimum of 18" long, parallel to and within 6" of the bottom of each pot. In the trawl fisheries, minimum mesh sizes regulations were recently adopted by the Council to reduce the bycatch of juvenile fish. Mesh regulations may also reduce the bycatch of small crabs. At the rebuilding committee meeting, one industry representative suggested that trawls fitted with bigger discs with wide spacing on the footrope would catch less crabs. Season adjustments could possibly be designed to structure the

fishing season to avoid times and areas of high crab bycatch, however, they have not been explored at this time.

Discussion

The Council has initiated analysis of several proposed measures to reduce potential negative impacts of groundfish fishing on crab stocks. Of all the measures examined, the proposed closure of northern Bristol Bay to protect juvenile habitat appears to offer the most conservation benefit to crab stocks. However, data on habitat and juvenile red king crab distribution suggest that a more comprehensive trawl/dredge closure area in the nearshore waters of Bristol Bay should be considered. Analysis also suggests that bycatch limits previously established for trawl and dredge fisheries could be reduced, but that conservation benefits to crab stocks would be negligible. Bycatch management through individual vessel bycatch accountability provides a means, within existing bycatch limits, to somewhat increase the removal of crab predators and competitors such as yellowfin sole and Pacific cod. However, these measures alone will not rebuild crab stocks.

Summary of alternative management actions and goals of reducing impacts of trawling and dredging.

Goal	Status quo	Offshore Closure	Nearshore Closure	PSC Reduction	VBA Program
Reduce crab bycatch by trawlers	0	+	?	+	+
Reduce crab predation/competition	0	-	?	-	+
Protect juvenile habitat	0	0	+	0	0

Crab stocks will rebuild only when recruitment increases. Managers can affect recruitment by ensuring there are adequate numbers of spawners, providing adequate habitat available for settlement, and reducing fishing mortality on juvenile crab. Conservation of spawning stocks can be accomplished by the State through adjustments to GHLs in crab fisheries. Adjustments to existing bycatch limits in other fisheries will have only a very small impact on increasing adult stocks sizes or reducing juvenile mortality. To reduce juvenile mortality by limiting bycatch of non-target crab in crab fisheries, the Council or State could consider implementing measures such as bycatch limits or a VBA program for crab fisheries.

Once these actions have been taken, then the crab stocks will be in the best possible position to recover if environmental and other ecological factors create a suitable situation for the stocks to flourish. This may take years. For example, although large areas around Kodiak Island have been closed to trawling and dredging since 1987, stocks of red king crab in that area have not recovered to levels which can support a crab fishery. In cases such as these, there is little more managers can do but wait.

This paper highlights the need for continuing research. Improved knowledge of crab recruitment, life history, habitat needs, the effects of trawling on habitat, as well as a review of crab management strategies around the world would aid in effective management of crab stocks. Some of this work is underway (e.g., Kruse 1995), and we would encourage government agencies and universities to continue this research.

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STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

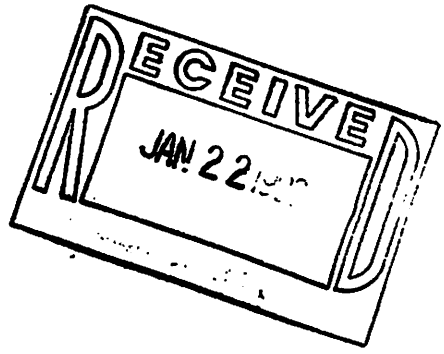
OFFICE OF THE COMMISSIONER

TONY KNOWLES, GOVERNOR

ITEM 6

#1

P.O. BOX 25526
JUNEAU, ALASKA 99802-5526
PHONE: (907) 465-4100
FACSIMILE: (907) 465-2332



January 19, 1996

Mr. Rick Lauber, Chairman
North Pacific Fishery Management Council
605 West 4th Avenue, Suite 306
Anchorage, AK 99501-2252

Dear Mr. Lauber:

The State of Alaska is compelled to comment on the recent action by the North Pacific Fishery Management Council on the Bristol Bay trawl closure area designed to protect red king crabs. The council closed the area from 162° to 164° W longitude, 56° to 57° N latitude from January 1 to March 31 each year to all non-pelagic trawling with a provision to reopen the area bounded by 56°00' to 56°10' N latitude in years when a guideline harvest level for Bristol Bay red king crab is available. We feel that the size of the closure area is sufficient, but the limited duration of the closure period will not provide the necessary protection for red king crab. This concern was also voiced in the November 7 letter to you by the Alaska Board of Fish (BOF).

The State remains seriously concerned about the depressed status of red king crab stocks in Bristol Bay (area T). For the second year in a row the estimated abundance of large female red king crab has been at or below threshold, and small female, sublegal and legal male crab abundance's have remained at low levels. As a result, the directed pot fishery for red king crab has been closed for the past two years. It is critical that all possible measures be taken to protect the crab stocks during this period of low abundance. For this reason, the BOF established regulations to close the directed *C. bairdi* fishery east of 163° W when Area T red king crab are at or below threshold. Additionally, the department will ask the BOF in March 1996 to set a reduced exploitation rate when the female population rebounds above threshold level.

The Council action of October 2 differed from the analysis both by allowing pelagic trawling in the area, and by opening the chosen closure area after March 30 to all trawling. The draft Environmental Assessment/Regulatory Impact Review/Initial Regulatory Flexibility Analysis (EA/RIR/IRFA), *Red king crab bycatch in the Bering Sea trawl fisheries and alternatives for closure areas*, considered six alternatives to the status quo for closure areas protecting red king crab in the Bristol Bay Area. While the analysis examined the temporal component of red king crab bycatch, and the results of the Bering Sea fishery simulation model provided weekly

estimates of catch and bycatch, all alternatives were based on year-round closure. The EA/RIR did not include an analysis of seasonal closures.

The portions of the EA/RIR analysis which do shed light on the seasonal component of crab bycatch in the fisheries indicate that assumptions based on this data are difficult to make. The domestic trawl fishery for rocksole is directed at spawning fish during the first two months of the year, and has been closed in most years out of Zone 1 because of red king crab bycatch, or closed out of the entire Bering Sea due to halibut bycatch by the middle of March. Thus, there is little catch or bycatch data available for late March or April from the rocksole fishery in the areas proposed for closure. Similarly, the yellowfin sole fishery was delayed until May 1 during the years 1990-1993 because of concerns over halibut bycatch during the first months of the year. Additional information indicates that in 1994, the fishery was allowed to begin on January 20, but was closed out of Zone 1 on May 6 because of Tanner crab bycatch. The fishery was again closed out of Zone 1 on April 4, 1995 due to Tanner crab bycatch. The emergency closure in 1995 effectively acted as an annual closure, since the yellowfin fishery was closed from Zone 1 prior to the reopening of the emergency closed area. Therefore, recent data are not available to examine the full impacts of trawling on red king crab during the early spring. Given the mobility of the groundfish fleets, fishing effort is likely to relocate to the closed area when it's reopened on April 1 and the impacts on crab stocks could be significant. Examination of foreign and JV fishing provides insight into possible impacts due to fishing this area on a monthly basis.

Attached are catch/bycatch maps from Alaska Fisheries Science Center Processed Report 91-07, *Fisherman's guide to catch per unit effort and bycatch data from the National Marine Fisheries Service observer program.* The maps from the Joint Venture fisheries, not included in the EA/RIR, indicate that while the closed areas can yield high bycatch of red king crab, the yellowfin sole fishery has low dependence on the area for harvest. From this information, it appears that closure of the area to bottom trawling will not have the adverse impacts on the catch of groundfish discussed at the September Council meeting. One aspect of the bycatch of red king crab made very clear in the attached maps is the importance of the maintenance of the closure of Area 516 to trawling between March 15 and June 15. The seasonal closure of area 516 provides some protection to mating and molting red king crab in the rocksole closure area which would otherwise be lost due to the councils' action to reopen the closure area on April 1.

The EA/RIR discussed the amount of crab bycatch and catch taken by the domestic yellowfin sole fishery by area. As indicated in Tables 1 and 4 of that document, the domestic yellowfin sole fishery took a high of 60,000 crab from the Bering Sea in 1992 of which approximately 25% (15,000 crab) came from the closure area. Alternatively, this area was not particularly important for groundfish in the yellowfin sole fishery, equaling 0.2% or less of their BSAI catch in 1990, 1991 and 1993 and only reaching 8% of the total groundfish catch in 1992. In fact, in three out of the four years more than 94% of the BSAI groundfish catch in the yellowfin sole fishery was taken outside of Zone 1 and outside of the Pribilof closure area.

The economic analysis in the EA/RIR also indicated little change from the status quo under any of the alternatives. Following the September Council meeting, the State performed a new model run to gauge the economic impacts of the seasonal closure adopted by the Council verses an annual closure. This new model run, which considered Alternative 4 using the 1993 data set, was made with a January-March closure. The resulting net benefits to the Nation were estimated to increase by $10,000 over an annual closure, an increase of only 0.003%. It appears that the marginal economic benefit to the groundfish fishery under the January-March seasonal closure, does not out-weigh the conservation gains for red king crab of an annual closure.

The State of Alaska continues to support a protective closure in this area, but the state does not believe that the proposed trawl closure adopted by the Council is sufficient to protect the red king crab stocks. During the first half of the year crab congregate in the vicinity of the closure area and are particularly vulnerable to mortality as they are in the process of molting and mating. The possibility that crab can survive the impacts of trawl gear are clearly diminished during this critical time of the year. This is true for both pelagic and on-bottom trawling. For example, because the pelagic trawl fishery is performance based (based on the number of crab brought to the surface in each haul), the impact on crabs by allowing pelagic gear to fish in the closure area will only be minimized if the foot rope gear does not lethally impact non-retained soft shelled crab. Moreover, the summer trawl survey, the fall directed crab fishery and the crab taken incidentally in groundfish fisheries all indicate the distributional presence of red king crab on these grounds year around.

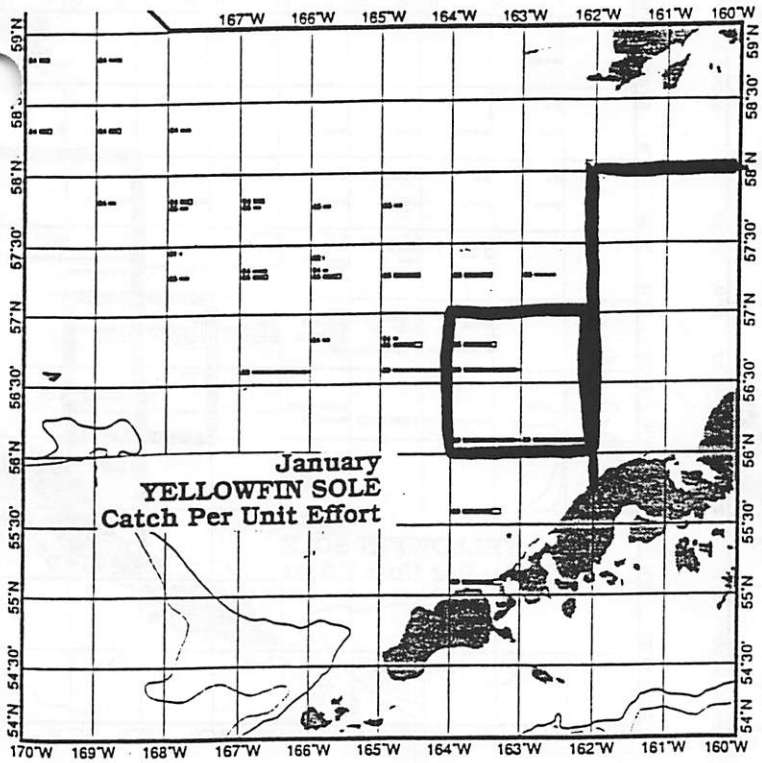
The Alaska Department of Fish and Game and the BOF have worked with the crab industry to implement a suite of management measures to protect crab resources when abundance is low. It is imperative that the Council and trawl industry recognize the seriousness of the decline in red king crab abundance and act in concert with the State to promote crab conservation through area closures until stocks rebuild. Therefore, the State strongly urges the council to revisit this issue and to take additional measures to protect red king crab for the entire year.

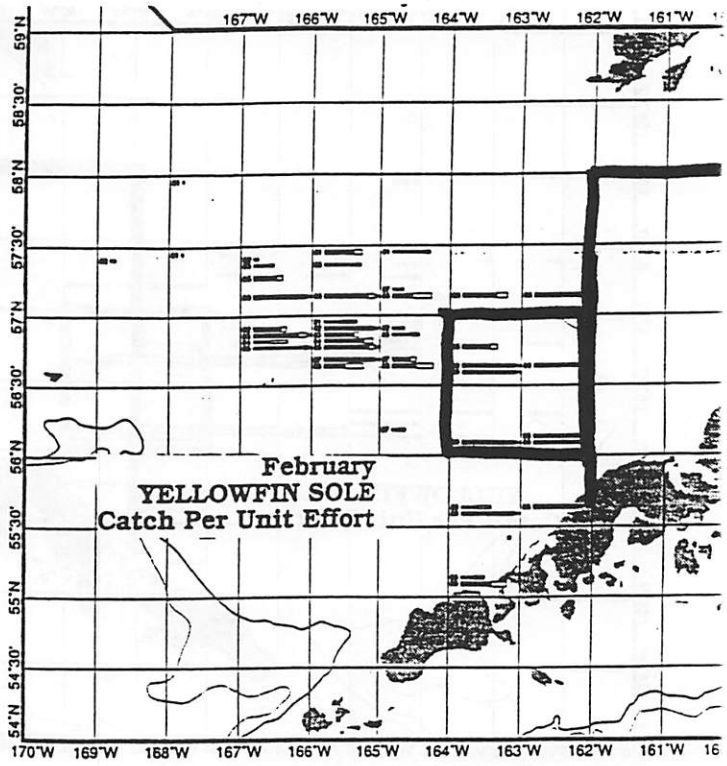
Sincerely,

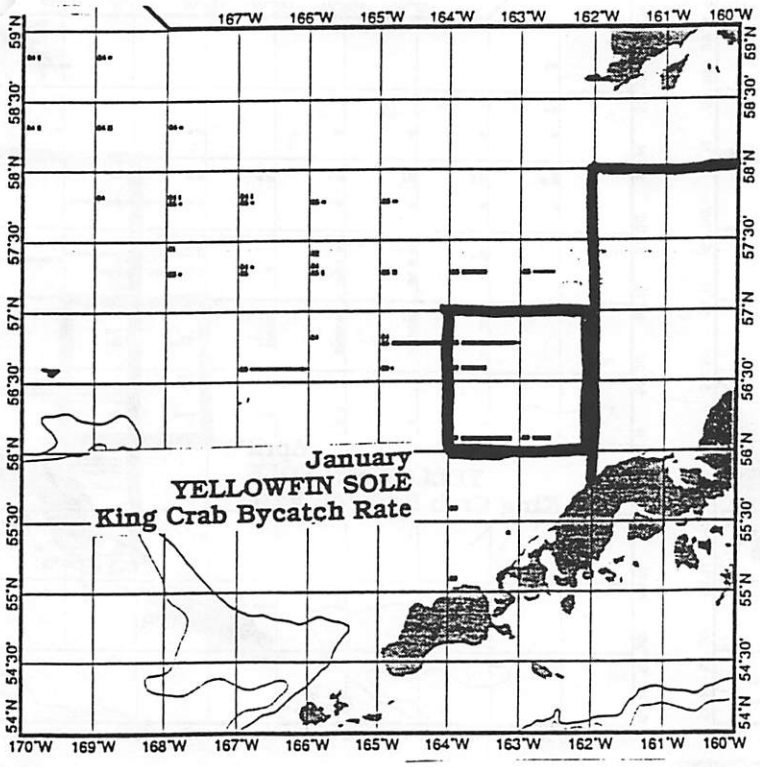
David Benton
Deputy Commissioner

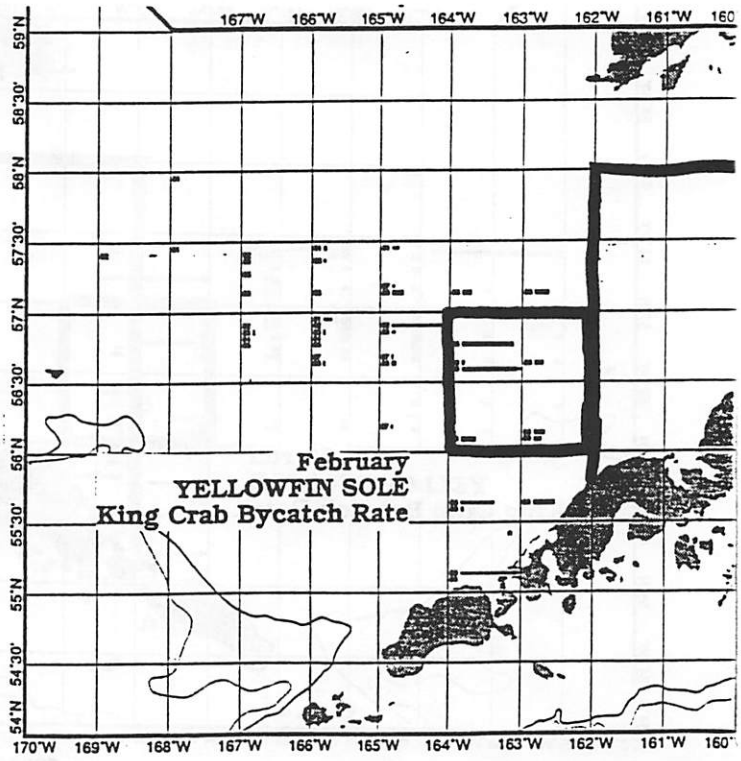
Enclosures

cc: Steve Pennoyer, Regional Director
National Marine Fisheries Service









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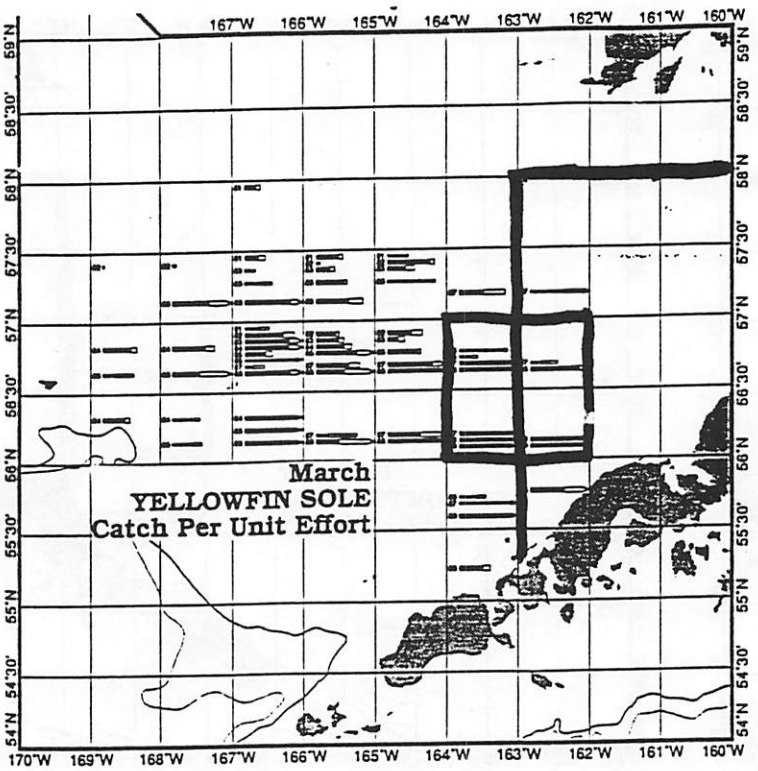
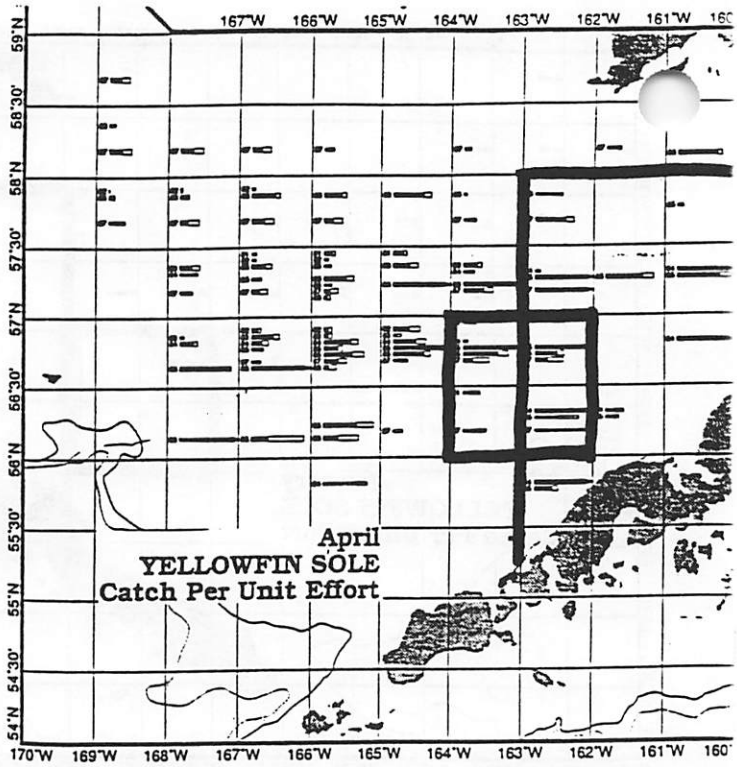
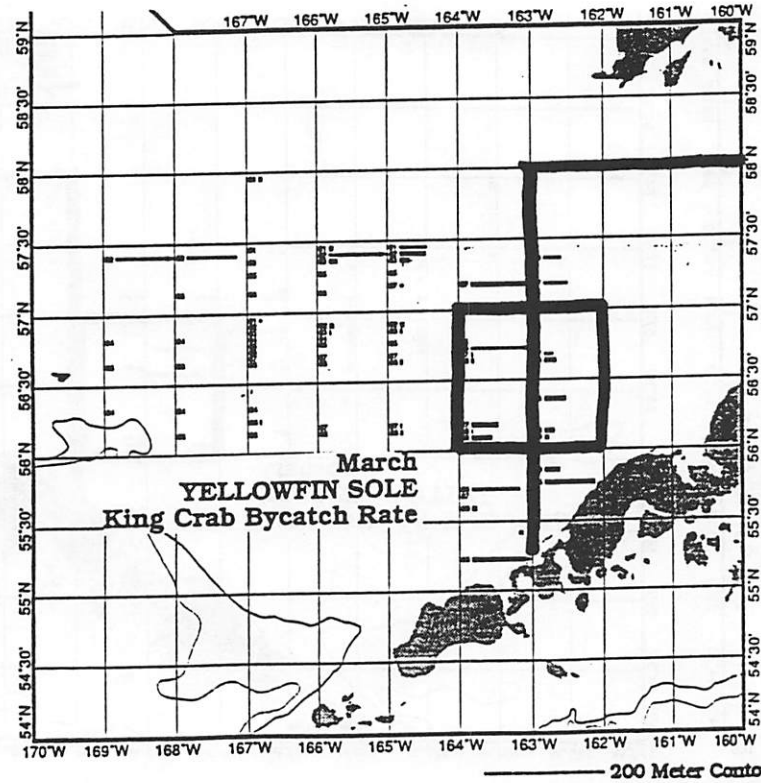
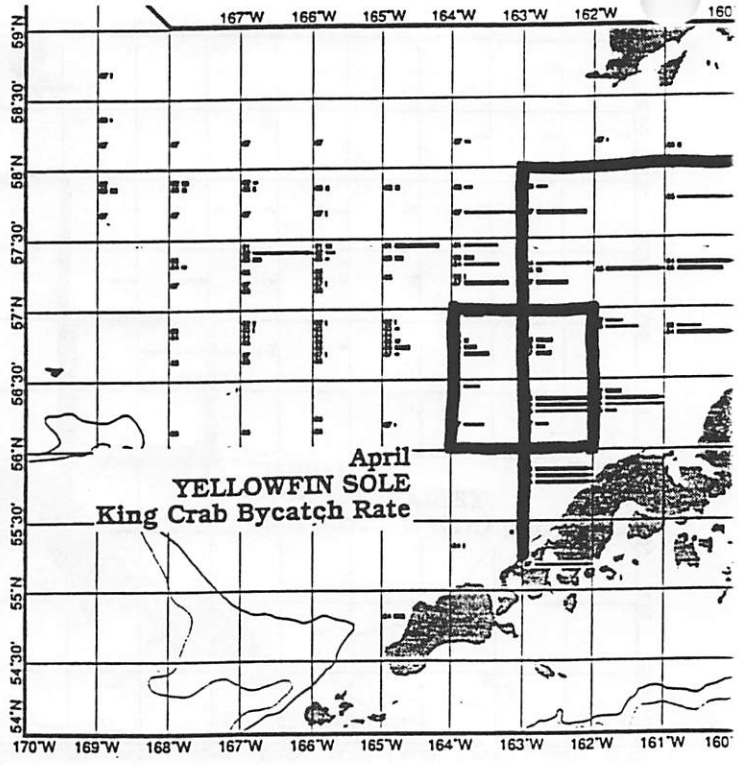
NOTES: Entire bar is Total CPUE; filled portion is Target CPUE.
Consult data tables (Section VIII) to determine offscale values.









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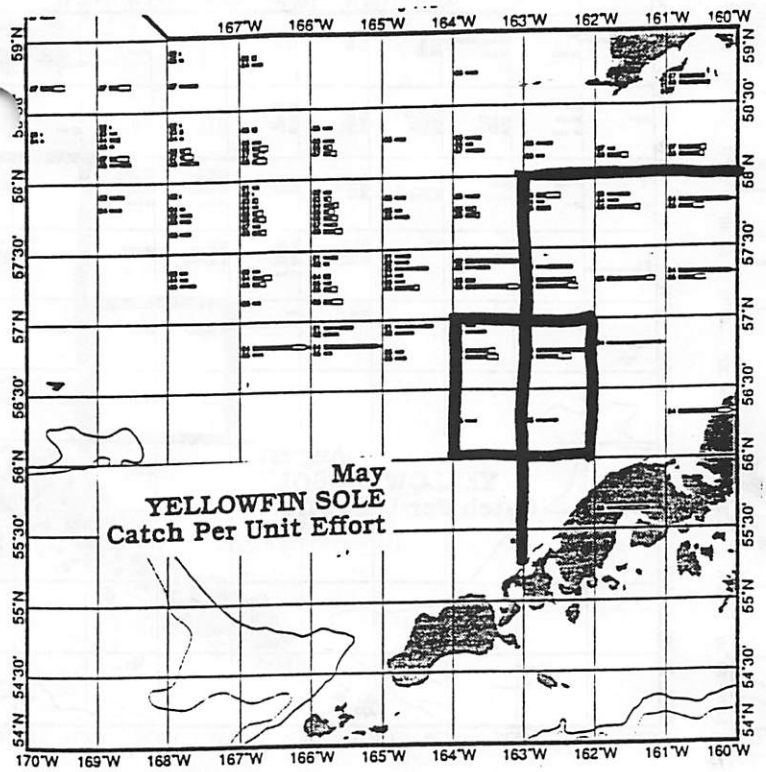

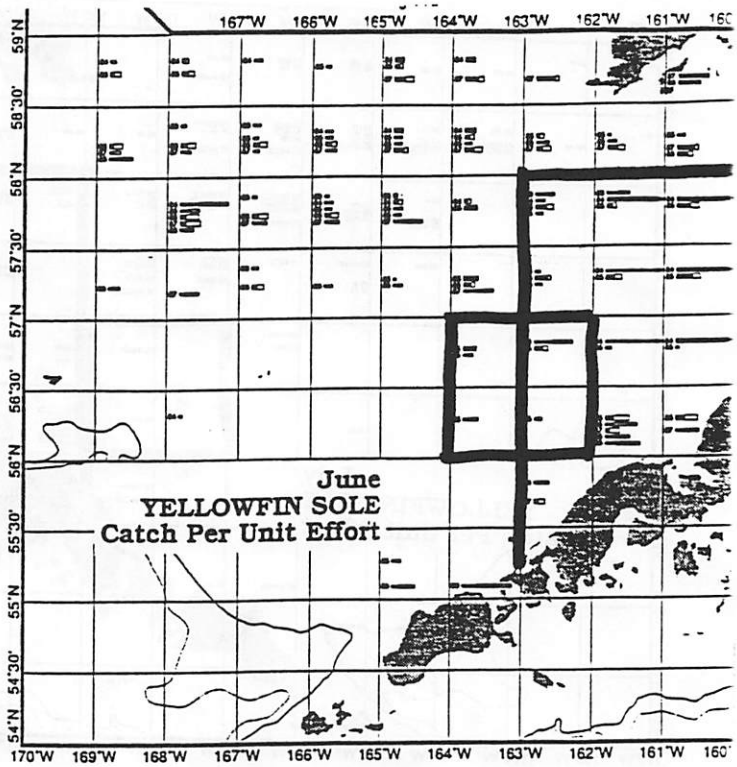

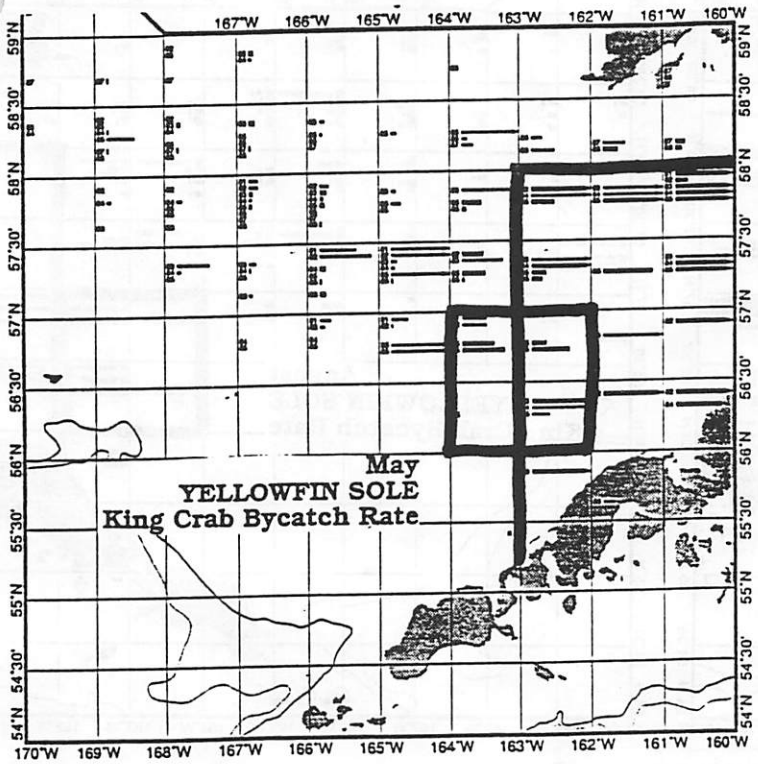

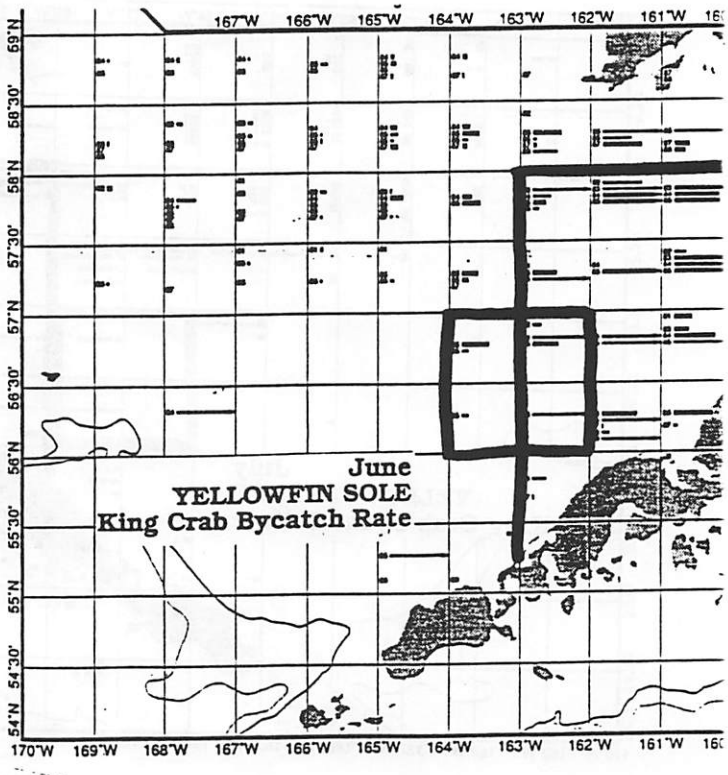

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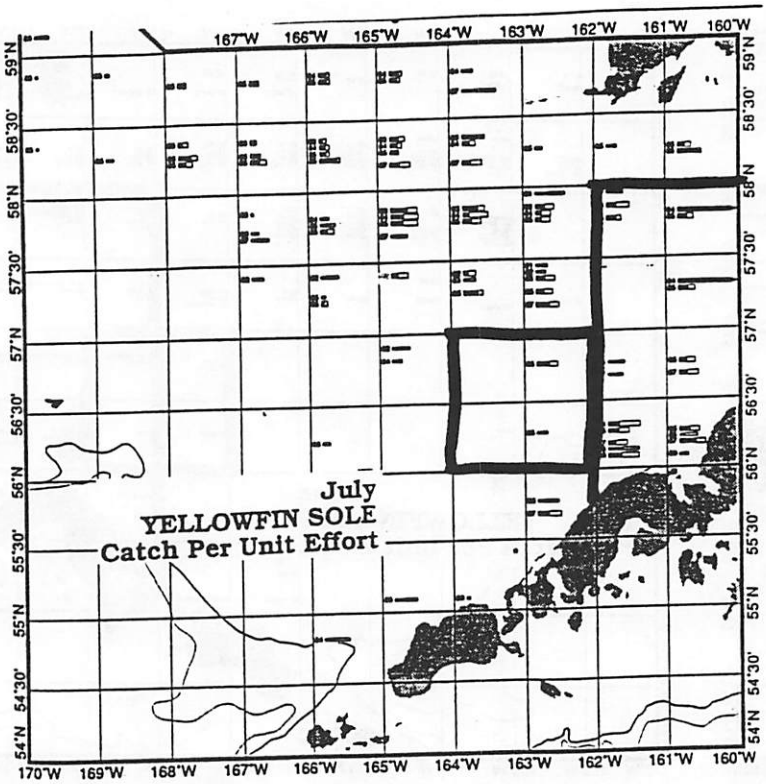

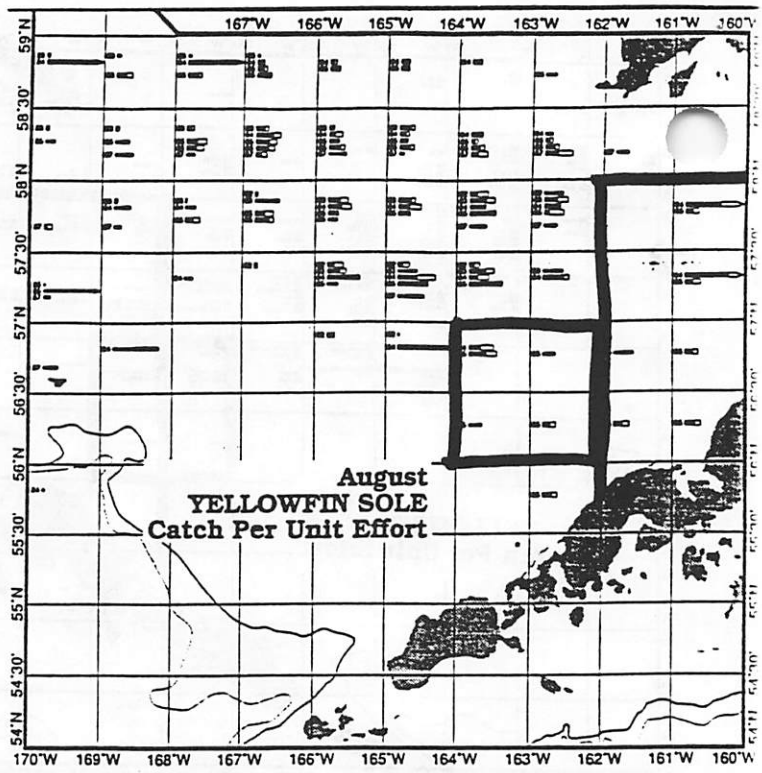

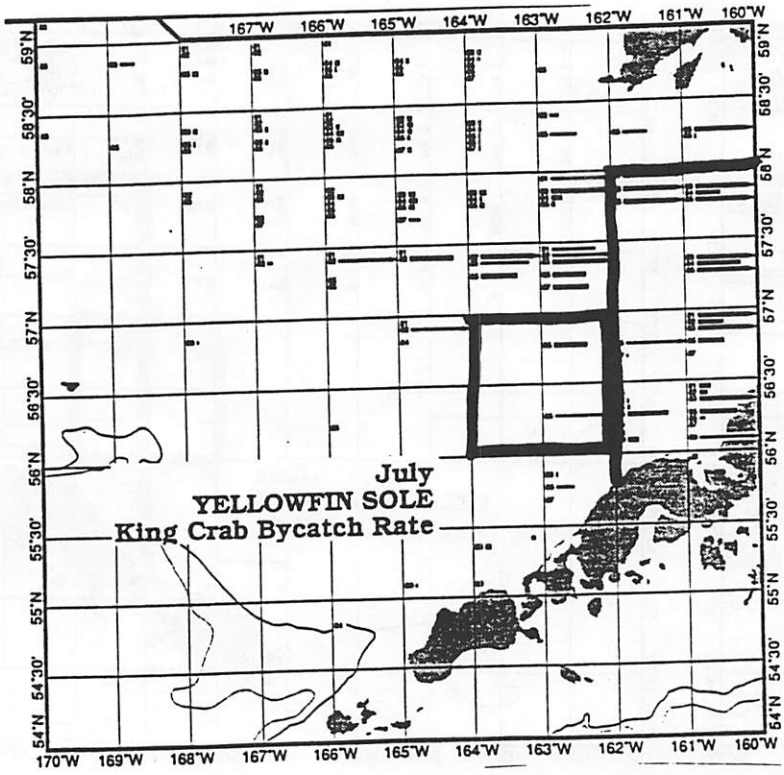

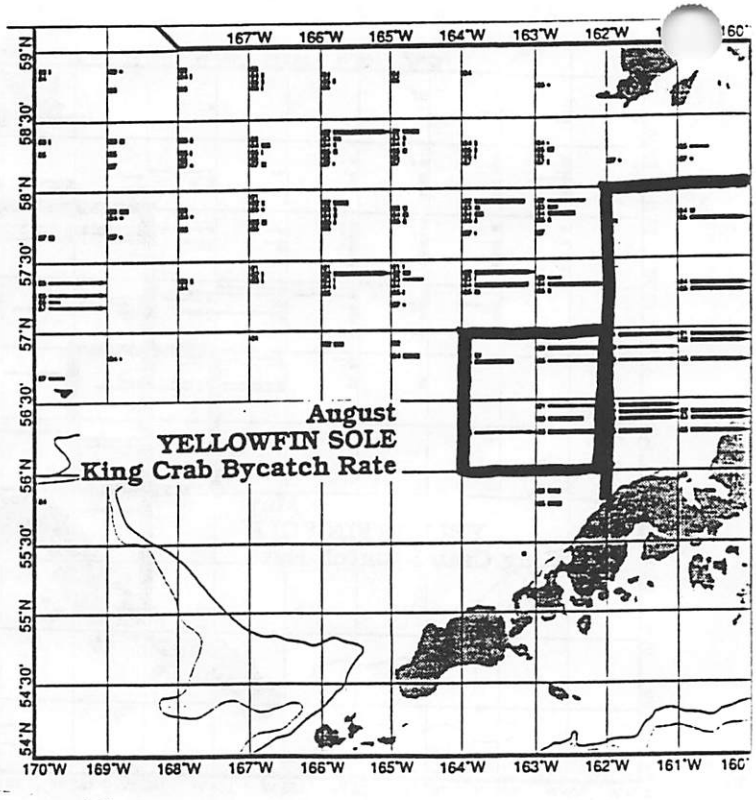

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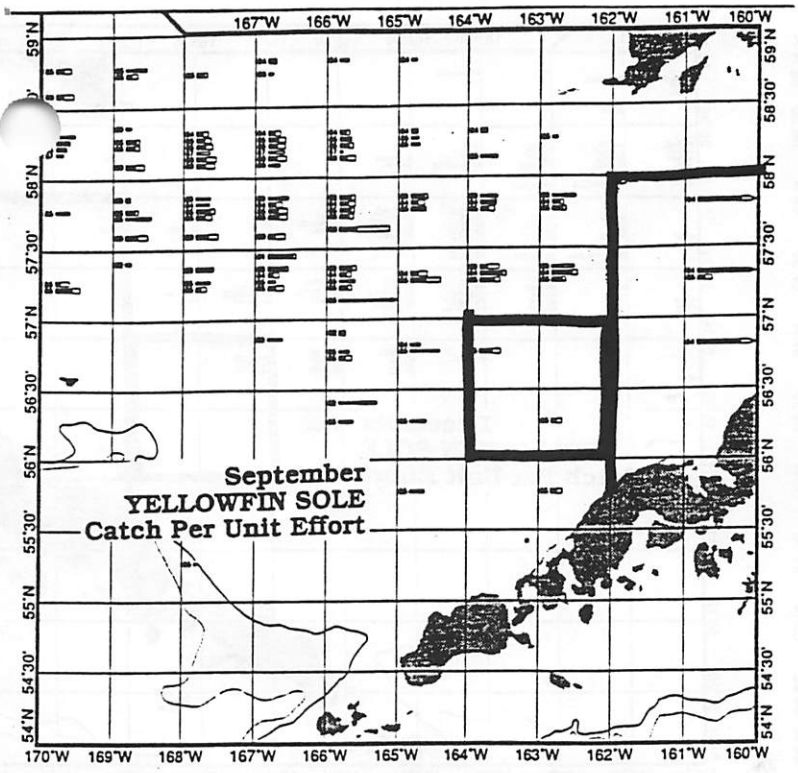

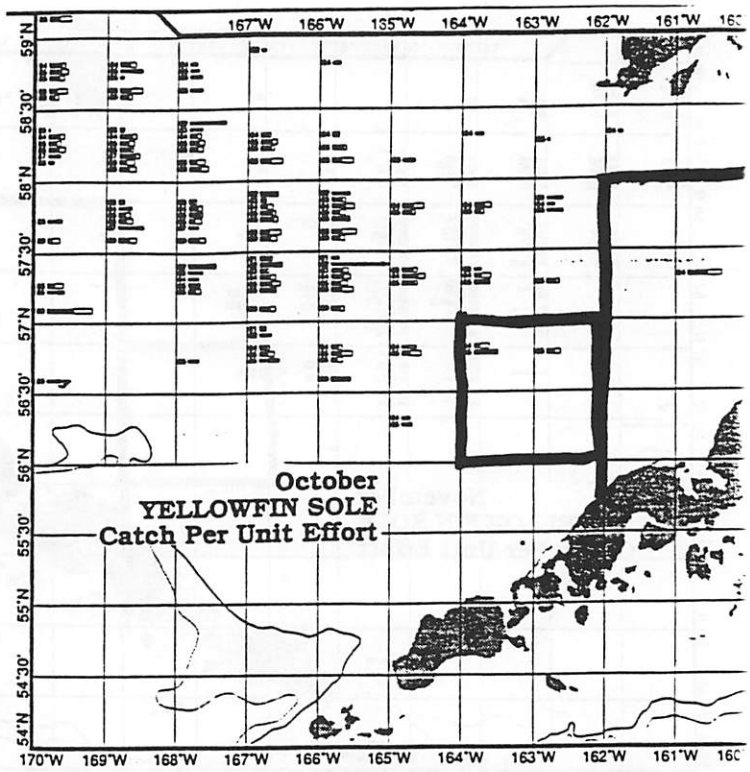

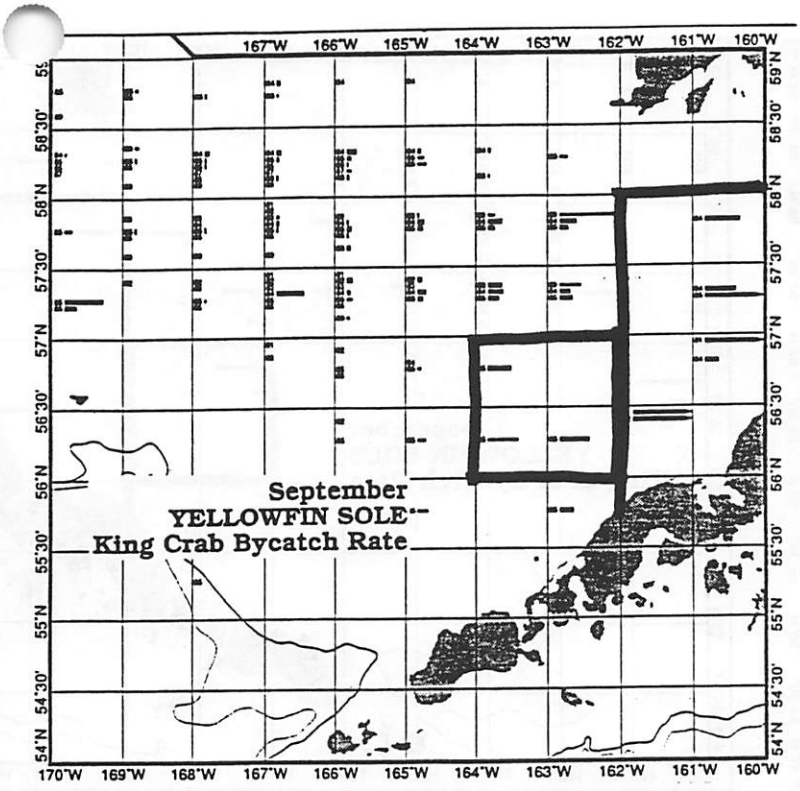

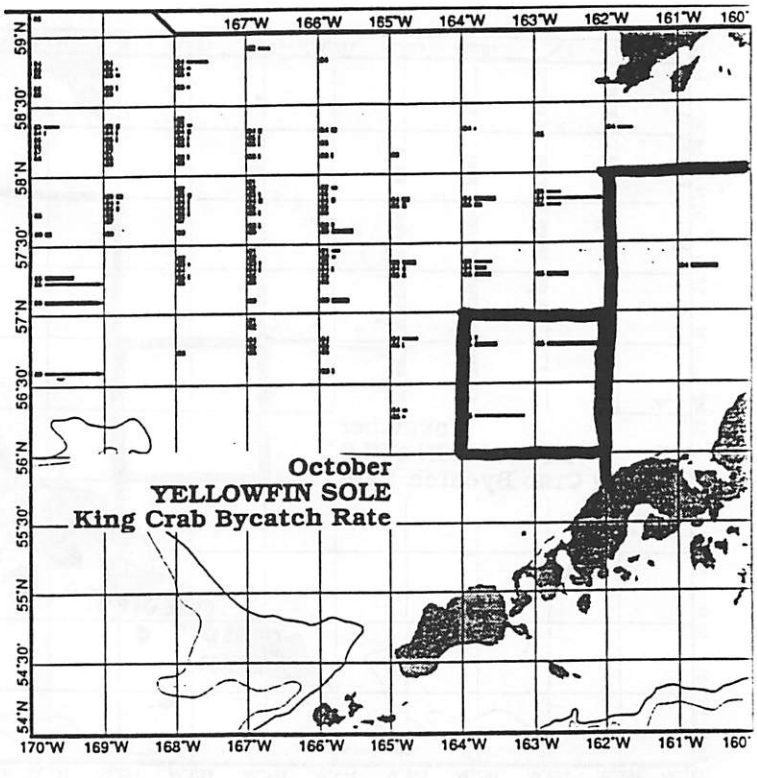

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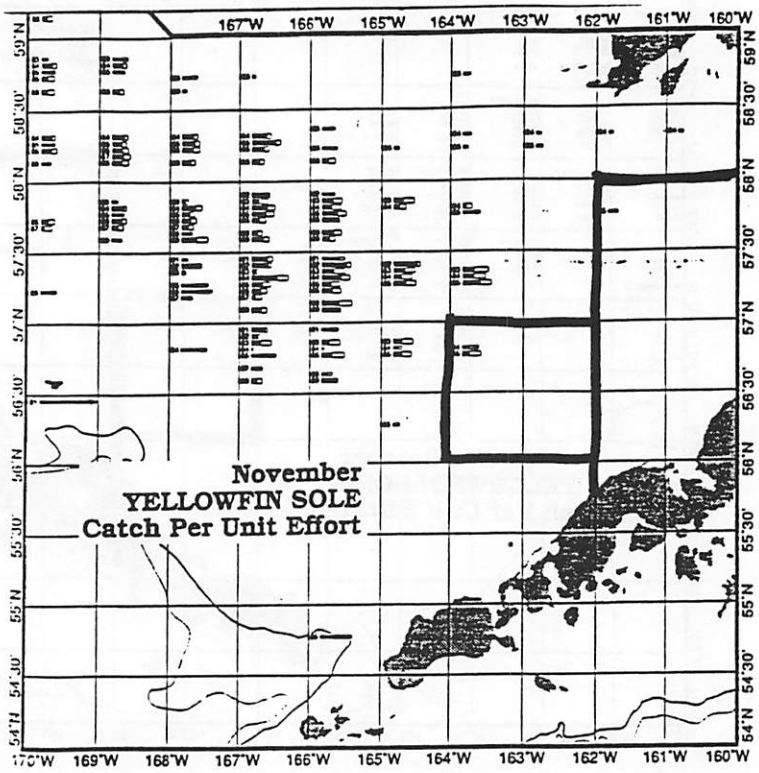
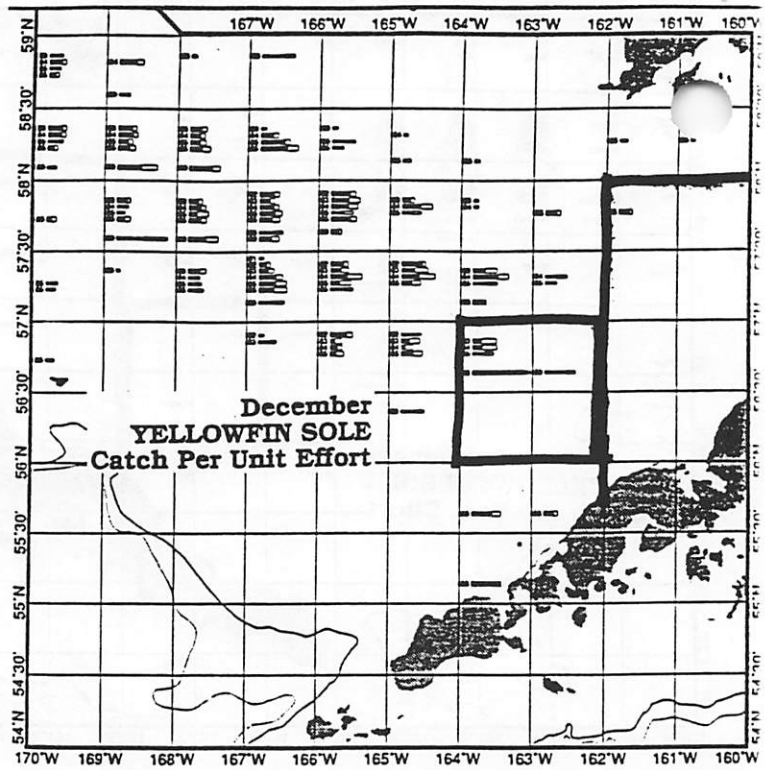
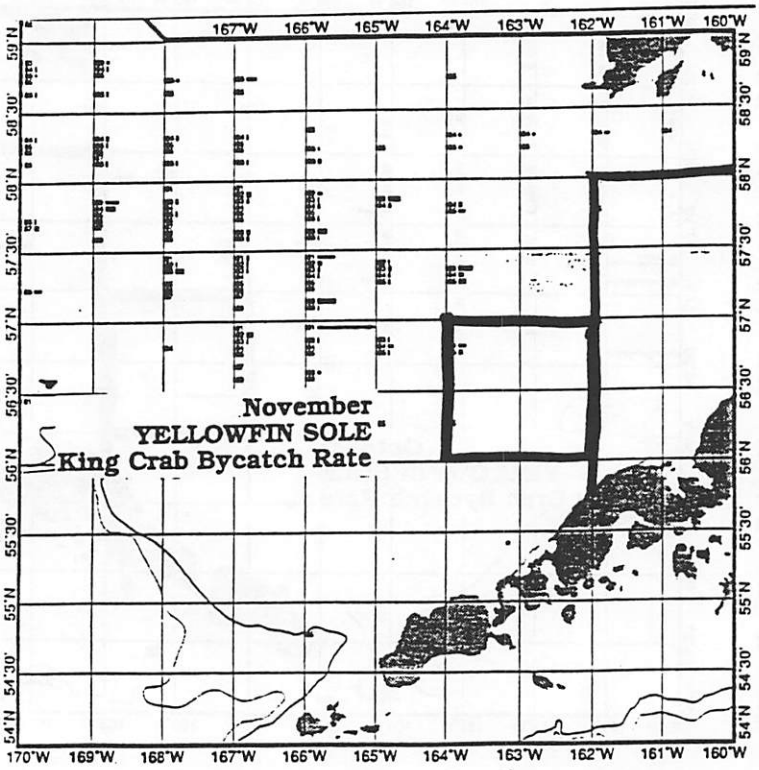
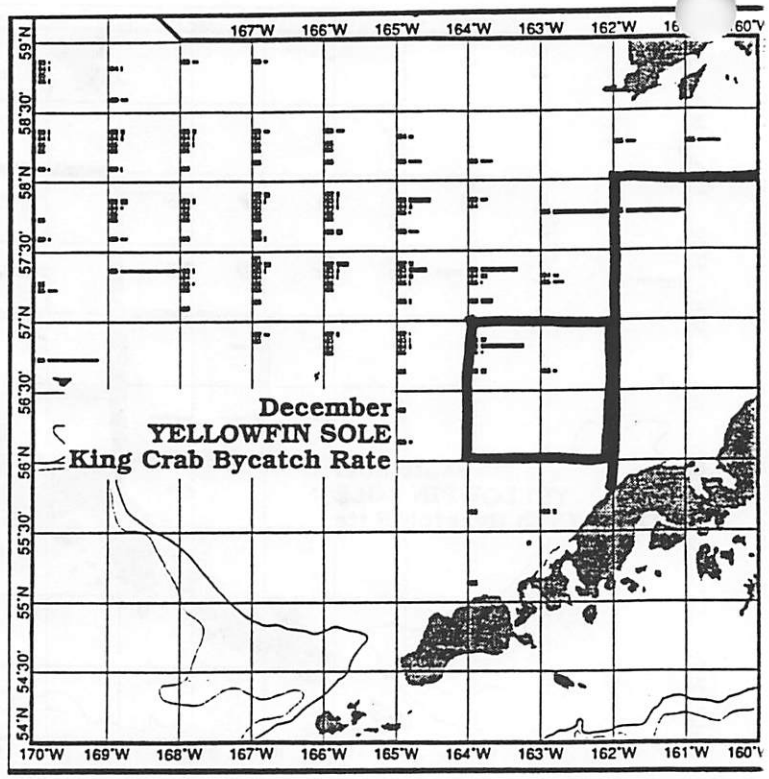








200 Meter Contour.
1000 Meter Contour.

0 5 10 SCALE: Metric Tons Per Hour.

81 1981 Both CPUEs Onscale. Five or More Tows (Wide Bar).
83 1983 Both CPUEs Onscale. Less than Five Tows (Narrow Bar).
85 1985 Both CPUEs Offscale (Pointed End). Five or More Tows.
87 1987 Total CPUE Offscale; Target CPUE Onscale. Less than Five Tows.

NOTES: Entire bar is Total CPUE; filled portion is Target CPUE.
Consult data tables (Section VIII) to determine offscale values.

STATE OF ALASKA

#2

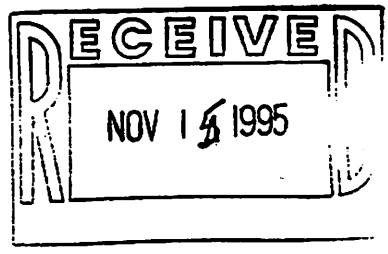
TONY KNOWLES, GOVERNOR

DEPARTMENT OF FISH AND GAME

BOARD OF FISHERIES

P.O. BOX 25526
JUNEAU, ALASKA 99802-5526
PHONE: (907) 465-4110
FAX: (907) 465-6094

November 7, 1995



Richard Lauber, Chairman
North Pacific Fisheries Management Council
605 West 4th Avenue, Suite 306
Anchorage, AK. 99501-2252

Dear Mr. Lauber:

During our October work session, the Alaska Board of Fisheries (board) received a staff report on the recent North Pacific Fishery Management Council (council) action regarding the non-pelagic trawl gear closure to protect Bristol Bay red king crab. The board is concerned that the alternative selected by the council may have adverse impacts on these already depressed king crab stocks.

According to the Alaska Department of Fish and Game (department), 1995 estimates of pre-recruit male and mature male and female red king crab abundance remains low and has declined from 1994. More importantly, the mature female red king crab population at or below the threshold level of 8.4 million animals for the second consecutive year. Concurrent with the decline in abundance, the distribution of red king crab has geographically contracted. Most of the stock now resides within Area 512 and the non-pelagic trawl closure area. Based on this information, we believe the stock remains in a depressed condition. A closure of the 1994 and 1995 directed king crab fishery and restrictions on C. bairdi Tanner crab east of 163 degrees W. longitude was necessary in accordance with Board's Policy on King and Tanner Crab Resource Management and the Council's Fishery Management Plan for Commercial King and Tanner Crab Fisheries in the Bering Sea and Aleutian Islands.

The board is very concerned with the continued protection and rebuilding strategy for Bristol Bay red king crab stocks, and that the less conservative trawl closure option chosen by the council may not afford the necessary protection. In 1994, the council adopted an Emergency Rule which closed red king crab habitat sensitive areas to all non-pelagic trawling. This closure, coupled with a closure of the directed crab fishery, prevented a further decline in the stocks. A less restrictive closure at this time may undo these conservation savings.

The department scientists and managers, the crab industry, and this board believes a comprehensive year round closure of non-pelagic trawling in this area is essential for protecting crab stocks during their sensitive life history periods and migration cycles.

The Board of Fisheries wants to discuss this subject with the council at our joint meeting on January 9, 1996. We understand that the council can not revisit this issue at its December meeting without jeopardizing protective regulations which will be in effect for the 1996 "A" season.

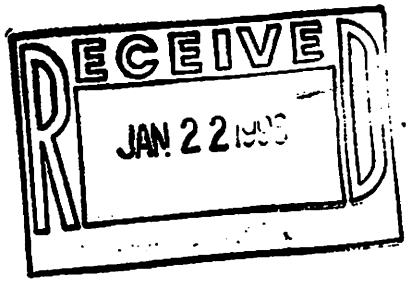
I look forward to your consideration of this issue.

Sincerely;

Larry Engel, Chairman
Alaska Board of Fisheries

cc: David Benton
Earl Krygier
Steve Pennoyer

#3



Gordon Kristjanson
F\V Aleutian Mariner
20301 191st AVE. N.E.
Woodinville, WA 98072

January 21 1996

Richard B. Lauber, Chairman
N. P. F. M. C.
605 West 4th Avenue, Suite 306
Anchorage, AK 99501-2252

Dear Mr. Lauber,

I am aware that the NPFMC has taken steps to reduce crab bycatch with the implementation of the seasonal non-pelagic trawl closure in the Bristol Bay Red King Crab Savings Area. Because Bristol Bay king crab stocks are in such a depressed state that they haven't warranted a commercial harvest in the last two years, I believe the non-pelagic trawl closure should be year round.

The seasonal closure has had little or no adverse effect on the Rock Sole Fishery, yet it has resulted in a very large reduction in king crab bycatch. If this closure remains only seasonal, it will allow the Yellow Fin Sole fishery to invade this crucial area and destroy any chance for recovery of the Bristol Bay King Crab and Bairdi Crab stocks. Yellow Fin Sole are widely distributed in the Bering Sea. I would expect the Yellow Fin Sole fishery would also harvest its TAC with a year round area closure of the Bristol Bay Red King Crab Savings Area, while substantially reducing the King and Bairdi Crab bycatch.

It is very difficult, as crab fishermen, to accept the fact that we cannot harvest Bairdi east of 163W, when we use only a three inch tunnel opening (which eliminates King Crab bycatch) yet the trawlers can drag the bottom and destroy would be harvestable King and Bairdi Crab to obtain fish.

Please convert the Bristol Bay Red King Crab Saving Area (56N-57N and 162W-164W) from a seasonal non-pelagic trawl closure to a year round non-pelagic trawl closure.

Sincerely,

Gordon Kristjanson
Captain, F\V Aleutian Mariner
President, AMK fisheries Inc.

#4

Pacific Northwest Crab Industry Advisory Committee

20 October, 1995

Garry M. Loncon
Chairman

Larry J. Engel
Chairman
Alaska Board of Fisheries
P.O. Box 25526
Juneau, Alaska 99802-5526

Re: Request For Board of Fisheries To Support Year-Around Closure To Bottom Trawling In The Bristol Bay King Crab Protection Area

Dear Larry:

The Pacific Northwest Crab Industry Advisory Committee hosted a well attended and rather successful Annual Meeting of the Alaska Department of Fish & Game with the Bering Sea crab industry October 16 and 17 of this week.

During the course of discussions on a wide range of issues, the subject of bycatch of king crab in the trawl fisheries surfaced a number of times. The bycatch discussion focused on the inequity between the conservation measures being practiced by crabbers and the NPFMC permissiveness in regards to trawlers continuing to be allowed king and tanner crab bycatch quotas and to use bottom trawl gear in the Bristol Bay area.

There was also considerable discussion and vehement opposition to the NPFMC recent action to modify the 1995 emergency rule regarding the expanded Bristol Bay king crab protection area, making the bottom trawl closure, merely a seasonal measure from January 1, to March 31st.

After polling the members of the PNCIAC, I wish to state for the record that the PNCIAC reiterates its support for the year-around closure in the Bristol Bay Protection area. The area in question, from 162 to 164 W. and 56 to 57 N. is a historic habitat for mature king crabs, not just during the winter season, but on a year-around basis.

At this time, the PNCIAC respectfully requests the Board of Fisheries to comment to the NMFS to change the final rule to a year-around closure.

In closing, I wish to point out to the Board of Fisheries, that the House version of the MFCMA amendments was approved by a vote on the floor of the House yesterday. HR 39 has just been amended to include significant bycatch and habitat restrictive

Pacific Northwest Crab Industry Advisory Committee

20 October, 1995

language. Prior to this, the NMFS had already proposed substantive habitat protection language. Thus the NMFS has the opportunity to take timely action in recognition that habitat protection, as it applies to fishing gear, is not just the concern of a few isolated sectors of the fishing industry and some environmentalists, it is now an issue of widespread national significance.

Sincerely,

Garry M. Loncon, Chairman
Pacific Northwest Crab Industry Advisory Committee
c/o Royal Aleutian Seafoods, Inc.
701 Dexter Avenue, Suite #403
Seattle, WA 98109
(206) 283-6605 fax (206) 282-4572

cc: Frank Rue, Com. ADF&G
Mary McDowell, Office of the Governor of Alaska
Steve Pennoyer, RD, NMFS, AKR
Rollie Schmitten, Asst. Admin. NMFS

#5

Brent C. Paine
Executive Director

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

Steve Hughes
Technical Director

RECEIVED
JAN 18

January 9, 1995

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

Re: Bering Sea Crab Management and Discards

Dear Rick:

United Catcher Boats continues to be concerned about the status of king and Tanner crab stocks in the Bering Sea, and we are very concerned about crab management practices. Because of these concerns, our membership of more than 50 catcher vessels has asked that we become further involved in Bering Sea crab management. As you know, many of our vessels have a long history in these crab fisheries, as well as trawling for pollock and cod.

Most of our involvement with crab has been directed at reducing crab bycatches in trawl fisheries through a variety of means including education, gear modifications, peer pressure, etc. These efforts will of course continue. In addition, the North Pacific Fisheries Management Council (NPFMC) and Alaska Department of Fish and Game (ADF&G) separately need to re-evaluate crab management in the directed crab fisheries. We believe that for many years crab pot induced crab mortalities are far in excess of crab landings, which in turn is a major causative factor of crab stock declines. We understand that ADF&G does not include these mortality factors when determining the annual GHL, and that crab discards are not counted against GHL achievement. We also believe the other main causative factor of crab stock decline is predation by cod, halibut, salmon and flounders.

Repeatedly, federal and state scientists have concluded that trawl induced crab mortality are insignificant, typically less than 1% of biomass. However, the State of Alaska apparently continues to believe that the decline of major Bering Sea crab stocks is due to trawling induced mortality.

Last year, at the joint NPFMC/BOF meeting, we presented a data set prepared from ADF&G field work (Tracy, 1994) showing that in 1993 *opilio*,

3040 West Commodore Way • Seattle, WA 98199 • Tel. (206) 282-2599 • Fax (206) 282-2414

bairdi, and red king crab fisheries, 20 bairdi crab were discarded for every 27 caught -- the *bairdi* landings were 7.2 million crab and the discards were 20.6 million crab. The *bairdi* retention was 25.8% of *bairdi* catch. Also in 1993, we presented similar data on red king crab showing landings of 2.0 million red king crab and discards of 5.7 million crab for a red king catch retention rate of 26%.

We have now analyzed the 1994 crab data set for St. Matthew blue king crab, Adak brown king crab, *opilio* Tanner crab and *bairdi* Tanner crab fisheries, following an identical analysis and presentation format. For St. Matthew blue king crab, the retained legal male catch was reportedly 791,180 crab out of 4.62 million crab caught, or about 17 % retention and 83% discard (Exhibit 1). The Adak brown king crab fishery in 1994 retained 1.44 million crab out of 6.30 million crab caught, or about 23% retention and 77% discarded. The *opilio* Tanner crab fishery reported a high legal male retention rate, but discarded more than 8.7 million sub-legal male and female *bairdi* crabs (Exhibit 3).

The 1994 *bairdi* crab fishery, reportedly retained 3.8 million legal crab from a catch of 13.37 million *bairdi*, which results in retention of 28% and discards of 72% (Exhibit 4).

Focusing specifically on the 1994 *bairdi* and *opilio* crab fisheries, a total of 22.12 million *bairdi* were caught and 18.32 million were discarded. Overall, the *bairdi* retention rate was about 17% and the remaining 83% were discarded (Exhibit 5). Exhibit 6 compares crab fishery *bairdi* discards with cod trawl and groundfish trawl *bairdi* discards plus making comparisons with the Zone 1 and 2 caps. Note that relative to the 18.32 million *bairdi* discarded in the crab fisheries, 226,179 *bairdi* were discarded in the Bering Sea cod trawl fishery and 2.45 million *bairdi* were discarded in all Bering Sea groundfish trawl fisheries.

Given the extremely high *bairdi* and red king crab discards in both absolute numbers and as a percentage of catch, it is obvious that even low crab discard mortality rates of 10%-20% for example, become very important in the calculation of crab sustained yields. Further, we must acknowledge that such fishery induced mortalities are independent of what are likely very substantial crab mortalities caused by tens of thousands of lost crab pots.

We believe Rick, that some well conceived comprehensive actions are required. The data and the talents are available. Working in concert with Dr. Fluharty's crab rebuilding committee, the crab management team and SSC should be tasked with some crab population modeling assignments, starting with Bristol Bay red king crab and *bairdi* Tanner crab. The modeling tasks should be focused on sustained yield calculations, properly

considering crab age dependent growth and natural mortality rates, legal male removals in the fishery and especially discards and assumed discard mortality rates from both the directed crab fishery and the groundfish trawl fisheries. Mortalities from lost pots should also be calculated based upon ADF&G pot loss rate data and observed catch rates, over time.

Hopefully, we can discuss this issue at the now rescheduled January Council meeting, and move forward with the state's support through the Fluharty committee process in February.

We thank you for reviewing this request and its distribution to the Council.

Sincerely,

UNITED CATCHER BOATS

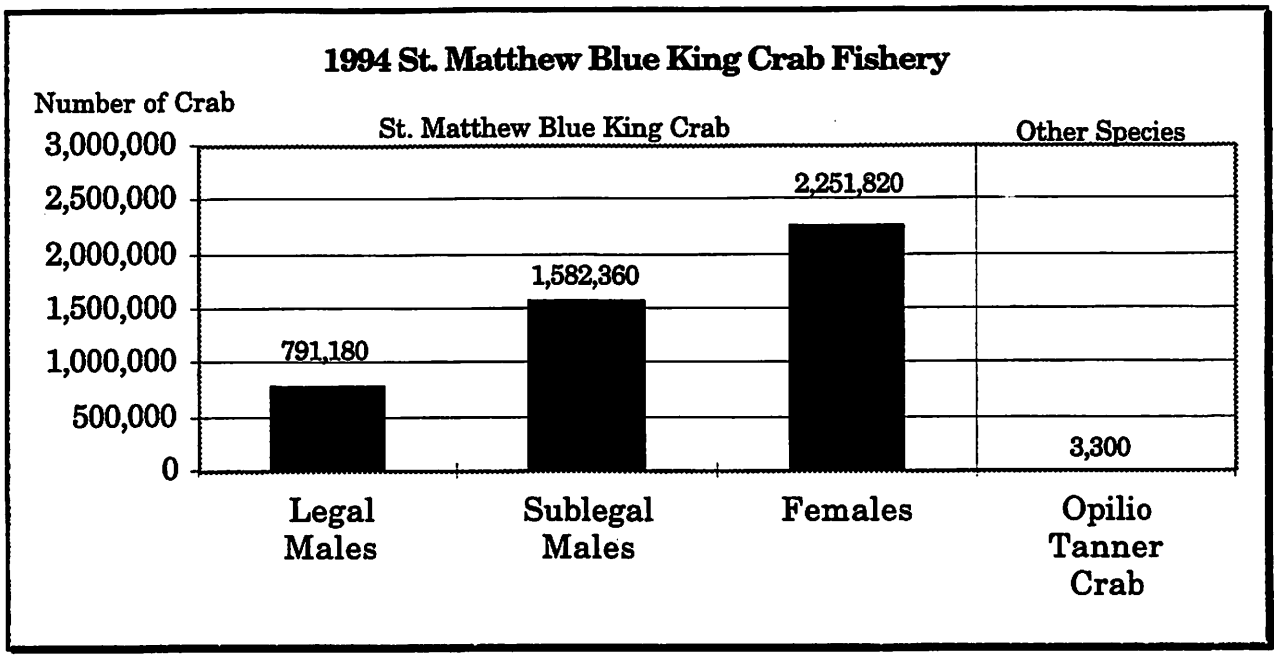
Steven E. Hughes
Technical Director

Brent Paine
Executive Director

SEH:emk

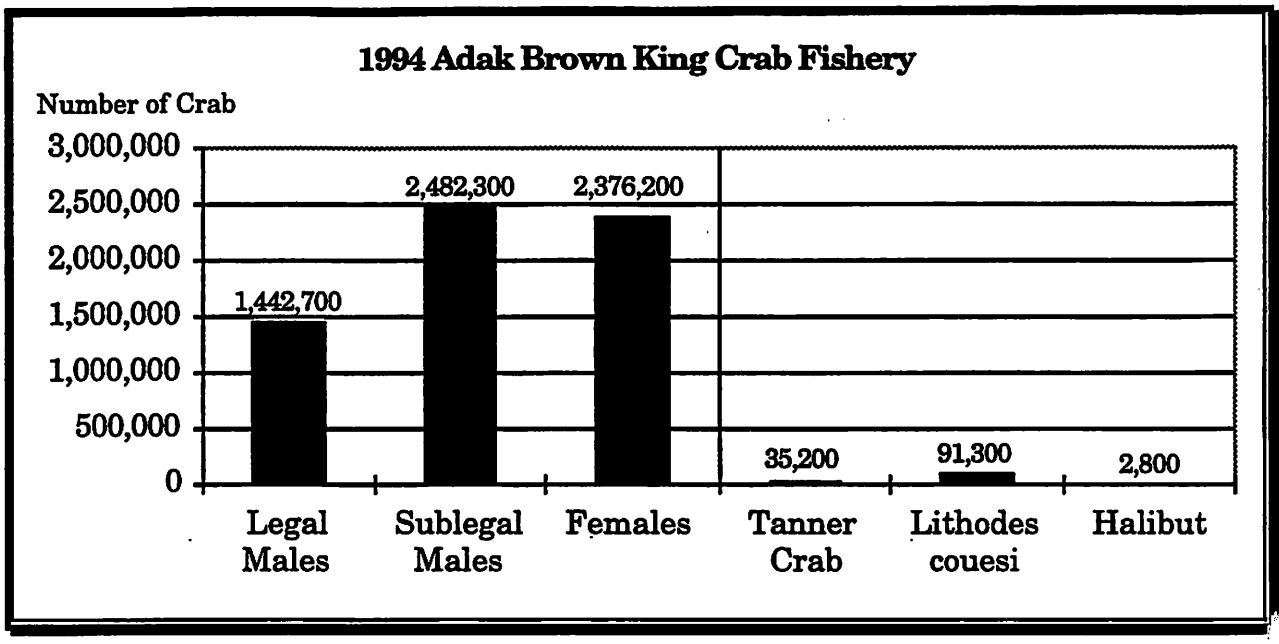
cc: Dr. Dave Fluharty
Dave Benton
Clarence Pautzke

Exhibit 1. Estimated-total crab catch (numbers of crab) from the 1994 St. Matthew blue king crab fishery based upon 203 random pot samplings taken onboard crab catcher processors during the fishery.



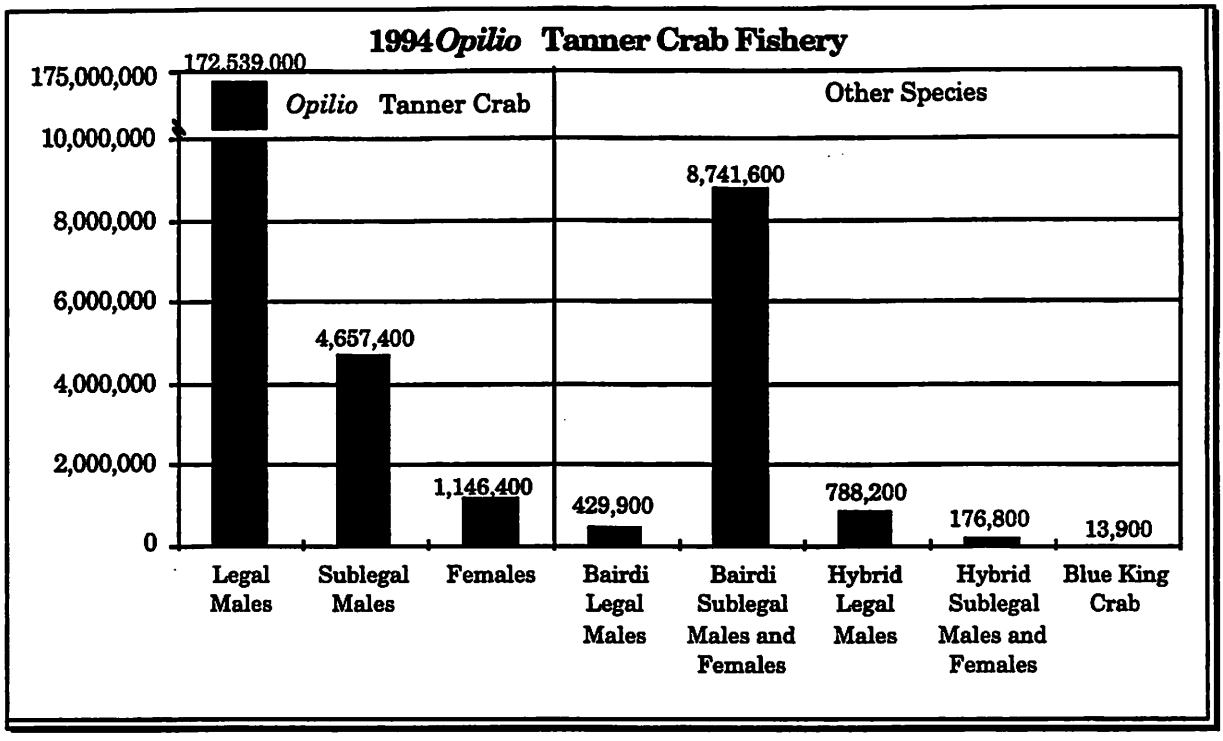
Type of Crab	Numbers of Crab
St. Matthew Blue King Crab	
Legal Males	791,180
Sublegal Males	1,582,360
Females	2,251,820
Opilio	3,300

Exhibit 2. Estimated total crab catch (numbers of crab) from the 1994 Adak brown king crab fishery based upon 308 random pot samplings taken onboard crab catcher processors during the fishery.



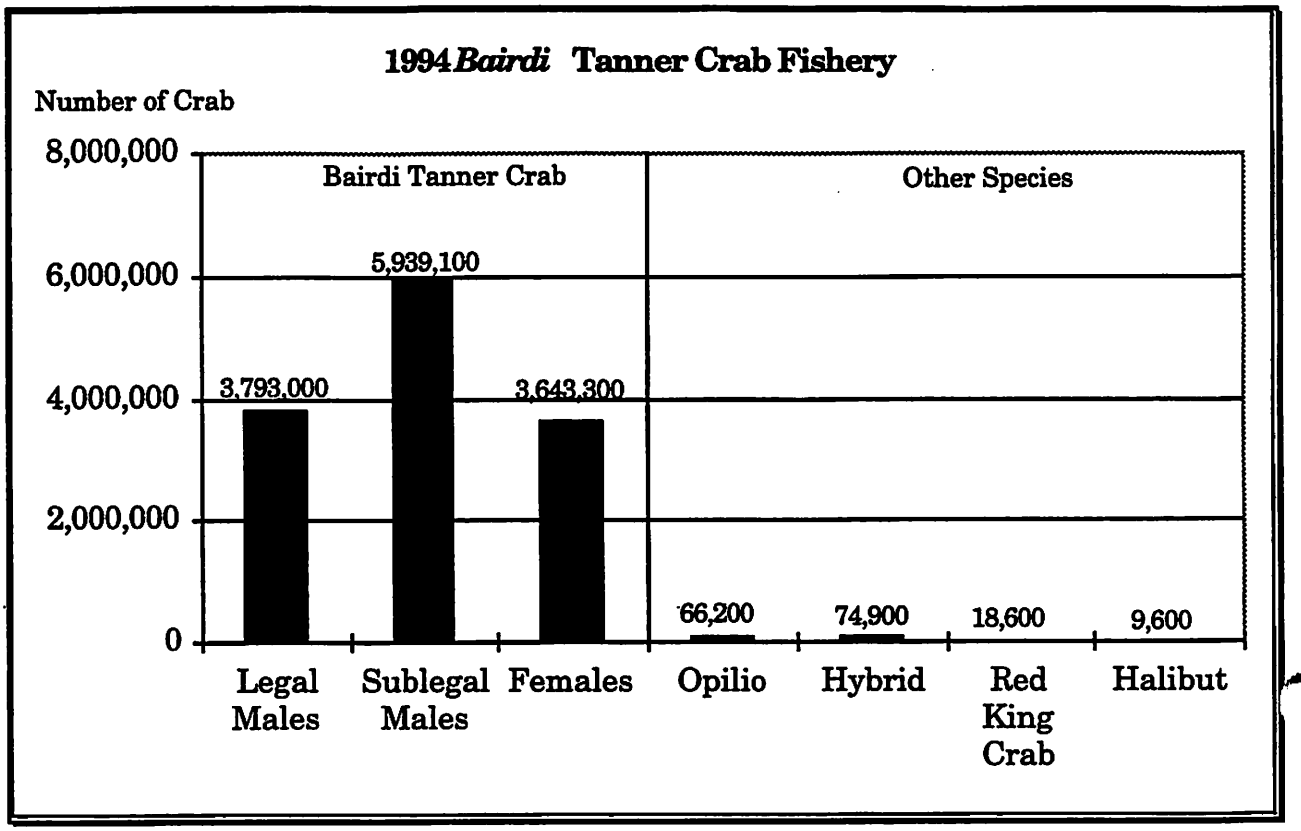
Type of Crab	Numbers of Crab
Adak Brown King Crab	
Legal Males	1,442,700
Sublegal Males	2,482,300
Females	2,376,200
Tanner Crab	35,200
Lithodes couesi (Scarlet king crab)	91,300
Halibut	2,800

Exhibit 3. Estimated total crab catch (numbers of crab) from the 1994 *opilio* Tanner crab fishery based upon 2,479 random pot samplings taken onboard crab catcher processors during the fishery.



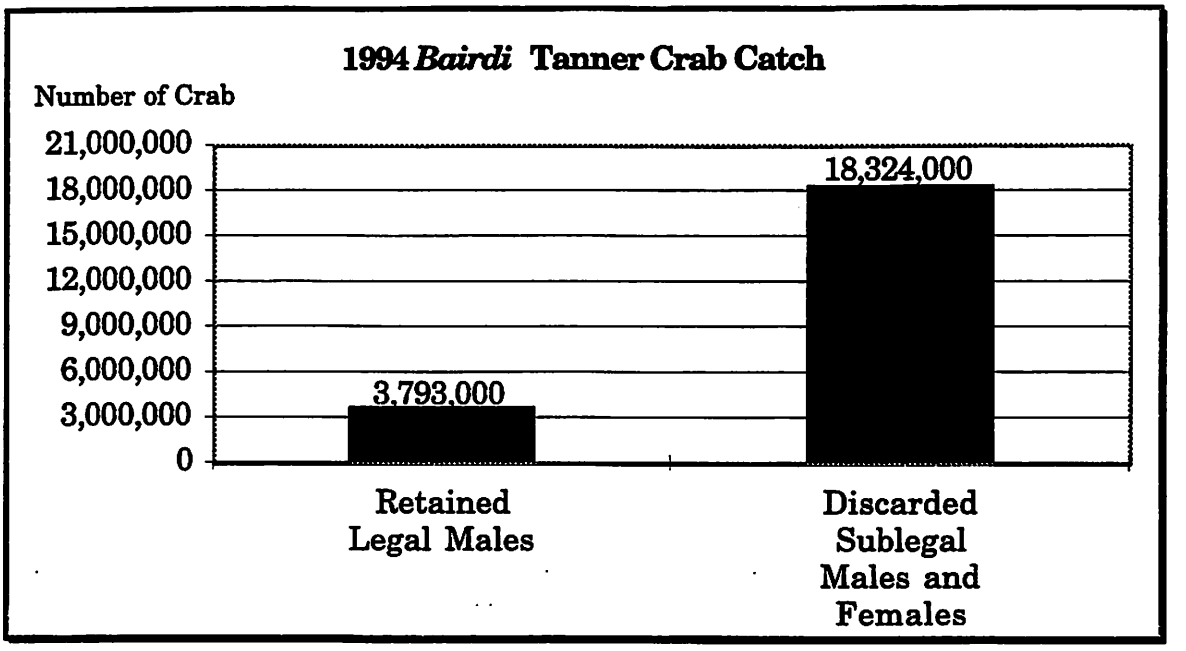
Type of Crab	Number of Crab
Opilio	
Legal Males	172,539,000
Sublegal Males	4,657,400
Females	1,146,400
Bairdi	
Legal Males	429,900
Sublegal Males and Females	8,741,600
Hybrid	
Hybrid Legal Males	788,200
Hybrid Sublegal Males and Females	176,800
Blue King Crab	13,900

Exhibit 4. Estimated total crab catch (numbers of crab) from the 1994 *bairdi* Tanner crab fishery based upon 415 random pot samplings taken onboard crab catcher processors during the fishery.



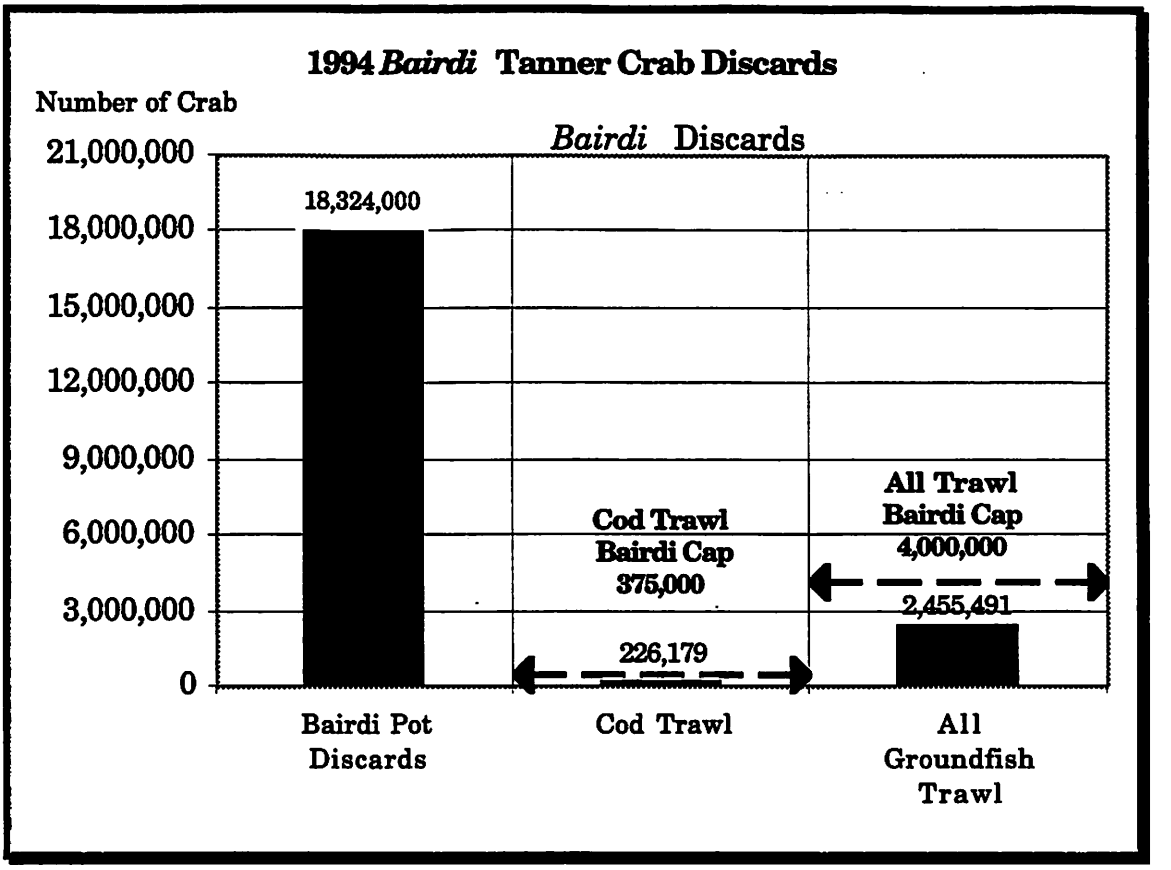
Type of Crab	Numbers of Crab
Bairdi	
Legal Males	3,793,000
Sublegal Males	5,939,100
Females	3,643,300
Opilio	66,200
Hybrid	74,900
Red King Crab	18,600
Halibut	9,600

Exhibit 5. *Bairdi* Tanner crab retained catch and discards estimated from the directed crab fisheries for *bairdi* and *opilio* Tanner crab.



Type of Crab	Numbers of Crab
Bairdi	
Retained Legal Males	3,793,000
Discarded Sublegal Males and Females	18,324,000
	Percent
Bairdi Use Efficiency	
Retained	17.00%
Discarded	83.00%

Exhibit 6. Discards of *bairdi* Tanner crab from the directed *bairdi* and *opilio* Tanner crab fisheries relative to discards of *bairdi* Tanner crab in the Bering Sea cod trawl fishery, 1994.



Fishery	Numbers of Crab
Crab Fisheries	
Bairdi Pot Discards	18,324,000
Trawl Fisheries	
Cod Trawl *Bairdi* Discards	226,179
Cod Trawl Fishery *Bairdi* Cap	375,000
All Groundfish Trawl *Bairdi* Discards	2,455,491
All Groundfish Trawl Fisheries *Bairdi* Cap	4,000,000

#6

Mr. Richard Lauber
Chairman
North Pacific Fishery Management Council
605 West 4th Avenue, Suite 306
Anchorage, AK 9901-2252

January 16, 1996

Dear Mr. Chairman:

We would like to encourage you to focus the upcoming meeting between the Alaska Board of Fish and the NPFMC on a broader range of issues other than trawl bycatch of crab. There is substantial evidence that other factors may explain the decline of certain crab stocks in the Bering Sea and yet the primary focus remains on the source of mortality that amounts to a fraction of one-percent of standing crab populations. To make the focus more balanced, we would appreciate having the following items considered at the Board/Council meeting so that crab management efforts and the research that supports it can more effectively find solutions that may reverse the decline of crab stocks.

1) Derelict Crab Pots: At the December Council meeting, the trawl industry presented information on the large number of errant king crab pots that were encountered while trawling last year. Despite the fact that there was no directed king crab fishery in 1993, a single company with five bottom trawl vessels testified that a total of 432 king crab pots were caught during rocksole fishing in 1994 alone. This is an extraordinary number of pots for only roughly one-fifth of the rocksole fleet to catch in a single fishery in a single year. Further, the number of pots encountered by these five vessels appears to corroborate estimates of pot loss in recent research, where an annual pot loss rate of 10% to 20% in the red king crab fishery was described (Stevens et al. 1993).

Given the large number of derelict pots, the potential for significant ghost fishing to be occurring appears great, and steps should be taken immediately to accurately quantify the number of pots lost each year and the effect these pots could be having on crab stocks. Evidence that lost pots have negative effects on crabs exists. Where escape devices fail or are inadequate, starvation may occur to crabs and the self-baiting phenomenon of fish and crab traps has been described (Breen, 1987). Laist (1995) states that there is evidence that octopus are attracted to king crab traps where they find an easy meal of crabs and fish temporarily using old traps for shelter. By such actions, lost pots may increase mortality of crabs by increasing their vulnerability to predators.

Efforts should be undertaken to accurately quantify the number of derelict pots in the Bering Sea and the potential ghost fishing effects of lost pots on crab stocks. Derelict pot abundance should be extrapolated from data on the number of pots used in the past

and realistic pot loss rates. To verify these estimates, observer reports and logbooks on trawl vessels should be reviewed to develop an estimate of the number of pots encountered and the condition of those pots.

Starting immediately, steps should be taken to effectively measure current pot loss rates. The numbered tag system that is currently required should be made foolproof. It should be required that tags are attached to all pots. Large fines should be issued to crab pots being set, hauled, or on vessels decks that do not have tags attached. Enforcement agents should be asked to make this a high priority for fishery enforcement. Additional tags should not be made available unless the owner reliably documents the loss of the traps or extenuating circumstances.

2. Handling Mortality in the Directed Crab Fisheries: Currently, the annual stock assessment assumes that handling mortality in the directed crab fisheries is zero. This assumption should be independently reviewed in the face of several studies that suggest that handling mortality in directed king crab fisheries is likely much higher. A recent study of the effective fishing mortality rates on Bristol Bay red king crab states "We contend that handling mortality rates in the range of 20% to 50% are realistic given our knowledge" (Zheng et al. 1995).

The short and long term effect of injuries to crabs on crab boat decks are evaluated in several recent studies: Kruse, (1993); Murphy and Kruse, (1995), Zheng et al. (1995). The effects of low temperature conditions on vessel decks are thought to have a dramatic effect on survival of undersize male and female crabs in crab fisheries (Carls and O'Clair, 1990). If handling mortality is being underestimated, then fishing mortality rates are being underestimated and overfishing may have occurred in the past and may still be occurring where directed fisheries are still prosecuted.

An independent review should be conducted on the question of an appropriate rate for handling mortality for stock assessment purposes. Questions for independent reviewers are: How does the State of Alaska's assumed handling mortality compare to other estimates of handling mortality? What handling mortalities are being assumed in other managed crab fisheries (abroad) for similar crab species and similar fishing conditions?

3. Exploitation Rates Incorporating Handling Mortality: Noting that handling mortality in the directed fishery was probably being underestimated and therefore total mortality was not being accounted for in the management of Bristol Bay king crab, Zheng et al. recommended:

> Our analysis of the Bristol Bay stock leads us to recommend adjustments to the current harvest strategy to guard against effects of handling mortality that were not addressed previously. The current strategy would be good if there were no handling mortality. However, if handling mortality is actually at low or moderate levels (10 to 30%), a robust harvest strategy would be to reduce the mature male harvest rate form 20% to 15%, and the maximum legal harvest from 60% to 50%.

The authors further recommend:

> Our recommendations try to achieve a balance between short-term gains in yield and fishing opportunity and long-term stability in yield and reproductive potential. We have evaluated the most robust options for a harvest strategy given the BOF policy and likely range of handling mortality for Bristol Bay red king crabs. Obviously, a decision on a specific harvest strategy falls within the purview of the BOF.

To resolve this issue, we are calling for an independent review of the effective exploitation rates (including handling mortality) for all managed crab fisheries in the Bering Sea. This review should involve outside stock assessment and management scientists working on similar crab species. Questions for this panel should include: Where crab populations have been effectively managed for sustainable yields, what exploitation rates have been placed on those crab populations? Considering directed fishing mortalities, bycatch mortalities, predation, and other environmental factors, which factors are most likely to be determining the status of Bering Sea crab populations?

4. Bycatch Avoidance Programs: The crab industry has lobbied the Council hard for more and more bycatch restrictions on the groundfish industry. Current measures resulting from Council actions on closed areas have created large economic impacts on the trawl fleet. The flatfish fisheries themselves have undertaken voluntary bycatch avoidance programs at their own expense so that crab are more effectively avoided. The most effective approach with crab has been the Sea State program where identification of areas where bycatch is high is made and these areas are avoided by the trawl industry. In 1996, all flatfish and cod trawl fisheries in the Bering Sea will be using Sea State to improve bycatch avoidance.

There is ample evidence that handling mortality in Bering Sea crab fisheries can be as high as 50% of the animals brought to the surface. The number of bycaught crabs in directed crab fisheries are staggering. For instance, the 1994 bairdi fishery discarded a total of 9.6 million sub-legal male and female bairdi, opilio, hybrid, and red king crabs while retaining 3.8 million legal males for a gross discard rate of 250%. Undoubtedly crab stocks would be far better off if spared the handling mortality of pot lifts. Vocal members of the crab industry continue to point their fingers at the trawl industry. There are things the crab industry could be doing to reduce its own bycatch- but this is not occurring.

We are aware of the modifications to the crab fisheries such as excluder devices for bairdi fishing and season adjustments to improve retention. These are, however, relatively small steps and bycatch remains high in the crab fisheries. It is time for the crab industry to take all available steps to reduce unnecessary bycatch of sub-legal male and female crabs. The need for a bycatch avoidance program for the crab fishery that identifies bycatch hotspots is apparent. This would minimize bycatch of non-target

crabs so that unnecessary handling mortality is avoided. Some members of the crab industry have attempted to minimize the benefits resulting from avoidance efforts the trawl industry have undertaken on a voluntary basis. If they do not believe in the trawl industry's approach to identification of bycatch hotspots, then crabbers should be encouraged to develop their own.

5. Consideration of Available Information on Predation: From the groundfish industry's perspective, the posture of the Council and Board of Fish toward the subject of predation of crab by groundfish is perplexing. It seems that whenever predation is identified as a factor in the decline of crab stocks, the attitude is either: the subject is without basis and a complete waste of time, or that predation is a factor over which managers have little or no control. In fact, there is a large body of scientific evidence that predation could be a major factor in the decline of some crab stocks and the lack of recovery of other stocks that were overfished by crab fisheries in the past. Further, the Council controls the level of groundfish removals and at a minimum, the increasing number of restrictions on bottom trawling for cod and flatfish are counterproductive in terms of holding groundfish populations in check or reducing them.

The Council and Board should set up an independent review of predation as a factor contributing to the decline of crab stocks. The growing bibliography of published works on predation suggests that scientists are convinced of the potential importance of the subject.

One suggestive piece of evidence that predation may be a factor in the decline of the Bristol Bay king crab population states that: "It has been documented that yellowfin sole do consume crab megalops larvae (Haflinger and McRoy, 1983; Livingston et al. 1993) and this could be a mechanism affecting red king crab" (Livingston et al., 1994). Evidence of this predator/prey relationship is demonstrated in Livingston et al. (1994). After finding no evidence for a correlation between bottom temperatures and recruitment of king crab, the paper states:

> A significant positive correlation, however, was found between a recruitment index of red king crab (numbers of age 6 males) and exploitation rate of yellowfin sole in red king crab year of birth and a significant negative correlation between yellowfin sole biomass lagged six years behind the abundance of age 6 red king crab males.

The paper goes on to report that " In this case, the high fishery exploitation rates of yellowfin sole would have the effect of reducing the standing stock of megalops predators and thus increasing the average survival rate of king crab" (Livingston et al., 1994). The high exploitation rates for yellowfin sole referenced in the paper are for the foreign fishing period when yellowfin harvests sometimes exceeded 500 thousand metric tons per year.

Given this very suggestive evidence, a thorough independent review of predation as a factor for the decline of king and bairdi stocks should be the highest priority. The

recommendations of this review panel could offer the Council and the Board of Fish important guidance of the merits of restrictions of bottom trawling and closing areas to trawling in the face of high (and in some cases expanding) populations of groundfish that may be significant crab predators.

Thank you in advance, Mr. Chairman for bringing these considerations to the attention of the Board of Fish and the Council. We look forward to a more balanced approach to crab rebuilding and groundfish management based on reliable independent scientific advice. Please feel free to contact us if you have questions or require any clarification.

Sincerely,

Laura Jansen for

John Gauvin	Dave Benson	Steve Hughes
AFTA	Tyson Seafoods	United Catcher Boats

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TAB 5(c)
Supplemental

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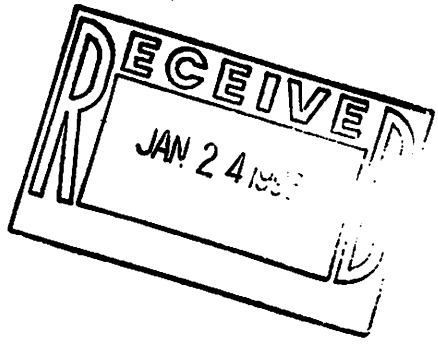

January 24, 1996

Rick Lauber, Chairman
North Pacific Fishery Management Council
605 West 4th Avenue, Suite 306
Anchorage, AK 99501

Dear Mr. Lauber,

In September 1995 the North Pacific Fishery Management Council took action to protect Bristol Bay red king crab stocks. Council action closed the area from 162° to 164°W longitude, 56°to 57° N latitude from January 1 to March 31 to non-pelagic trawling and provided for an opening of the area from 56°to 56°10' N latitude in years when a guideline harvest level for Bristol Bay red king crab is achieved. This action has been of great concern to many: participants in Bering Sea crab fisheries; the State of Alaska; Alaska Board of Fish; as well as many other conservation minded individuals. This accumulation of concern has prompted me to comment further on this issue.

ADF&G Deputy Commissioner David Benton's January 19 letter to the council eloquently illustrates a variety of concerns. Mr. Benton describes the state's actions to protect red king crab stocks, including the restriction of directed fishing of *C.bairdi* during years when red king crab at or below threshold, and ADF&G intention to reduce the exploitation rate of red king crab. The EA/RIR/IRFA released for public review did not anticipate final council action and so did not address the impacts of a seasonal closure or the allowance of pelagic trawling in the area. The Alaska Fisheries Science Center information on the yellowfin sole fishery accompanying Mr. Benton's letter shows a high king crab bycatch rate coupled with a low dependence on the area for groundfish harvest, indicating the area closure would not inflict the ruinous effects on the groundfish fishery described in September. Further described are the lack of substantial economic benefit, and the lack of protection to red king crab during the extremely vulnerable periods of molting and mating.

This list of concerns should serve as a compelling indicator of the need for further red king crab protection. The Council should fully acknowledge the critical status of red king crab stocks and act accordingly to promote stock rebuilding. On behalf of the KVOA membership I urge the Council to heed Mr. Benton's suggestion to revisit this issue and take additional steps to more adequately protect red king crab year round.

Sincerely,

Lisa Polito
Executive Director