**UNITED STATES DEPARTMENT OF COMMERCE**
**National Oceanic and Atmospheric Administration**
NATIONAL MARINE FISHERIES SERVICE
Washington, D.C. 20235

APR 6 1989

MEMORANDUM FOR: Distribution*

FROM: F/CM2 - Joe P. Clem

SUBJECT: Secretarial Review of Amendment 12a to the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Area

The North Pacific Fishery Management Council has submitted the subject amendment for Secretarial review, approval, and implementation under the Magnuson Fishery Conservation and Management Act (Magnuson Act).

This amendment contains several management measures designed to control bycatch of red king crab, C. bairdi Tanner crab, and halibut by groundfish fishermen in the Bering Sea and Aleutian Islands. If approved, the amendment will only be effective for the 1989 and 1990 fishing seasons (calendar years).

Please provide your comments (including "no comment") on this amendment by May 5. If you have questions, please call Mark Millikin at 427-2343.

Attachments

*Distribution

F/CM - Schaefer, Hochman
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SBA - Hankins

# ENVIRONMENTAL ASSESSMENT

# AND REGULATORY IMPACT REVIEW/INITIAL REGULATORY FLEXIBILITY ANALYSIS

# FOR AMENDMENT 12A

# TO THE FISHERY MANAGEMENT PLAN FOR THE

# GROUNDFISH FISHERY OF THE

# BERING SEA/ALEUTIAN ISLANDS

Prepared by the
Bering Sea/Aleutian Islands Groundfish Plan Team
and Staff of the
North Pacific Fishery Management Council

Anchorage, Alaska

March 29, 1989

AMENDMENT 12A TO THE FISHERY MANAGEMENT PLAN
FOR THE GROUNDFISH FISHERY OF THE
BERING SEA/ALEUTIAN ISLANDS

Amendment 10 to the Bering Sea/Aleutian Islands Groundfish Fishery Management Plan (FMP) provided prohibited species catch (PSC) limits to the incidental take of C. bairdi Tanner crab, red king crab, and Pacific halibut by domestic and joint venture flatfish fisheries. That amendment, and accompanying regulations, were implemented for a period of two years ending December 31, 1988. Concern about continued bycatch of crab and halibut has prompted the North Pacific Fishery Management Council to develop more comprehensive controls to replace those that sunset at the end of 1988. During more than a full year of analysis and debate the Council has considered conservation and allocative aspects of the bycatch control issue and, at its December 1988 meeting, voted to approve crab and halibut bycatch controls for bottom trawl fisheries, both domestic (DAP) and joint venture (JVP), for flatfish and other groundfish species. The five management alternatives considered were: (1) taking no action to replace the expiring controls of Amendment 10; (2) continuing the Amendment 10 controls; (3) adopting a bycatch management regime suggested by the Council's Bycatch Committee; (4) adopting a management regime similar to but more restrictive than that of Amendment 10; and, (5) replacing the Amendment 10 controls with a similar but more comprehensive management system for a period of two years while further developing a management system similar to that of Alternative 3 (preferred). Following further analysis of the recommended management regime, the Council reaffirmed its decision at the January 1989 meeting.

This proposed rule will close specific groundfish "target fisheries" in particular areas when prohibited species catch (PSC) limits of C. bairdi Tanner crab, red king crab, and Pacific halibut are taken by trawl gear. Overall PSC limits recommended by the Council are:

| | |
|---|---|
| C. bairdi Tanner crab: | 1,000,000 crabs in Zone 1 for Zone 1 closure<br>3,000,000 crabs in Zone 2 for Zone 2 closure |
| Red king crab: | 200,000 crabs in Zone 1 for Zone 1 closure |
| Pacific halibut: | 4,400 mt catch in BSAI for Zones 1 and 2H closure<br>5,333 mt catch in BSAI for BSAI closure |

Figure 1 outlines bycatch protection zones in relation to statistical management areas. Zone 2H includes that portion of Area 513 south of 56° 30' N. The Crab and Halibut Protection Zone (160° to 162° W., south of 58° N.), originally created under Amendment 10, will be expanded westward to 163° W. for the period March 15 to June 15 in order to provide additional protection to crab during molting. The associated exemption for domestic trawling for Pacific cod will also be extended to 163° W. during this period, along with existing requirements for approved data gathering programs and a 12,000 crab PSC limit for red king crab.

The aggregate PSC limits for C. bairdi had originally (September 1988) been set at 0.5% of the estimated population in the respective zones. Preliminary analysis of the constraints that these limits would place on the groundfish fleet prompted the Council to raise them to the proposed levels listed above (December 1988). These proposed PSC limits are still below 1% of the respective population estimates (176.1 and 412.8 million for Zones 1 and 2).

The aggregate PSC limit for red king crab had originally been set at 135,000 crab, similar to the limit imposed on the flatfish fishery under Amendment 10. In consideration that the new bycatch control program will be applied to all bottom trawl fisheries, not only the flatfish fishery, but still recognizing a desire to strictly control the extent of king crab bycatch, the Council raised the limit to 200,000 animals, still below 1% of the population estimate for Zone 1 (25.9 million).

The aggregate PSC limits for halibut were derived by industry consensus between halibut and groundfish interests and are based upon presumed mortality resulting from these catch limits of 3,300 mt for Zones 1 and 2H and 4,000 mt for the entire Bering Sea/Aleutian Islands. These mortality limits were derived to provide protection to halibut nursery areas in Zones 1 and 2H and to provide an overall cap on total bycatch mortality in the BSAI area of approximately 4,000 mt (which along with 2,000 mt in the Gulf of Alaska equals 6,000 mt total for North Pacific groundfish fisheries, a number recommended by the International Pacific Halibut Commission).

The bycatch limits will be apportioned to the following four fisheries in proportion to their anticipated bycatch "need": U.S. processed (DAP) flatfish fisheries (including yellowfin sole, rock sole, and other flatfish), other DAP groundfish fisheries, joint venture (JVP) flatfish fisheries, and other JVP groundfish fisheries. If a flatfish fishery attains one of its bycatch apportionments, then bottom trawling for flatfish (yellowfin sole, rock sole, and other flatfish) will be closed in the appropriate area (zone). If the other fisheries attain one of their bycatch apportionments, then bottom trawling for pollock and Pacific cod will be closed in the appropriate zone.

Based upon a bycatch prediction model that accounts for fishing patterns and differential bycatch rates by gear, area, and target groundfish species, initial PSC apportionments to the groundfish fisheries will be as follows:

C. bairdi Tanner Crab (Zone 1 and Zone 2)

| | |
|---|---|
| DAP flatfish fisheries: | Zone 1 - 86,970 animals; Zone 2 - 260,910 animals |
| DAP other fisheries: | Zone 1 - 609,519 animals; Zone 2 - 1,828,558 animals |
| JVP flatfish fisheries: | Zone 1 - 93,359 animals; Zone 2 - 280,077 animals |
| JVP other fisheries: | Zone 1 - 210,152 animals; Zone 2 - 630,455 animals |

Red King Crab (Zone 1 only)

| | |
|---|---|
| DAP flatfish fisheries: | 50,579 animals |
| DAP other fisheries: | 20,879 animals |
| JVP flatfish fisheries: | 111,858 animals |
| JVP other fisheries: | 16,684 animals |

Halibut (Zones 1 and 2H; BSAI-wide)

| | | |
|---|---|---|
| DAP flatfish fisheries: | Zones 1 and 2H - 181 mt; | BSAI-wide - 220 mt. |
| DAP other fisheries: | Zones 1 and 2H - 3,408 mt; | BSAI-wide - 4,131 mt. |
| JVP flatfish fisheries: | Zones 1 and 2H - 146 mt; | BSAI-wide - 177 mt. |
| JVP other fisheries: | Zones 1 and 2H - 665 mt; | BSAI-wide - 805 mt. |

The Regional Director of NMFS is expected to reapportion the respective bycatch apportionments among fisheries as necessary to achieve optimum yield from the groundfish resource.

Fishery simulation

The bycatch prediction model was used to simulate the performance of the 1989 groundfish fishery under the assumption that the PSC limits listed above were in place. The model assumed that the fishery, when faced with an area closure, would increase effort in the remaining open areas to make up any foregone groundfish catch (unless the closure was for the entire BSAI). Bycatch predictions were most sensitive to (1) the expected bycatch rates for crab and halibut in 1989, and (2) the amount of pollock taken by bottom trawl as opposed to mid-water trawl. Various scenarios were examined ranging from an assumption that bycatch rates for halibut in 1989 would be exactly the same as those observed in 1988 (Scenario 1) to half those observed in 1988 (Scenario 2 and 4); and that the proportion of pollock taken by bottom trawls would

be approximately 70% (as suggested by industry - Scenario 1) or as low as 30% (Scenario 3 and 4). Although Scenario 1 is deemed the most likely from the perspective of unmodified fleet behavior, any of the scenarios could be realized depending on actual fleet performance in 1989.

Scenario 1 (1988 crab and halibut bycatch rates; approximately 70% of the pollock taken by bottom trawl) suggests a closure to the joint venture other species fishery for attainment of their BSAI-wide halibut apportionment at the end of the first quarter of 1989. This closure will end joint venture bottom trawling for cod and pollock for the remainder of the year. BSAI-wide halibut PSC apportionments are attained in the joint venture flatfish and domestic other species fisheries at the end of the second quarter, closing these fisheries for the balance of 1989. The final fishery, the DAP flatfish fishery, is expected to attain its BSAI-wide halibut limit near the end of the third quarter, thereby eliminating all remaining bottom trawling in the BSAI.

Because of the premature closure of the four target fisheries prior to the groundfish quotas being achieved, the total groundfish catch foregone is predicted to be 889,000 mt. The estimated cost of this shortfall in groundfish harvest, in terms of gross revenue, is $398 million for the DAP fisheries and $36 million for the JVP fisheries.[1] In terms of foregone profits, losses are between $241 and $289 million for the DAP fisheries and about $23 to $25 million for the JVP fisheries.

Accompanying this reduction in groundfish harvest is a reduction in bycatch taken in the groundfish fisheries. Bycatch savings, relative to an uncontrolled 1989 fishery, are estimated to be 770,000 C. bairdi Tanner crab, 7,600 red king crab, and 4,100 mt of halibut. This reduction of bycatch translates to a dollar savings of $1.5 million for C. bairdi, $113,000 for red king crab, and $22 million for halibut, all in terms of the present wholesale value of the directed fishery harvest. These savings reduce the total economic impact on crab and halibut fisheries attributable to groundfish harvest to $32.7 million.

Scenario 2 assumed that 1988 observed halibut bycatch rates are anomalous and that in 1989 rates will be exactly one half of those observed in the joint venture fishery in 1988. Under these assumptions no groundfish catch is foregone as the predicted closures of the Bering Sea to bottom trawling occur simultaneously with the full attainment of groundfish apportionments. Bycatch saved is estimated as 2,800 red king crab, relative to the uncontrolled case. Bycatch of C. bairdi is predicted to increase by 45,000 animals because the fleet is forced to fish in areas with relatively higher densities of C. bairdi than under the no PSC limit scenario. The value of bycatch saved is predicted to be $42,000 for red king crab. The foregone value of C. bairdi to the directed fishery is estimated as $88,000.

Scenario 3, which assumes that 30% of the pollock in the domestic fishery is taken by bottom trawl with the balance taken by mid-water trawl, indicates diminished catch and bycatch impacts relative to Scenario 1. Groundfish catch foregone is estimated as 284,000 mt worth $169 million in lost gross revenue. Profits lost to the groundfish fleet are predicted to be between $94 and $120 million (all in DAP). Bycatch savings are estimated as 193,000 C. bairdi, 2,500 red king crab, and 1,200 mt of halibut. The present value of these bycatch savings is estimated as $376,000 for C. bairdi, $37,000 for red king crab, and $6.6 million for halibut.

A final scenario (Scenario 4) examined the combined impact of the assumptions of a 30% share of pollock by DAP bottom trawl operations and halved halibut bycatch rates. Under these assumptions no closures were predicted to occur during the year, thus, the proposed management measure's result is no impact to the groundfish fleet relative to a scenario which imposed no PSC limits on the groundfish fishery.

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[1]Gross revenue is calculated at the primary processing level for each fishery using an overall conversion factor and processed price per pound (Wiese and Burden, 1988).

Fleet Behavior

Crucial to the impact of the proposed rule is the fleet's ability to modify its behavior so as to approach the situation modeled under Scenario 4. This, of course, relates to the ability of the fleet to reduce the bycatch rates for crab and halibut. The Council heard considerable public testimony at its January 1989 meeting that, given imposition of these bycatch controls, the groundfish industry would use all available technology and techniques to reduce their bycatch of crab, and, particularly, halibut, to avoid costly closures. In light of this testimony and in recognition that a bycatch management regime imposed on the foreign fleet in 1983 and on the joint venture flatfish fishery in 1985 resulted in an immediate and significant decline in observed bycatch rates for all species, the Council believes that imposition of the preferred bycatch management regime will lead to significant declines in bycatch rates, particularly the incidental catch rates for halibut. To the extent that the groundfish fleet is able to modify its fishing pattern and practice to reduce bycatch rates and bycatch, any negative revenue and profit impacts will be mitigated, yet, at the same time, bycatch reductions will be realized, yielding direct benefits to the crab and halibut fisheries.

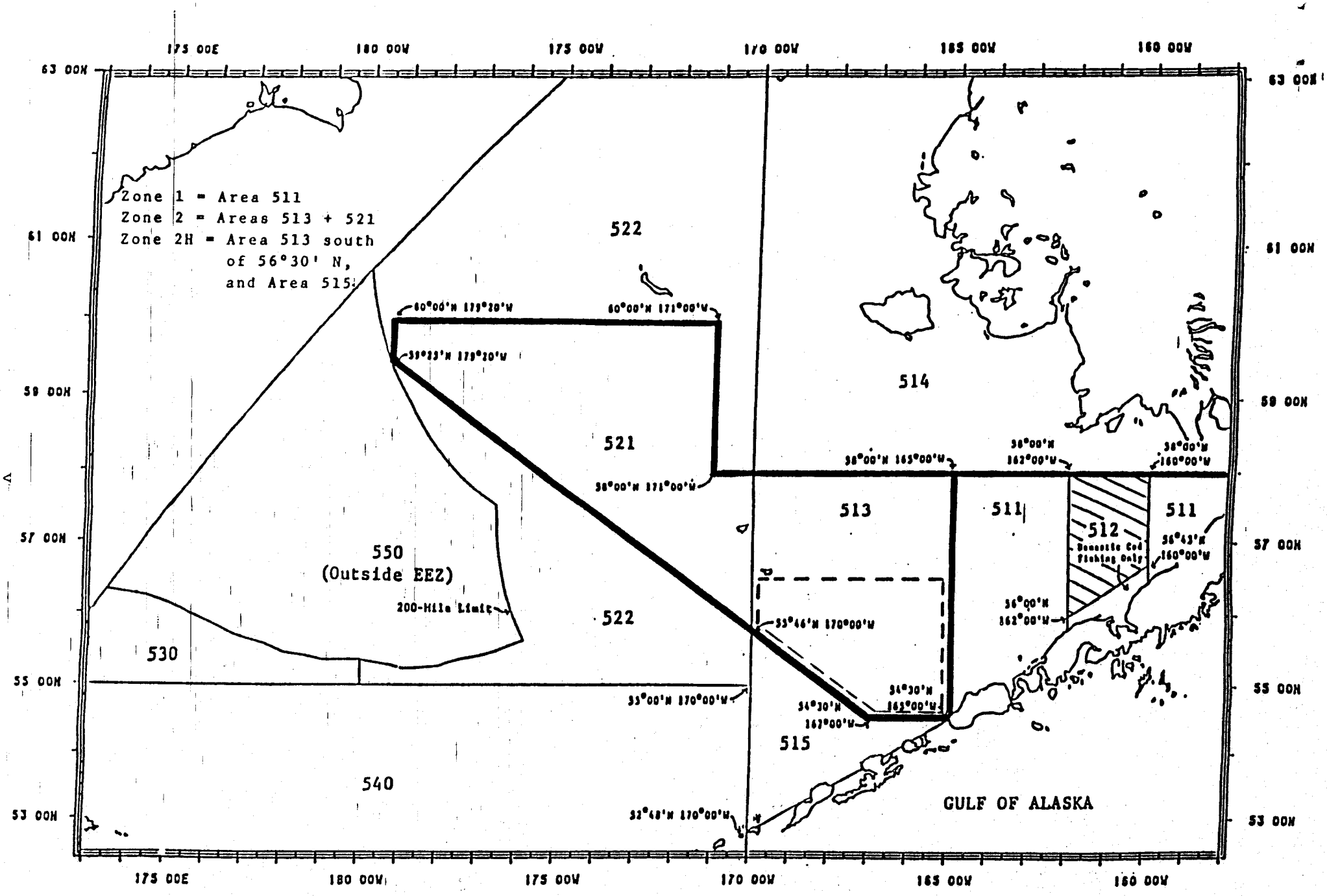


Figure 1. --Bycatch protection zones in BS/AI (Amendment 12a).

TABLE OF CONTENTS

## 1.0 INTRODUCTION

Domestic and foreign groundfish fisheries in the Exclusive Economic Zone (EEZ) of the United States (3-200 miles offshore) in the Bering Sea and around the Aleutian Islands are managed under the Fishery Management Plan for the Groundfish Fishery of the Bering Sea and Aleutian Islands (FMP). The FMP was developed by the North Pacific Fishery Management Council under authority of the Magnuson Fishery Conservation and Management Act (Magnuson Act). The FMP was approved by the Assistant Administrator for Fisheries of the National Oceanic and Atmospheric Administration (NOAA), became effective on January 1, 1982 (46 FR 63295, December 31, 1981), and is implemented by Federal regulations appearing at 50 CFR 611.93 and Part 675. Ten of twelve amendments to the FMP have subsequently been implemented.

The Council solicits public recommendations for amending the FMP on an annual basis. Amendment proposals are then reviewed by the Council's Bering Sea Plan Team (PT), Plan Amendment Advisory Group (PAAG), Advisory Panel (AP), and Scientific and Statistical Committee (SSC). These advisory bodies make recommendations to the Council on which proposals merit consideration for plan amendment. Amendment proposals and appropriate alternatives accepted by the Council are then analyzed by the PT for their efficacy and for their potential biological and socioeconomic impacts. After reviewing this analysis, the AP and SSC make recommendations as to whether the amendment alternatives should be rejected or changed in any way, whether and how the analysis should be refined, and whether to release the analysis for general public review and comment. If an amendment proposal and accompanying analysis is released for public review, then the AP, SSC, and the Council will consider subsequent public comments before deciding whether or not to submit the proposal to the Secretary of Commerce for approval and implementation.

### 1.1 Development of the Proposal

Between January and June 1988 the Council followed its regular plan amendment cycle in developing and analyzing a bycatch control program for the incidental catch of C. bairdi Tanner crab, red king crab, and Pacific halibut in trawl fisheries of the Bering Sea/Aleutian Islands. At its meeting on June 22-24, 1988, the Council deferred consideration of a bycatch management program until its September meeting so that analysts and industry representatives could further refine the proposals. On September 30 and October 1, 1988, the Council approved a set of prohibited species catch (PSC) limits and a management program for the control of incidental harvests of C. bairdi, red king crab, and Pacific halibut by groundfish fisheries in the Bering Sea/Aleutian Islands. A detailed analysis was prepared on the probable impact of the Council's action. During its meetings in December 1988 and January 1989, at the request of various industry representatives, the Council reconsidered several details of the proposed program including the PSC limit numbers.

### 1.2 Purpose of the Document

This document provides background information and assessments necessary for the Secretary of Commerce to determine that the FMP Amendment is consistent with the Magnuson Act and other applicable law. Other principal statutory requirements that this document is intended to satisfy are the National Environmental Policy Act (NEPA), the Regulatory Flexibility Act (RFA), and Executive Order 12291 (E.O. 12291); other applicable law addressed by this document include the Coastal Zone Management Act, the Endangered Species Act, and the Marine Mammal Protection Act.

### 1.3 Description of the Domestic Fishing Fleet

The domestic fleet in the Gulf of Alaska and Bering Sea/Aleutian Islands is made up of vessels targeting on several species of fish, including halibut and groundfish. The halibut fleet is larger than the groundfish fleet. Some of the vessels fish for both groundfish and halibut.

### 1.3.1 Halibut Fleet

Information obtained from the International Pacific Halibut Commission shows that 3,893 U.S. vessels reported halibut landings in 1987, which is an increase of 14% from 1986. In 1987 about 63% of the fleet was larger than 5 net tons and 23% were larger than 20 net tons, which represented only slight increases from 1986.

### 1.3.2 Groundfish Fleet

As of April 16, 1988, NMFS has issued 1,775 permits to fish groundfish in the Bering Sea and Gulf of Alaska in 1988 (Table 1.1). This number includes vessels that engage only in harvesting operations (catcher vessels), vessels that harvest and process their catches (catcher/processor vessels), vessels that will only process fish (mothership/processor vessels), and support vessels that will engage in transporting fishermen, fuel, groceries, and other supplies.

Seven percent of the total vessels, or 131 vessels, are less than 5 net tons. Ninety-three percent, or 1,644 vessels are 5 net tons or larger.

They are located in non-Alaska ports, including Seattle, and Alaska ports, including Sitka, Kodiak, and Dutch Harbor, and others (Table 1.2). The numbers of vessels that come from Alaska is 1,120; the number from the Seattle area is 399 and the number from other areas is 256.

The total number of catcher vessels (harvesting only) and catcher/processor vessels (harvesting/processing) is 1,582 and 167, respectively. Most catcher vessels employ one of three types of gear: hook-and-line (longline), trawls, or pots. The predominant gear type is hook-and-line (Table 1.3). Hook-and-line vessels are the generally small vessels in the fleet, having average capacities of 27 net tons and average lengths of 45 feet.

Most catcher/processor vessels also employ hook-and-line, trawls, or pots. The predominate gear type is hook-and-line gear (Table 1.4). They are the smallest of the catcher/processor vessels, having average capacities equal to 61 net tons and average lengths of 56 feet, but are larger than the catcher vessels using hook-and-line gear.

The next most numerous catcher/processor vessel are trawl vessels, which number 55 vessels and have an average displacement of 375 net tons and an average length of 148 feet. Pot vessels number 9 and have a mean displacement of 428 net tons and an average length of 143 feet. Other catcher/processor vessels that may have combinations of other gear may exist but have not registered with NMFS as of April 16, 1988.

Table 1.1 Numbers of groundfish vessels that are less than 5 net tons or 5 net tons and larger that are Federally permitted in 1988 to fish off Alaska.

| | Number of Vessels | | |
|---|---|---|---|
| | Less than 5 net tons | Over 5 net tons | Total |
| HARVESTING ONLY | 90 | 1,167 | 1,257 |
| HARVESTING/PROCESSING | 8 | 136 | 144 |
| PROCESSING ONLY | 0 | 3 | 3 |
| SUPPORT ONLY | 0 | 17 | 17 |
| Total vessels | 98 | 1,323 | 1,421 |

Table 1.2 Numbers of groundfish vessels Federally permitted to fish off Alaska in 1988 from the Seattle area, Alaska, and other areas.

| | Number of Vessels | | | |
|---|---|---|---|---|
| Mode | Seattle Area | Alaska | Other Areas | Total |
| HARVESTING ONLY | 256 | 824 | 177 | 1,257 |
| HARVESTING/PROCESSING | 58 | 70 | 16 | 144 |
| PROCESSING ONLY | 3 | 0 | 0 | 3 |
| SUPPORT ONLY | 7 | 2 | 8 | 17 |
| Total | 324 | 896 | 201 | 1,421 |

Table 1.3 Numbers and statistics of catcher vessels by gear type that are Federally permitted to fish off Alaska.

| | Number | Ave Net Tons | Ave Length (ft) |
|---|---|---|---|
| HOOK-AND-LINE | 1,017 | 27 | 45 |
| POTS | 13 | 122 | 88 |
| TRAWL | 214 | 122 | 91 |
| OTHER GEAR[1/] | 13 | 18 | 38 |
| TOTAL | 1,257 | | |

1/ Other gear includes combinations of hook-and-line, pots, trawls, jigs, troll gear, and gillnets.

Table 1.4 Numbers and statistics of catcher/processor vessels by gear type that are Federally permitted to fish off Alaska.

| | Number | Ave Net Tons | Ave Length (ft) |
|---|---|---|---|
| HOOK-AND-LINE | 86 | 51 | 59 |
| POTS | 9 | 428 | 143 |
| TRAWL | 49 | 374 | 146 |
| OTHER GEAR[1/] | 0 | N/A | N/A |
| TOTAL | 144 | | |

1/ Other gear includes combinations of hook-and-line, pots, trawls, jigs, troll gear, and gillnets.

## 2.0 BYCATCH CONTROLS[2]

### 2.1 Description of and Need for the Action

Trawl, hook-and-longline and pot fisheries are partially non-selective harvesting technologies; catch composition is typically diverse, including targeted species and incidental (bycatch) species. A conflict is created when the bycatch in one target fishery impacts the level of resource available to a second, separate directed fishery. Thus, the pursuit of one fishery can have important adverse effects, both biologically and economically, on other fisheries. Bycatch management attempts to balance the needs of various fisheries as they affect one another. Of particular concern has been the incidental catch of Tanner crab, king crab, and Pacific halibut in target fisheries for groundfish.

For the Bering Sea/Aleutian Islands, bycatch rate controls were first introduced in the foreign groundfish fishery in 1983. If a fishery exceeded one of these rates (usually expressed in terms of units of bycatch per metric ton of groundfish), then operations were terminated. A declining bycatch rate schedule was imposed, by plan amendment, to encourage foreign fisheries to increase their efficiency in reducing their bycatch. Depth restrictions, a form of time/area closure, were also used successfully to keep both foreign longline and domestic fishing operations out of areas known to promote high bycatch.

Numerical bycatch limits, or "caps," as opposed to bycatch rates, were imposed on domestic harvesters by emergency rule for the 1986 fishing season and by Amendment 10 to the Bering Sea/Aleutian Islands Groundfish FMP for the 1987 and 1988 fishing seasons. The caps were applied by management area for C. bairdi Tanner crab, red king crab and Pacific halibut in the yellowfin sole and other flatfish fisheries.

Many potential solutions are available to address bycatch issues. These range from more traditional approaches (time/area closures, numerical caps, gear restrictions) to the more innovative (selling bycatch, managing groups of fisheries as a complex). For example, a number of management jurisdictions use mesh restrictions as a means to target on marketable groundfish species and avoid bycatch of smaller-sized fish.

Another approach is use of an individual transferable quota (ITQ) system which allows fishermen to obtain quota for all species, including bycatch, encountered in a fishery. Incidentally-caught fish would then be sold with the target species. The bycatch would not be discarded if there was value in its delivery to a processor, but would not be targeted upon because insufficient quota would be available to support targeted operations.

Still another view is that bycatch is inevitable and that solutions must (1) encourage fishermen to land all their catch (not dump their bycatch at sea), but (2) still discourage targeting on the bycatch species. However, simple retention of bycatch would have to be limited to marketable products and also be limited to bycatch species with a high mortality rate, since there would be little net benefit in retaining bycatch that survives well and eventually contributes to traditional directed fisheries and/or spawning stocks.

Bycatch control measures can be implemented by a variety of methods such as annual TAC determination, permit conditions, emergency rules, plan amendments, or voluntary controls. Some examples can be seen in the nearby Gulf of Alaska where reduced TACs for Pacific cod and flounders have been used to limit bycatch, especially that of halibut. In 1986, several areas around Kodiak Island were closed by emergency rule to protect a depressed king crab population. A plan amendment continued those closures, and

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[2] Alternatives 1-4 were specified and analyzed in early 1988. Alternative 5 was first specified in September 1988, was modified in December 1988, and analyzed in late 1988 and early 1989. As such, the information contained herein is not completely contemporaneous. The analysis of the preferred alternative is, however, current as of this date.

Amendment 14 to the Gulf of Alaska Groundfish FMP established a framework procedure for setting the halibut bycatch level on an annual basis.

This wide array of potential solutions is constrained, however, by prevailing conditions in the Bering Sea/Aleutian Islands area. Some measures such as mesh size restrictions are incapable of addressing major bycatch concerns regarding large specimens such as crab and halibut. Other potential options such as ITQs must await implementation of a system capable of controlling the units of "fishing effort" which are allowed to participate in various fisheries. The ability to sell bycatch is also contingent upon it being of marketable size and quality--a situation often lacking for species in Alaskan waters. A final, but important, constraint is the fact that BSAI fisheries are in transition. Foreign harvesting has ceased but the evolution from joint venture to full domestic harvesting and processing is still in progress. Target species, fishing areas, and types of fishing operations are all changing simultaneously which, in turn, leads to changes in bycatch rates, total bycatch harvests and mortality rates of bycatch species.

To accommodate the changing character of these fisheries, and to offer a range of control measures that might be feasible considering the species mix in the BSAI, the Council has considered alternatives ranging from fixed numerical bycatch limits and management controls to framework procedures that would annually set limits and subsequent controls (Alternatives 1 through 4). This plan amendment (Alternative 5) is intended to provide interim bycatch controls, for a period of one or two years, while a more comprehensive control framework can be developed.

## 2.2 The Alternatives

The Council considered the following alternative plan amendment proposals during 1988. Alternative 5, described below, is the Council's preferred action for plan and regulatory amendment. This amendment is expected to be in place for a period of one or two years during which time the Council intends to develop a more comprehensive bycatch control framework, likely similar to Alternative 3 described below.

### 2.2.1 Alternative 1: Do nothing.

Adoption of this alternative would essentially eliminate direct bycatch control measures, except for those already established for foreign harvesters, since the existing domestic harvesting (DAH = DAP + JVP) bycatch cap provisions and the closed area between 160° and 162° W. south of 58° N., from Amendment 10, expire on December 31, 1988.

Thus, under this alternative, regulatory bycatch control measures for domestic fishermen would be limited mainly to the prohibited species classification itself that prevents retention. This would remain an effective deterrent to targeted fishing for crab species, Pacific halibut, Pacific salmon, herring and any other fish resources managed outside the Bering Sea/Aleutian Islands Groundfish FMP, but would provide no particular incentive to fish cleanly (i.e., with minimal bycatch) for targeted species.

Uncontrolled incidental taking of crab species and Pacific halibut by groundfish harvesters is unacceptable to those who target on these species. Industry negotiations and internal industry guidelines have been effective in resolving some of the difficulties caused by the competition for crab species and Pacific halibut between target fisheries and non-target groundfish fisheries. It has generally been necessary, however, to establish a regulatory regime within which the negotiation process can take place.

### 2.2.2 Alternative 2: Extend the specific bycatch provisions established in Amendment 10.

Adoption of this alternative would extend (for an indefinite period of time) the bycatch provisions of Amendment 10. These prohibited species catch (PSC) limits, established for specific areas (Figure 2.1), are as follows:

(a) C. bairdi Tanner crab: 80,000 animals in Zone 1 applicable to DAH fishery for yellowfin sole and other flatfish.

(b) C. bairdi Tanner crab: 326,000 animals in Zone 2 applicable to DAH fishery for yellowfin sole and other flatfish.

(c) Red king crab: 135,000 animals in Zone 1 applicable to DAH fishery for yellowfin sole and other flatfish.

(d) Pacific halibut: 828,000 animals in BSAI applicable to JVP fishery for yellowfin sole and other flatfish. When limit is reached, only Zone 1 is closed to JVP.

The use of management Zones 1, 2, and 3 would continue as presently described in the FMP. The area closure south of 58° N. latitude and between 160° and 162° W. longitude would be retained, along with an exemption for domestic Pacific cod fisheries within 25 fathoms.

As noted, however, crab limits would apply only in certain zones to the DAH fishery for yellowfin sole and other flatfish and the Pacific halibut limit would apply only to the joint venture fishery for yellowfin sole and other flatfish, but over the entire BSAI area; attainment of this halibut bycatch limit would only result in closure of joint venture fisheries in Zone 1.

This alternative originally resulted from industry negotiations in 1985 and 1986, but it would be improper to characterize it as a "compromise" beyond the agreed to expiration date of December 31, 1988. The nature of the fishery as well as the status of stocks have both changed significantly since negotiations occurred several years ago. Two major changes include: (1) a marked improvement in the abundance for several crab species; and (2) significant reductions in the joint venture fishery and development of a major domestic fishery with different but unknown bycatch potential (due mainly to a different target species emphasis, not necessarily a reduced ability to minimize bycatch).

2.2.3 Alternative 3: Establish a framework management procedure to control bycatch of Tanner crab, red king crab and Pacific halibut.

The Bycatch Committee, appointed by the Council in 1986, developed a framework to annually specify bycatch limits (caps) for individual groundfish target fisheries and to limit the aggregate bycatch of each species to a specific percentage of their annually estimated population size. Each target fishery would be required to abide by an individually calculated bycatch cap and would be subject to increasingly limiting management control as it approached or was allowed to exceed that cap. The aggregate allowable DAP and JVP bycatch of C. bairdi Tanner crab and red king crab would be a maximum of one percent of the C. bairdi population and of the red king crab population in the Bering Sea/Aleutian Islands; and the aggregate allowable DAP and JVP bycatch of halibut would be a maximum of 3,900 metric tons (mt). The Amendment 10 area closure between 160° and 162° W, south of 58° N, would be retained, including the exemption for domestic Pacific cod trawling within 25 fathoms with approved onboard observer coverage.

Table 2.1 depicts the correspondence of target fisheries, originally specified in the Bycatch Committee's recommendations, and bycatch limits. Twenty-eight individual bycatch allowances would be derived, monitored and enforced. Target fisheries would be defined by the following rules, based upon weekly catch composition per vessel:

| | |
|---|---|
| Pacific cod, longline: | 70% or more of the catch is P. cod |
| Pacific cod, trawl: (within 25 fm, Zone 1) | Any trawl fishery within the 25 fathom line is defined as a P. cod trawl fishery |
| Pacific cod, trawl: | 60% or more of the catch is P. cod |
| Rock sole, trawl: | 35% or more of the catch is rock sole |
| Pollock, trawl: | 50% or more of the catch is pollock |
| Turbot, trawl: | 35% or more of the catch is G. turbot |
| Yellowfin sole/ other flatfish: | Any bottom trawl operation not classified into one of the above |

**Notes:** If any fishery satisfies two of the above definitions simultaneously and one of the target fisheries is rock sole (e.g., rock sole/pollock, rock sole/cod, rock sole/turbot) it would be classified as a rock sole fishery. If any bottom trawl fishery fails to be defined by the above rules it would be defined as a yellowfin sole/other flatfish fishery. All target fisheries are defined for both DAP and JVP.

This set of definitions would require a detailed accounting system that is tied directly to catch reporting and observer reporting systems to assess the progress toward each of 28 bycatch allowances and the aggregate bycatch limits for C. bairdi, red king crab, and halibut.

The Bering Sea/Aleutian Islands groundfish Plan Team simplified the Bycatch Committee's recommendations by aggregating target fisheries to reduce immediate complications of accounting and enforcement. Initially, target fisheries would be defined by gear type as:

(a) DAP bottom trawl.

(b) JVP bottom trawl.

(c) DAP longline.

(d) JVP longline.

Table 2.2 depicts the correspondence of aggregated target fisheries and bycatch limits; eight individual bycatch allowances would be derived, monitored and enforced. Aggregate allowable bycatch of C. bairdi, red king crab, and halibut mortality remain 1%, 1%, and 3,900 mt, respectively. Progress toward any of the eight resulting caps would be more easily monitored and attainment of PSC limits would terminate the relevant fisheries for the remainder of the fishing year.

Alternative 3 would establish regulations imposing bycatch controls on the four aggregate fisheries listed above, with provision for the Council to define more specific target fisheries on an annual basis. As more information and monitoring capability becomes available, the Council would designate more specific target fisheries, as depicted in Table 2.1.

The complexity of defining all implementation measures required for this framework prompted the Council to decide that more time is required to develop and analyze this proposal. A revised framework is expected to be developed during 1989.

2.2.4 Alternative 4: Establish fixed, but increasingly restrictive, numerical limits for particular zones.

This alternative would broaden and intensify bycatch control measures initiated under Amendment 10. The closed area would be expanded to include waters south of 58° N. between 160° and 163° W., with no exemption for domestic Pacific cod trawl fisheries within 25 fathoms.

Bycatch caps for DAH fisheries in Zone 1 would be:

(a) C. bairdi Tanner crab: 80,000 animals in 1989; 72,000 animals in 1990.

(b) Red king crab: 80,000 animals in 1989; 72,000 animals in 1990.

Bycatch caps for DAH fisheries in Zone 2 would be:

(a) C. bairdi Tanner crab: 300,000 animals in 1989; 270,000 animals in 1990.

(b) Red king crab: to be determined by NMFS and ADF&G with industry input.

Bycatch caps for C. opilio Tanner crab in Zones 2 and 3 combined would be one million animals.

In both Zones 1 and 2, prudent controls would be placed upon bottom-trawl fisheries by NMFS when 75% of the bycatch caps are reached so as to prevent the fisheries from exceeding the caps. A Bering Sea/Aleutian Islands halibut cap for DAH trawl and longline fisheries would be 2,000 mt in 1989 and 1,800 mt in 1990. Apportionments of these bycatch limits between DAP and JVP would be set annually by the Council based upon the relative apportionments of groundfish TACs.

Relying upon the basic structure established under Amendment 10, this alternative would require that all groundfish fisheries reduce their effort on other target fishery resources, rather than allow bycatch controls to fluctuate according to relative abundance of resources. The limits applicable for 1990 would remain in effect until subsequent plan amendment. This alternative also requires bycatch limits originally intended solely for the flatfish fishery to be applied to all groundfish trawl fisheries.

2.2.5 Alternative 5 (Preferred): Establish aggregate PSC limits, apportioned by "target fishery" and area.

Given various objections to immediate acceptance of any of the above alternatives, the Council developed a set of aggregate PSC limits for C. bairdi, red king crab, and Pacific halibut to be applied to DAP and JVP flatfish and other groundfish fisheries for 1989 and possibly 1990:

C. bairdi: 1,000,000 crabs in Zone 1 for Zone 1 closure
3,000,000 crabs in Zone 2 for Zone 2 closure

Red king crab: 200,000 crabs in Zone 1 for Zone 1 closure

Pacific halibut: 4,400 mt catch (assumed 3,300 mt mortality) in BSAI for Zones 1 and 2H closure
5,333 mt catch (assumed 4,000 mt mortality) in BSAI for BSAI closure

Figure 1 (in Summary) outlines bycatch protection zones in relation to statistical areas. Zone 2H includes that portion of Area 513 south of 56° 30' N. The Crab and Halibut Protection Zone (160° to 162° W., south of 58° N.), originally created under Amendment 10, will be expanded westward to 163° W. for the period March 15 to June 15 in order to provide additional protection to crab during molting. The associated exemption for domestic trawling for Pacific cod will also be extended to 163° W. during this period, along with existing requirements for approved data gathering programs and a 12,000 crab PSC limit for red king crab.

The bycatch limits will be apportioned to the following four fisheries in proportion to their anticipated bycatch "need:" U.S. processed (DAP) flatfish fisheries (including yellowfin sole, rock sole, and other flatfish), other DAP groundfish fisheries, joint venture (JVP) flatfish fisheries, and other JVP groundfish fisheries. If a flatfish fishery attains one of its bycatch apportionments, then bottom trawling for flatfish (yellowfin sole, rock sole, and other flatfish) will be closed in the associated area (zone). If the other fisheries attain one of their bycatch apportionments, then bottom trawling for pollock and Pacific cod will be closed in the associated zone.

Based upon bycatch projections which account for fishing patterns and differential bycatch rates by gear, area, and target groundfish species, initial 1989 PSC apportionments to the groundfish fisheries would be as follows:

C. bairdi Tanner Crab (Zone 1 and Zone 2)

| | |
|---|---|
| DAP flatfish fisheries: | Zone 1 - 86,970 animals; Zone 2 - 260,910 animals |
| DAP other fisheries: | Zone 1 - 609,519 animals; Zone 2 - 1,828,558 animals |
| JVP flatfish fisheries: | Zone 1 - 93,359 animals; Zone 2 - 280,077 animals |
| JVP other fisheries: | Zone 1 - 210,152 animals; Zone 2 - 630,455 animals |

Red King Crab (Zone 1 only)

| | |
|---|---|
| DAP flatfish fisheries: | 50,579 animals |
| DAP other fisheries: | 20,879 animals |
| JVP flatfish fisheries: | 111,858 animals |
| JVP other fisheries: | 16,684 animals |

Halibut (Zones 1 and 2H; BSAI-wide)

| | |
|---|---|
| DAP flatfish fisheries: | Zones 1 and 2H - 181 mt; BSAI-wide - 220 mt. |
| DAP other fisheries: | Zones 1 and 2H - 3,408 mt; BSAI-wide - 4,131 mt. |
| JVP flatfish fisheries: | Zones 1 and 2H - 146 mt; BSAI-wide - 177 mt. |
| JVP other fisheries: | Zones 1 and 2H - 665 mt; BSAI-wide - 805 mt. |

The Regional Director of NMFS is expected to reapportion the respective bycatch apportionments among fisheries as necessary to achieve optimum yield from the groundfish resource.

## 2.3 Biological and Physical Impacts

### 2.3.1 Terms of Reference

To understand the proposed alternatives for bycatch management it is necessary to define and describe several terms:

Target fishing is defined as planned, deliberate operations designed to harvest certain animals within a species or a group of species in the most cost-effective legal manner possible. Fishing pots for hard shell male crab over a certain size, longlines for halibut over the minimum size limit, and trawls for a mixture of marketable flounder species are all examples of targeting. All major regulatory restrictions which are applied to a target fishery will limit the options available to fishermen to some degree. However, controls specific to a target species (such as protection of female crab) are intended to increase sustained yields from the resource (in this case male crab). Similarly, minimum size limits are used in the halibut fishery since it is believed that the estimated 25% hooking mortality on small fish (plus additional natural mortality) will be more than offset by weight gains in the survivors. Target fisheries are managed to harvest the available

surplus production and commonly exhibit significant year-to-year changes in both amount of harvest and percentage of biomass taken. It is important to note that this short-term surplus production does not necessarily parallel changes in overall biomass.

Bycatch is different from target species catch, because it is an incidental byproduct of operations targeting other resources. Examples include crab and halibut taken in groundfish trawl fisheries. In contrast to target fishing, an important variable determining amount of bycatch is the density of that part of the population susceptible to the gear. Thus, a large trawl bycatch of small crab might be taken in the same year that the directed crab pot fishery was completely shut down due to a low abundance of legal-sized males. However, size of the susceptible bycatch biomass is not the only variable. Magnitude of the target fishery (both amount and rate of fishing) is important along with harvesting areas and times and fishing strategy and technique.

Substantial modifications in bycatch can also occur due to specific bycatch regulatory controls. In this case, regulations are intended to indirectly benefit sustained yields in fisheries directed at the bycatch species and not the target fishery being regulated for bycatch. Whenever this latter group's ability to harvest from the greatest concentrations of fish is impaired, then significantly greater total effort will be required to take the same level of target harvest. Under such controls, costs of target fishing invariably go up. In addition, catches of other bycatch species, which perhaps were not covered under the original regulations, may increase markedly due to forced changes in target fishing operations.

Fishing and bycatch rates are expressed in a number of different ways which sometime add confusion to the bycatch issue. For example, a 40% annual exploitation rate on crab normally means that, on the average, 40% of the available male crab over a certain minimum size are taken each year by the directed pot fishery. The situation is similar for the halibut longline fishery since quotas and rates of harvest are generally computed for the exploitable or legal-sized biomass. However, bycatch is normally computed as impact on the entire biomass that is available to the groundfish gear. Assuming that trawl fishery bycatch and crab biomass trawl survey estimates are sampling similar sized animals, crab bycatch in trawl fisheries averaging 1% of the biomass per year would take 1% of the sublegal males that are susceptible to capture by the trawl gear. This group might be the same individuals that would support the directed crab pot fishery four years later.

Bycatch mortality is the sum of (1) bycatch retained, (2) non-retained bycatch that is dead or dies soon after release, and (3) individuals that are somehow killed by the gear but are not observed in the landed bycatch. There can be a great deal of variability in mortality depending upon gear and mode of operation as well as size and condition of the individuals present. An example at the "low end" of the possible mortality range is the 1.2% mortality rate observed by ADF&G personnel during 1978-1981 for trawl-caught hard shell king crab in the Kodiak area (this estimate did not include mortality caused by deck time or delayed mortality caused by injuries once the crab were returned to the sea). At the high end of the range is the common assumption of l00% crab and halibut mortality in trawl fisheries with codend transfers or long towing and sorting times. Examples of intermediate values would be rates of halibut mortality of 50% for short trawl tows with rapid sorting and 25% from longline gear. The latter rates are currently used by the IPHC and the Gulf of Alaska Plan Team in assessing halibut bycatch. However, there are no similar estimates available for crab bycatch mortality rates.

Adult equivalents is a term that expresses catch of different age groups in standardized units and requires use of growth estimates as well as fishing and natural mortality rates. For example, pounds of halibut observed in the trawl catch are adjusted for expected mortality of discarded fish and then multiplied by 1.58 by the IPHC to convert to adult equivalents in pounds. The 1.58 value incorporates estimates for growth and natural mortality between the average age of bycatch and subsequent recruitment to the directed fishery. The poundage numbers derived can then be directly compared to harvests made by the directed longline fishery. Potential for confusion comes from the three different units of expression (capture, mortality, loss). In addition, if the conversion were to be made for numbers of halibut instead of pounds,

then the conversion factor would be significantly less than 1.0 (due to natural mortality) and three different numbers would be generated.

### 2.3.2 Biological Background

Basic data on historical population status and the bycatch of C. bairdi, red king crab, and halibut in foreign and joint venture groundfish fisheries are presented in Tables 2.3 - 2.6. Crab data are for the Bering Sea only but the data for Pacific halibut are, by necessity, presented in a broader context due to significant stock interchanges between management areas. These tables report only foreign and joint venture bycatch, derived from the foreign fisheries observer program; DAP bycatch is largely unknown, but estimates are developed in Section 2.4.1.

It is apparent from these data (Table 2.3) that numbers of C. bairdi legal males are depressed relative to their status in the late 1970s. The Bering Sea harvest of C. bairdi has fallen from 42.5 million pounds in 1979 to 1.2 million pounds in 1984. Harvest increased to 3.3 million pounds in 1985, but the fishery was closed in 1986 and 1987. Foreign and joint venture trawl fishery bycatch of C. bairdi has fluctuated, not necessarily in direct proportion to crab population size, from a high of 7.5 million animals in 1979 to values less than one million since 1982. Under various control programs since 1980, including no limits on joint ventures in early years, bycatch of C. bairdi other than DAP has been well below 1% of the concurrent population estimate. Current estimates of total population (summer 1988) indicate 176.1 million C. bairdi in Zone 1 and 412.8 million in Zone 2 (R. Otto, pers. comm.).

The abundance of legal male red king crab has also declined sharply since the late 1970s (Table 2.4). From a high of 130 million pounds in 1980, the directed fishery in Bristol Bay took an average of only 2.8 million pounds during 1982-85, including no fishing in 1983. Harvests increased to 11.4 million pounds in 1986, and 12.3 million pounds in 1987. For 1988 the initial guideline harvest level has been set at 7.5 million pounds. Foreign and joint venture trawl bycatch has remained below 1% of the concurrent population estimate of Bering Sea red king crab, except during 1985 after which emergency bycatch controls preceding Amendment 10 were implemented. Current estimates of total population (summer 1988) indicate 25.9 million red king crab in Zone 1 (R. Otto, pers. comm.).

The estimated coastwide exploitable biomass of Pacific halibut has declined slightly from 254.5 million pounds in 1986 to 252.1 million pounds in 1987. The overall biomass, however, has remained near historical levels and the minor decline of the exploitable biomass of Pacific halibut was caused by a drop in abundance of young fish. It is not certain if the decline in young fish is a short-term or long-term trend. Stock assessments for the Bering Sea/Aleutian Islands area indicate that biomass more than doubled from 1974 to 1987 and estimated abundance for that area is near the biomass that produces MSY.

Foreign and joint venture trawl and longline bycatch has resulted in an estimated 2,000-3,000 mt of halibut mortality since 1982. Coastwide, halibut bycatch mortality has steadily decreased since 1980 (Table 2.5 and Figure 2.2). Adult equivalents of this bycatch mortality accounted for approximately 12%-13% of total estimated halibut removals in 1986 (Table 2.6 and Figure 2.3); joint venture and foreign bycatch in Bering Sea/Aleutian Islands groundfish fisheries accounted for approximately 63% of coastwide incidental mortality, or approximately 8% of total removals.

The groundfish fishery incidentally takes crabs of smaller size and younger age than the directed fisheries. Average age of male C. bairdi taken as bycatch is four years less than the average age of males in the pot fishery (Figure 2.4). Although data for 1987 do not show strict correspondence (Figure 2.5), a necessary simplifying assumption would equate the size distribution of crabs taken as trawl fishery bycatch with the distribution of crabs sampled in population trawl surveys. Under such an assumption, if bycatch of crab took a certain percentage of the available population, that same percentage would be removed from each age class surveyed. Eventual impact on exploitable population size and future directed crab harvest could then

be estimated by applying an additional bycatch mortality to each year between the average age of bycatch and the average age of crab taken in the directed fishery.

The following example shows what would happen to 1,000 small C. bairdi subject to four years of bycatch before the expected directed crab harvest, under an assumption of 0.22 annual average natural mortality (D. Schmidt, pers. comm.):

| Assume 22% Annual Loss (no bycatch) 78% Survival | Assume 23% Annual Loss (1% bycatch) 77% Survival |
|---|---|
| 1,000 Crabs | 1,000 Crabs |
| Year 1 X 0.78 = 780 crabs | Year 1 X 0.77 = 770 crabs |
| Year 2 X 0.78 = 608 crabs | Year 2 X 0.77 = 593 crabs |
| Year 3 X 0.78 = 475 crabs | Year 3 X 0.77 = 457 crabs |
| Year 4 X 0.78 = 371 crabs | Year 4 X 0.77 = 352 crabs |

One percent bycatch would have reduced the exploitable population by 19 crabs (371-352), a 5.1% reduction (19/371) from that which would have been available had no bycatch occurred. This is actually an overestimate of the bycatch impact, because the 1% bycatch mortality is not strictly additive; those crabs taken as bycatch would otherwise also have suffered from natural mortality before reaching harvestable size.

There are approximately two years between average age of bycatch and directed catch of red king crab (Figures 2.6 and 2.7). An exercise similar to that developed above for C. bairdi would predict a 2.9% impact on exploitable populations of red king crab resulting from an annual bycatch:

| Assume 30% Annual Loss (no bycatch) 70% Survival | Assume 31% Annual Loss (1% bycatch) 69% Survival |
|---|---|
| 1,000 Crabs | 1,000 Crabs |
| Year 1 X 0.70 = 700 crabs | Year 1 X 0.69 = 690 crabs |
| Year 2 X 0.70 = 490 crabs | Year 2 X 0.69 = 476 crabs |

Again, this 2.9% impact [(490-476)/490] is overstated due to the natural mortality that the bycatch of red king crab would have suffered if left on the grounds.

Less than 10% of the bycatch of halibut, by number, in joint venture trawl fisheries is of animals of size (80 cm) and age that occur in the directed longline fishery. On average, there is a difference of five years between age of trawl bycatch and directed longline harvest (Figure 2.8). Groundfish longline bycatch of halibut tends to be of larger animals but available data are not sufficient to generalize length frequency or age differences (R. Trumble, pers. comm.).

The situation for Pacific halibut needs to be examined in a somewhat broader context than that used for crab since there is a major migration of fish between management areas. There is a general eastward migration from the Bering Sea to the Gulf of Alaska and a southward shift from Alaskan waters to areas off British Columbia, Washington and Oregon (Figure 2.9). The proportion of Bering Sea bycatch yield loss that occurs in any area depends on the migration rate from the Bering Sea, however these rates are currently unknown. However, yield loss to the coastwide halibut fishery is estimated with a general factor of 1.58 derived by the IPHC (1988) to account for natural growth and mortality between the age of bycatch and the age fish are taken in the directed fishery.

General Caveats for Biological Impacts

As is evident from the preceding discussion, bycatch is primarily an issue of allocating surplus production among different resource users. When abundant fish and crab resources are involved there is essentially no biological risk associated with anticipated levels of bycatch. However, when any population is reduced to a low level, potential for risk appears and accelerates rapidly as the population declines further, particularly if bycatch is restricted with numerical limits that do not reflect current stock conditions of the bycatch species. In some recent years, there have been no directed fisheries for C. bairdi and red king crab in the Bering Sea; thus only bycatch and natural mortality took place. With any population, a realistic assessment of risk requires an understanding of types of mortality and relationships between spawners and recruits. Unfortunately, these types of relationships are poorly defined for Bering Sea bycatch species. The absence of this information requires that management of bycatch be particularly conservative for depressed populations such as C. bairdi and red king crab.

Another aspect of caution is the relative imprecision of population estimates for C. bairdi, red king crab, and possibly halibut. Crab surveys conducted since 1976 have a stated average confidence of plus or minus 35% for C. bairdi and plus or minus 53% for red king crab (Stevens et al., 1987). Such wide confidence limits discount the relative importance of low percentage rates of bycatch; bycatch mortality is essentially masked by this variability. Assumptions of average annual mortality, such as 22% for C. bairdi, 30% for red king crab, and the 1.58 adult equivalent conversion for halibut, are also imprecise. Moreover, ADF&G reports errors of 6.6% to 19.9% in managing actual harvests of red king crab (1985-1988) to match inseason target levels (D. Schmidt, pers. comm.). Although the impact of bycatch is real, it is difficult to anticipate with any degree of certainty what impact it has on eventual directed harvests.

Yet another type of important information that is currently not available is the rate and amount of bycatch encountered in DAP fisheries. Currently, observer coverage is only required on foreign processors, which helps to obtain bycatch information in joint venture catches. There is no comprehensive program to obtain similar information from wholly domestic fisheries. This lack of domestic observer coverage will impact each of the bycatch control alternatives discussed here and will become an increasingly important issue as DAP operators capture greater proportions of the total groundfish harvest. In lieu of a domestic observer program, accounting of DAP bycatch must rely upon discarded-catch reports filed by DAP fishermen or by assumptions equating DAP bycatch rates to some proportion of those identified for JVP fisheries. In the past, the reporting of discards has not been uniformly complied with, and there is no method to validate such reports.

2.3.3 The Alternatives

Alternative 1: Do nothing.

This alternative would result in no action; bycatch limitations on DAH fisheries under Amendment 10 expired on December 31, 1988. These measures would not be extended or replaced with different bycatch control procedures.

The technical data base describing the recent history of the fishery (Tables 2.3 through 2.6) provides some useful information on possible impacts of this alternative, but its utility is severely limited by the fact that the fishery is in transition. In the case of a relatively stable fishery, its recent history is normally valuable for predicting the outcome of proposed future resource management options. In the case of BSAI groundfish fisheries, however, the recent 10-year history begins with a domination by foreign fishing activities that have now largely disappeared. Thus, these historical data have little value in predicting fishery results from a future dominated by domestic trawler operations.

Under this alternative, the primary measure to control bycatch would be the current prohibited species classification that prevents retention. Any additional control would have to come from voluntary industry

restrictions. Emergency regulatory action would remain as a management tool for any unforseen circumstances, however no direct controls on bycatch would exist in terms of either rates of capture or total numerical quantities of animals taken. Catches of C. bairdi Tanner crab could be expected to vary mainly with the size of the crab population and, if history before bycatch controls is an appropriate guide, could be as high as 1.63% of the population. Using the 1987 population estimate (Table 2.3), the maximum expected bycatch could be 8.8 million animals (538.7 X 0.0163).

Red king crab bycatch levels would again vary with population size. If impacts were of the same magnitude as the highest historical proportion to population size (2.92%, Table 2.4), the bycatch could be 2.2 million animals (75.7 X 0.0292).

If only the Bering Sea/Aleutian Islands were considered, current halibut bycatch in that area (after conversion to adult equivalents) would exceed the directed fishery catch. However, the Bering Sea accounts for only 5% to 10% of the overall halibut biomass. This, plus the migrations described above, precludes any meaningful examination of Bering Sea halibut bycatch in isolation. The outcome of any general lack of halibut bycatch controls is obvious, however, when total removals are examined. For example, in the Bering Sea alone, the 5,570 mt halibut bycatch mortality in 1980 would translate into a 8,801 mt directed fishery loss coastwide (when converted to adult equivalents by a factor of 1.58).

Elimination of the area closure between 160° and 162° W, south of 58° N, would be especially significant. Based on the most recent annual survey of the eastern Bering Sea crab populations, almost all (approximately 90%) of the red king crab resource is distributed in the area south of 58° N latitude and east of 165° W longitude, and the highest concentrations of mature female red king crabs appears to be in the area between 160° W and 163° W longitude. Surveys indicate that legal male and large female C. bairdi Tanner crab are concentrated within this area also.

Elimination of this closure could dramatically increase the bycatch of C. bairdi and red king crab, particularly in flatfish trawl fisheries, due to the high densities of crabs in the area.

Alternative 2: Extend the specific bycatch provisions established in Amendment 10.

Under this alternative, specific numerical limitations established under Amendment 10 would continue to apply for an indefinite period of time. Thus, C. bairdi bycatch would be limited to 80,000 crab in Zone 1 and 326,000 crab in Zone 2 for the DAH fishery for yellowfin sole and other flatfish. This same fishery would have a 135,000 red king crab cap in Zone 1. In addition, the BSAI JVP fishery for yellowfin sole/other flatfish would have a halibut cap of 828,000 fish; attainment of this limit would result in a closure of Zone 1 to JVP.

Continuation of these restrictions would likely keep bycatch levels substantially below higher values recorded in some recent years, although fisheries other than for yellowfin sole/other flatfish would remain unrestricted. With restriction of the major fishery taking C. bairdi Tanner crab bycatch, the total bycatch in all fisheries might be expected to continue as in recent years (596,000 animals in 1988). Similarly, restriction of the primary fishery taking bycatch of red king crab would likely limit overall bycatch for all fisheries to about 173,000 animals, as in 1988. Restrictions in Zones 1 and 2 would, however, force groundfish fleets to operate in areas of much higher C. opilio Tanner crab abundance. This alternative would provide no direct bycatch controls for this species and, if historic bycatches continue, might be expected to be about 2 million animals, as in 1988.

The halibut cap for the JVP fishery would likely, at least in the short term, keep overall bycatch well below that recorded in 1980. Still, the "short term" connotation is important in a fishery where JVP operations are rapidly being replaced by domestic processors. The latter would not be subject to halibut bycatch controls under this alternative.

Problems inherent in this alternative are the fixed, inflexible bycatch limits. Fixed bycatch numbers are not responsive to: (1) population changes in the bycatch species, (2) changes in harvests of the target species or (3) different mixes of harvesters. From 1985 to 1987, the biomass estimate for Bering Sea C. bairdi Tanner crab increased from 119.4 to 538.7 million individuals. The abundance of red king crab remains low but did show an increase from 39.8 million crab in 1986 to 75.7 million in 1987. As crab abundance increases, fixed bycatch controls will make it increasingly more difficult to actually harvest the target groundfish species in a cost-effective manner at the same time that the percentage impact on the bycatch species decreases. Conversely, maintenance of fixed bycatch limits will increase the percentage impact if crab populations are further depressed. Thus, the highest percentage impacts on the bycatch species populations will occur when their populations are severely depressed and need the most protection.

Finally, the use of fixed numbers is not responsive to changes in the nature of the target fishery. For example, a developing fishery will generally have higher bycatch needs because fishermen will have less experience. New domestic fisheries may exhibit bycatch rates different than JVP even after their development period. Alternative 2 does not address these types of concerns.

Alternative 3: Establish a framework management procedure to control bycatch of Tanner crab, red king crab and Pacific halibut.

This alternative would allow bycatch limits to increase or decrease with the population size of the bycatch species. Also, bycatch amounts for each groundfish target fishery would be limited to realistic expectations attainable in "clean" fishing operations. These allowances would be computed annually based on the best available information. Total impact on bycatch species would be limited to a certain maximum allocation percentage and each groundfish target fishery would be allowed a proportion of that bycatch allocation, provided the total required fell within the aggregate limits necessary to protect the bycatch species populations.

For example, it is estimated (based on age and natural mortality assumptions discussed earlier) that this program for C. bairdi Tanner crab could represent a 5.2% potential loss of the total harvestable population from annual bycatch amounting to 1% of the population. This means that the directed crab pot fishery is assumed access to a minimum of 94% of the harvestable adult populations. Similar protection (approximately 97%) would be provided to populations of red king crab.

For halibut, this alternative would prescribe a fixed numerical limit (a maximum halibut bycatch mortality of 3,900 mt) which could translate into an adult equivalent in directed harvests of 6,162 mt spread among different areas from the Bering Sea southward.

Alternative 4: Establish fixed, but increasingly restrictive, numerical limits for particular zones.

Similar to Alternative 2, this alternative would impose specific numerical bycatch limits. Thus, C. bairdi bycatch would be limited to 80,000 crab in Zone 1 and 326,000 crab in Zone 2 for all DAH fisheries in 1989; in 1990 those limits would decrease to 72,000 in Zone 1 and 270,000 in Zone 2. These same fisheries would have an 80,000 red king crab cap in Zone 1 in 1989; in 1990 the limit would be 72,000. In addition, the BSAI halibut cap would be 2,000 mt in 1989 and 1,800 mt in 1990; attainment of this limit would result in a closure of all trawl fisheries in the BSAI. An additional cap for C. opilio Tanner crab in Zones 2 and 3 would be one million animals.

These restrictions would keep bycatch levels substantially below higher values recorded in some recent years, and further reduce them from levels allowed under Amendment 10. With restriction of the major groundfish fishery taking C. bairdi Tanner crab, the total bycatch in all fisheries can probably be held under that described under Alternative 2. Similarly, greater restrictions on the primary groundfish fishery taking bycatch of red king crab would insure a lower overall bycatch for all fisheries.

Restrictions in Zones 1 and 2 would, however, force groundfish fleets to operate in areas of much higher C. opilio Tanner crab abundance, potentially causing bycatch of this species to attain the proposed cap of one million animals and thereby restrict further groundfish harvesting.

Under current conditions these bycatch limits provide the most protection to crab and halibut stocks of any alternative. However, if crab or halibut populations were to become depressed, then these numerical limits could result in higher removals than would occur under the framework provided by Alternative 3. Also, the other difficulties associated with the use of fixed numbers described for Alternative 2 would also apply under this alternative.

Alternative 5 (Preferred): Establish aggregate PSC limits, apportioned by "target fishery" and area.

Aggregate PSC limits for C. bairdi, red king crab, and Pacific halibut to be applied to DAP and JVP flatfish and other groundfish fisheries would be:

| | |
|---|---|
| C. bairdi: | 1,000,000 crabs in Zone 1 for Zone 1 closure<br>3,000,000 crabs in Zone 2 for Zone 2 closure |
| Red king crab: | 200,000 crabs in Zone 1 for Zone 1 closure |
| Pacific halibut: | 4,400 mt catch in BSAI for Zones 1 and 2H closure<br>5,333 mt catch in BSAI for BSAI closure |

Figure 1 (in Summary) outlines bycatch protection zones in relation to statistical areas. Zone 2H includes that portion of Area 513 south of 56° 30' N. The Crab and Halibut Protection Zone (160° to 162° W., south of 58° N.), originally created under Amendment 10, will be expanded westward to 163° W. for the period March 15 to June 15 to provide additional protection to crab during molting. The associated exemption for domestic trawling for Pacific cod will also be extended to 163° W during this period, along with existing requirements for approved data gathering programs and a 12,000 crab PSC limit for red king crab.

Because this program is proposed only for one or two years, the fixed nature of the PSC limits, which have been developed with current data on the abundance of the prohibited species, does not constitute the same risk as those in Alternatives 2 and 4 above. The PSC limits for C. bairdi and red king crab are less than 1% of their respective population estimates in the respective zones which constitute the bulk of the crab resource. The catch and assumed mortality of halibut will be accounted for by the IPHC in setting future directed halibut catch limits, therefore no biological impact is anticipated.

The biological benefits, in terms of protecting red king crab and C. bairdi, attributable to the March 15 - June 15 extension of the Crab and Halibut Protection Zone are difficult to estimate. Recent stock assessment survey results show that extension of the protection zone will increase the proportion of male and female red king crab in the zone by 40% and 65%, respectively (Brad Stevens, pers. comm.). Increases in the proportion of the population of C. bairdi Tanner crab within the protection zone are also expected. However, the crab population surveys are conducted during the summer months and population and sex distributions observed during the time of the survey may not reflect spring, fall, or winter distributions. Because of the migratory behavior of king crab, it is not possible to determine whether the closed zone will continue to encompass the above percentages of the king crab population during the March 15 - June 15 period. Closing a certain area to groundfish fishing does not, of course, change the protection provided by an overall PSC limit. Such closures, however, may allow increased groundfish harvest at the same level of bycatch protection.

Another benefit of the March 15 - June 15 extension of the protection zone is that it protects king and C. bairdi crab in the extended area during their soft-shell or molting period; the time of year that most sexually mature king and Tanner crab in the Bering Sea shed their hard exoskeleton as part of their growth

and reproductive processes. Crab in the soft-shell phase are extremely vulnerable to fishing mortality (observed and unobserved) during this period.

## 2.4 Socioeconomic Impacts

As discussed above, current regulations controlling bycatch in the Bering Sea/Aleutian Islands management area expired at the end of 1988, thus Alternative 1 implies expiration of all bycatch controls except maintenance of the ban on retention of the species. Alternative 2 would continue the current set of controls, Alternative 3 would implement a bycatch control framework, and Alternative 4 would establish even more restrictive numerical limits than Alternative 2.

Alternative 5 would set PSC limits for a period of one or two years, during which time a more comprehensive program will be developed.

### 2.4.1 Analysis of the Alternatives

To project the possible consequences of the alternatives, beyond the general discussion presented under Section 2.3, it is useful to predict the bycatch that might occur under each. This is difficult due to a lack of specific ability to predict a future target catch or TAC, bycatch rates that will occur in the future, and the magnitude of the biomass of the bycatch species and how that biomass will be distributed spatially and temporally.

However, projection of TACs into 1989 and 1990 for Bering Sea/Aleutian Islands groundfish fisheries was part of the analysis of the possible consequences of raising the upper limit on optimum yield (see Amendment 12, Revising the upper limit to the OY Range, Draft SEIS, 1988). In that analysis, several possible upper limits to OY and procedures for moving to such limits were considered. However, at its June 1988 meeting, the Council chose the no action alternative for this amendment proposal, implying that, at least for 1989, the upper limit of the sum of TACs will remain at 2.0 million mt. For Alternatives 1 through 4, which were analyzed prior to December 1988, the estimates of future TACs developed in the draft SEIS were used. For Alternative 5, analyzed after the December Council meeting, actual 1989 groundfish TACs are used.

A second analytical issue is the choice of appropriate bycatch rates. Future bycatch rates are unknown; only historically observed rates are available. This means that the rates used will be at least one year out of date (1988 vs. 1989). However, bycatch rates are extremely variable. The best approach available is to use the most recent bycatch data and to examine the sensitivity of bycatch predictions to those rates. This has been the approach taken here, with 1988 bycatch rates used in evaluating impacts under Alternatives 2, 3, and 5. For Alternative 4, 1987 bycatch rates, at that time of that analysis, were the most recent data set available. It would be inappropriate to use those rates for examination of the impacts of Alternative 1, however, since the observed rates occurred in a fishery operating under bycatch controls. For Alternative 1, therefore, the fishery performance data from 1985, the last year of the uncontrolled fishery, is used to derive bycatch rates and future bycatch.

The determination of bycatch rates is not independent of the distribution of bycatch species. Moreover, the relationship between bycatch rates, biomass of the bycatch species, and harvest of the target fisheries is poorly understood. For example, if the biomass of the bycatch species increases, presumably the bycatch rate for that species will also increase. Those kind of relationships cannot currently be quantified.

Lastly, the need for projections of future biomass levels and distribution for crab and halibut for use in bycatch prediction cannot currently be satisfied. First, as stated above, the relationship between the biomass of the bycatch species and bycatch rates is poorly understood. Second, NMFS and ADF&G do not currently project population estimates into the future. In the analysis to follow, therefore, the most

current population estimates, those of 1987 (NMFS, 1987) are used. To allow comparisons of predicted bycatch to current bycatch levels, estimates of current (1987 and 1988) total bycatch in the various target fisheries and in the management zones of Amendment 10 are presented in Tables 2.7 and 2.8.

Alternative 1: Do nothing.

Under this alternative, the DAH bycatch provisions of Amendment 10 expire on December 31, 1988. Thus, in 1989 and beyond, there would be no PSC limits in effect for DAP or joint venture fisheries. The incidental catch of C. bairdi and C. opilio Tanner crab, red king crab, and halibut would be non-retainable but otherwise unlimited.

The joint venture flatfish fishery (yellowfin sole and other flatfish) reached its fullest, non-area restricted, development in 1985. Bycatch restrictions, by area, were introduced in 1986 and have continued since. Bycatch rates and amounts for flatfish fishing by this part of the fleet in 1985 were as indicated in Table 2.9. Bycatch rates and amounts for all other fishing in 1985 are also included in Table 2.9.

The projected yellowfin sole and other flatfish ABCs and the expected JVP portion of these TACs were included as part of the analysis of raising the upper limit on OY (Table 4.2, Table 4.3, Amendment 12, draft OY SEIS). Using the projected ABCs, JVP apportionments, and observed 1985 bycatch rates, and, given the maintenance of the 2.0 million mt upper limit on OY, assuming no changes in fishing patterns or bycatch population abundance, the unrestricted 1989 and 1990 bycatch amounts would be as indicated in Table 2.10. These projections assume that the fleet would return to fishing practices used in 1985 and that target species' abundance and distribution remain as in 1985. To the extent that 1987 and 1988 fishery patterns hold into 1989 and beyond, rather than the 1985 patterns as assumed, Tanner crab bycatch would be underestimated. Also changes in fishing areas and markets may influence these projected bycatch rates. When the JVP fleet was closed out of Zone 1 in 1986, it moved to other areas of the Bering Sea to search for yellowfin sole. Through these searches fishermen found harvestable concentrations of fish. These yellowfin sole were still harvested along with a bycatch of prohibited species but the average bycatch rates were, for some species, lower. The red king crab bycatch was greatly reduced, the C. bairdi rate was reduced, the halibut rate was virtually unchanged, and the C. opilio rate greatly increased (compare to Amendment 10, EA/RIR/IRFA, Tables 2.9, 2.10 and 2.11). The extent to which the fleet would continue to operate in these waters if the bycatch restrictions were lifted is unknown. It is probable that at least some of the fleet would return to the areas fished in 1985 while some would remain in the areas discovered in 1986 and 1987. The combination of resulting bycatch rates is not estimable at this time.

Market factors are also shaping the future of the flatfish fishery. Japanese markets are beginning to develop for roe-bearing sole. This was evident in 1987 and 1988 with a relatively large market demand for roe-bearing rock sole. In 1988 there is anecdotal evidence of a developing market for roe-bearing yellowfin sole. It has not been possible to estimate the size of the roe-bearing sole market nor is it possible to anticipate the growth of yellowfin sole in this market. However, to the extent that the market for roe-bearing rock sole affects the temporal or areal take of yellowfin sole or other flatfish, the associated bycatch rates will also change.

Understanding the above cautions, comparison of the projections of Table 2.10 to current bycatch levels (Table 2.7) indicates large potential increases in bycatch in the joint venture yellowfin sole/other flatfish fishery should the Amendment 10 restrictions be removed. Those projections indicate an approximate doubling of the bycatch of Tanner crab, red king crab, and halibut in 1989. This increase is due to expected higher bycatch rates.

These projections only include part of the total fleet. As DAP harvest replaces JVP harvest, bycatch will continue to occur and, in the case of the wholly domestic fleet, may go unreported unless an onboard observer program is instituted. It is possible to project future bycatch for DAP by using observed 1985 JVP

and foreign bycatch rates as indicative of bycatch rates in the DAP fishery, and assuming, that the future fishery, in the absence of PSC limits, would fish as they did in 1985.

The bycatch projections for these other fisheries are shown in Table 2.10. With regard to the bycatch in a potential foreign fishery, current PSC rate limits would remain in effect into 1989 and 1990. This means that only a TALFF fishery may be constrained by these previously established limits (Amendment 3 to the FMP). Given the continuing expansion of DAP and JVP demand, it is not considered likely that any TALFF would be allocated in 1989 and beyond.

Alternative 2: Extend the specific bycatch provisions established in Amendment 10.

This alternative would continue the bycatch controls implemented under Amendment 10. The limits apply to the DAH yellowfin sole/other flatfish fishery, that is to both DAP and JVP, but, in the absence of effective accounting of DAP bycatch, attainment of the cap may imply that JVP has taken the full amount of the PSC limit with all additional bycatch from DAP being in excess of that limit. If this is the case, the Regional Director (RD) must make a determination as to whether DAP target fishing for yellowfin sole/other flatfish should be allowed to continue. He would base that determination on the predicted additional incidental catch, the status of the bycatch stocks, the potential socioeconomic harm to the DAP groundfish harvesters of not continuing the fishery, and the ability to account for the additional bycatch. Recent decisions by the RD imply that satisfaction of this last factor will require mandatory industry-funded observer coverage, perhaps at a level of 100% coverage. The cost of a program of this nature is discussed in a subsequent section of this chapter. All other bycatch loss attributable to other segments of the groundfish industry are unaccounted for, imposing potentially significant adverse impacts on crab and halibut directed fisheries.

The existing PSC limits of 80,000 C. bairdi in Zone 1, 326,000 C. bairdi in Zone 2, 135,000 red king crab in Zone 1 and 828,000 halibut Bering Sea wide, may be viewed as potential constraints to the full prosecution of the JVP yellowfin sole/other flatfish fishery. An approximate prediction of the consequences of continuing the provisions of Amendment 10 can be made through a simulation using recent fishery performance data for the joint venture fisheries (1988 bycatch rates), the pattern of fishing by zone (1988), and the observed bycatch. Given this estimation, a future fishery can be simulated by choosing some level of harvest and assuming that the fishing pattern (in space and time) used to estimate the model would hold into the future. The analysis is approximate as it is impossible to predict the behavior of the fishery following closure of Zone 1 or Zone 2. The key issue is whether closure of Zone 1 or Zone 2 would automatically preclude full attainment of the TAC when the fleet moves outside the closed areas. Evidence from the fishery in 1986, 1987, and 1988, indicates that it is possible for this fishery to attain the full TAC for yellowfin sole and other flatfish in areas outside Zone 1, and that the Zone 2 cap for C. bairdi will not be exceeded. Whether this would remain true in the future is unknown.

Of course, forced relocation of the fishing fleet imposes costs on the harvesters. These costs include those resulting from any increased running time should harvesters and processors be forced to operate further apart (fuel costs, and opportunity cost of lost fishing time), and those resulting from decreased fishing opportunities, such as lowered CPUE (assuming that the fleet was fishing first in the "best" area), or grounds preemption due to the presence of seasonal sea ice.

Allowing overall harvest to increase, as might result from increases in a species' TAC, also would impose costs on the fleet if the limits on bycatch are not also raised. This is because it will be necessary for the constrained vessels (vessels targeting on flatfish) to lower their bycatch rate resulting in some expense (poorer grounds, new gear, inefficient fishing techniques).

In relative terms, continuation of the Amendment 10 controls, into 1989 and 1990, would be less constraining to the joint venture yellowfin sole/other flatfish fishery than is currently the case. This is because JVP TACs for flatfish are projected to decrease over the next three years (254,000 mt - 1987; 332,000 - 1988; 209,000 - 1989).

Since this result is due to a reduction in JVP harvest, overall bycatch may not be reduced because of projected increases in DAP. Projections of total bycatch in the groundfish fisheries into 1989 and 1990 is included in Table 2.11. This projection differs from that of Table 2.10 (Alternative 1) in two ways. First, 1988 bycatch rates (Table 2.12) are used rather than 1985 rates and, second, it is assumed that the pattern of fishing which occurred in 1988 under Amendment 10 would continue should the Amendment 10 regulations remain in force.

As might be expected, the bycatch limits of Amendment 10, particularly the Zone 1 closure in approximately mid-April of the fishing year, lead to a prediction of less overall bycatch than estimates in the analysis of Alternative 1. Specifically, C. bairdi bycatch in the JVP yellowfin sole/other flatfish fishery would be reduced by approximately two-thirds (295,000 animals versus 862,000 animals - 1989), total red king crab bycatch by 94% (1989) and 92% (1990), and total halibut bycatch (all fisheries) would be more than doubled (2.5 million animals versus 1 million animals - 1989).

Alternative 3: Establish a framework management procedure to control bycatch of Tanner crab, red king crab, and Pacific halibut.

An analysis of Alternative 3 is problematic because the target fishery definitions do not simply correspond to groundfish species catch limits, but rather depend upon commonly experienced catch compositions in what are historically viewed as distinct "target fisheries."

If Alternative 3 had been in place for the 1988 fishing year the overall PSC limits for C. bairdi, red king crab, and halibut would be as shown in Table 2.13. Note that the crab calculations are based on 1987 population estimates. This is because when the future bycatch is predicted only the current year's population estimate (1987 in this case) is available. Although it would be preferable to use crab population projected into the next year so that the caps and predicted bycatch would be computed contemporaneously, there is not sufficient confidence in such population projections.

To examine the nature of the potential constraints on groundfish fisheries given the adoption of Alternative 3, bycatch predictions are made for each fishery, summed across all fisheries, and contrasted with the percentage determined totals of Table 2.13.

Predictions of bycatch were made using a simulation model which determines bycatch amounts based on a simultaneous examination of all target fisheries in the Bering Sea/Aleutian Islands. This means that the methodology accounts for the mixed species nature of each target fishery and recognizes that, for example, pollock are taken in the pollock directed fishery, the cod bottom trawl fishery, and in the flatfish bottom trawl fishery. Therefore, the model determines the only possible solution that allows simultaneous attainment of all user group allocations. A second product of the exercise is the prediction of all target species' weights in each target fishery (this is always less than the user group allocation) and, hence, the model accurately predicts bycatch using the units of number of bycatch animals/mt of target species (as accurately as the bycatch rates and gear share estimates allow).

The model's predictions were examined for the 1989 fishing year assuming that the TACs and apportionments would be as suggested in Table 4.2 of the draft SEIS for Amendment 12 (Table 2.14). Note that the allocations differ somewhat from those of the SEIS in that small amounts of sablefish, POP, and other rockfish were allocated to JVP as bycatch. This is necessary to allow prosecution of the JVP target fisheries.

The second part of Table 2.14 illustrates the gear assumptions used in the model, and the third part shows the product of the allocation and the gear share. The next four pages summarize the predicted bycatch results for C. bairdi Tanner crab, other Tanner crab, red king crab, and halibut. C. bairdi Tanner crab bycatch is estimated to total about 1.3 million animals, well below the suggested lower limit of 4.0 million

animals. For the category other Tanner crab (mostly C. opilio) predicted bycatch in all fisheries in 1989 is about 2 million animals. Total red king crab bycatch is expected to be about 126,000 animals, an amount below the suggested limit of 757,000. Total predicted halibut bycatch for all DAH fisheries is 3.1 million fish, which at an average weight of 1.48 kg/animal (1988 - all fisheries) is equivalent to approximately 4,650 mt. Assuming 100% mortality to, this bycatch also implies a total halibut bycatch mortality of 4,650 mt, an amount in excess of the recommended upper limit of 3,900 mt.

Thus, under Alternative 3, the halibut bycatch limit recommended by the Bycatch Committee may constrain the groundfish fishery. Obviously, the actual mortality in the fishery depends on the actual bycatch rates occurring. Until individual target fishery/bycatch allowances are set annually by the Council it is not possible to anticipate which portions of the groundfish fishery would suffer most under constraint of the halibut bycatch mortality limit.

The distinction between monitoring specific or aggregated target fisheries is not one of total bycatch, since under either option the same caps will or will not be attained, but rather one of any particular fishery's impact on another. Therefore, the practical distinction will be one of timing in the fishery. Under aggregate definitions, the individual target fishery that is prosecuted earliest will be least likely to be terminated and the fishery that occurs latest in the year the most likely to be shut down. For Bering Sea trawl fisheries that would mean a favorable position for the rock sole fishery, an intermediate position for the yellowfin sole/other flatfish fishery, and a disadvantaged position for the fall Pacific cod fishery.

Alternative 4: Establish fixed, but increasingly restrictive bycatch limits for particular zones.

Possible bycatch impacts of Alternative 4 are summarized in Table 2.15 using a model which simulates weekly fishing patterns and their associated bycatch. The simulation examines the effects on closures, bycatch, and target harvest that the proposal would have had if it had been imposed during the 1987 season, assuming that the fleet would have behaved as if they knew of the regulations. A zone-by-zone comparison was made to compute the numbers (or in the case of halibut, the weight) of the prohibited species taken at the closing date. In Zone 1 the proposed regulations would bring about closure prior to the actual 1987 or 1988 closing date and for this reason bycatch in these areas would be reduced relative to status quo. However, because fishing effort would then be reallocated to Zones 2 and 3, bycatch could potentially increase in Zone 3 under the proposal. However, in spite of the increased effort applied to Zone 3, Bering Sea JVP bycatch of C. bairdi, C. opilio, red king crab, and halibut in all zones would be reduced by 40%, 72%, 33%, and 65%, respectively, relative to actual 1987 incidental catch.

The simulation indicates closure of Zone 1 on April 11 (whereas fishing actually continued in 1987 until May 30, and in 1988 until March 8), when the C. bairdi and red king crab caps of 80,000 animals would be simultaneously attained. As of April 11, the JVP-DAP bycatch of C. bairdi and red king crab would have been 113,914 and 90,523 animals respectively. This compares to the 115,960 C. bairdi and 105,081 red king crab actually taken by the JVP fishery alone in 1987.

Expanding the trawl prohibition area within Zone 1 with the additional strip between 162° and 163° W, south of 58° N, results in an additional bycatch reduction of more than 10,000 red king crab. The closing date of April 11, however, would not be affected by prohibiting trawling in this additional strip.

Under the simulation, Zones 2 and 3 would be expected to close shortly after Zone 1 on April 18, because of attainment of the C. opilio PSC limit of 1 million animals. As of April 18, overall JVP-DAP C. bairdi bycatch is estimated to be 249,076 animals, and JVP-DAP red king crab bycatch is estimated to be 91,239 animals. A significant red king crab bycatch would not be expected in Zone 2 until September (based on actual 1987 JVP results). The Zone 2 C. bairdi cap appears ineffectual. By the time the C. opilio cap closes Zones 2 and 3, C. bairdi bycatch in Zone 2 is about 178,000 animals short of the limit. With Alternative 4, the largest bycatch of C. opilio Tanner crab occurs in Zone 3.

Because of the regulations governing the flatfish fishery, it is difficult to predict how the closing of one or another components of the flatfish complex will affect effort directed at the remaining components. For instance, flatfish fishermen were allowed to fish west of the 170° W. longitude when the yellowfin sole TAC was reached in 1987 but could not keep yellowfin sole. That year the yellowfin TAC was reached on July 4, so it is clear that the flatfish fishermen responsible for the 1.68 million C. opilio bycatch were fishing west of 170° W. for something other than yellowfin sole. Flatfish targeting ceased after July 25.

Table 2.16 summarizes the effects of Alternative 4 regulations on groundfish harvest for each of the zones and for the Bering Sea as a whole. Not surprisingly, if we assume that target catch rates in Zone 3 are as in 1987, groundfish harvest is reduced relative to actual 1987 harvest level in Zones 1 and 2 as a result of the earlier closures. The reduction in groundfish take is minimal for Zone 1 but quite substantial for Zones 2 and 3. For the Bering Sea as a whole, the new regulations could produce a 45% decline in total groundfish catch. The target fishery most affected is the yellowfin sole complex which suffers a 66% reduction in catch because of low catch rates exhibited in Zone 3. The pollock harvest would be reduced 30%, related mostly to reduced catch in Zone 2.

The anticipation of a reduction of 45% in overall groundfish catch would be expected to cause a redirection of effort early in the year. Although outside the scope of the simulation, it is probable that all catch rates would be changed as harvesters attempted some form of self-control in order to lengthen the season.

Alternative 5 (Preferred): Establish aggregate PSC limits, apportioned by "target fishery" and area.

**Simulation Model -- Methods**

The simulation model used to predict bycatch under this management regime is based on a series of interconnected catch and bycatch accounting models (computer spreadsheets) which simulate the four defined fisheries on a quarterly basis. To begin the prediction, the expected groundfish apportionments for 1989 were entered. Next, given assumptions on how the DAP and JVP apportionments might be distributed over the year (on a quarterly basis) and how, in a given quarter, a particular species might be harvested by bottom trawl, mid-water trawl, and longline gear, groundfish species' harvests were computed by quarter and gear type.

The following assumptions are employed in the initial (Scenario 1) model:

(1) Groundfish TACs and apportionments to DAP and JVP are basically those approved by the Council at its December 1988 meeting, with distribution of reserves mostly to JVP except for those of fully-utilized DAP species (Table 2.17).

(2) Distribution of harvests over the year, by quarter and area are derived from input from the trawl industry (Table 2.17).

(3) "Target" fisheries are defined by the following dichotomous rules, based upon weekly catch and separate for DAP and JVP:

- If total groundfish catch is equal to or greater than 95% pollock, then catch attributed to "other" fishery (midwater pollock), else
- If equal to or greater than 50% pollock and cod (in the aggregate), then catch attributed to "other" fishery (bottom trawl), else
- If equal to or greater than 20% flatfish, then catch attributed to "flatfish" fishery (bottom trawl), else

- If equal to or greater than 20% Atka mackerel, then catch attributed to "other" fishery (Atka mackerel).

- If none of the above, then catch attributed to "other" fishery (bottom trawl).

(4) Bycatch rates used for estimation are those experienced by the joint venture fisheries in 1988, by appropriate fishery, quarter, and area (Table 2.18).

(5) The bycatch of pollock midwater trawl and Atka mackerel fishing is calculated, but is not used as a component to apportion bycatch allowances nor as a contributor to attainment of PSC limits for the "other" fisheries.

(6) The bycatch of fixed gear (longline and pot) fisheries is not calculated nor accounted for.

To contrast the predictions of the impact of the management regime with that which would exist in the absence of bycatch controls, the simulation model was run through the fishing year, assuming the PSC limits were not in place. This produced estimates of "uncontrolled" bycatch which have been used in three ways:

(1) The contribution of each fishery to the total predicted bycatch of a species was used to equitably apportion the overall species' PSC limit to the four competing fisheries as outlined above.

(2) Predictions of "unconstrained" bycatch amounts served as a baseline from which to compare the bycatch protection afforded by the PSC limits and area closures.

(3) Predictions of "unconstrained" bycatch amounts served as a point of reference for a fishery-relative cost projection model discussed below.

Following the initial "unconstrained" prediction, the regulated groundfish fishery was simulated by predicting the quarterly bycatch in each fishery. These quarterly projections of bycatch by fishery and area were then compared with the relevant PSC limits for the fishery and area. If the predicted bycatch of a species in an area was in excess of the PSC limit, then the contributing fishery was closed out of the relevant areas for the remainder of the fishing year. To account for relative temporal imprecision in the prediction model and in the monitoring program adopted to implement the proposed regime, the fishery was also closed out of an area if the predicted bycatch amount was less than, but within 90% of, the specified PSC limit.

The simulation then continued for the next quarter taking into account the areas which had been closed to the specified target fisheries. The assumption was made that no groundfish catch would be foregone.[3] Thus, following closure of an area to a fishery the subsequent period's fishing effort was adjusted upward to account for the area not available to the fishery such that the groundfish catch for the fishery was exactly the same as had there been no closure, that is, catch in each period was held constant by increasing catch in the areas that remained open. This assumption is warranted on empirical grounds as previous bycatch management regimes of this nature have not led to a reduction in either groundfish or target species harvest.

However, this expansion of effort is not without cost. Presumably, the fishery's historical distribution is a result of preferences on fishing grounds determined by CPUE and other cost considerations. If a preferred area is closed to a fishery, the fishery may relocate and may be able to harvest at pre-amendment levels,

[3] This is not true, of course, for the BSAI-wide PSC limit for halibut. If a fishery reaches its PSC apportionment of halibut the fishery will be closed for the remainder of the fishing year.

but costs will necessarily increase. An examination of the cost and profit consequences of the proposed management regime is the topic of a following section.

The simulation proceeded through the year, tracking the cumulative catch and bycatch by fishery and area, and tracking, at the end of each period, the open-closed status of each of the statistical management areas in the Bering Sea and Aleutian Islands.

Other scenarios

Three other bycatch management scenarios examined were:

- Scenario 2 employed the same assumptions listed above expect that halibut bycatch rates in 1989 were assumed to be half of those that had occurred in the 1988 fishery.

- Scenario 3 predicted bycatch using the assumptions of Scenario 1 except the industry-supplied assumption that approximately 70% of the pollock in the DAP fishery would be taken by bottom trawl gear, with the remaining 30% taken by mid-water trawl, was reversed, that is, 30% of the pollock was assumed taken by bottom trawl and 70% by mid-water trawl.

- Scenario 4 combined the assumptions of Scenario 2 and Scenario 3, that is, the model assumes that halibut bycatch rates in 1989 are half those observed in 1988, and that the bottom trawl share of the pollock DAP is 30%.

**Effort/Cost Modeling -- Methods**

It is difficult to predict the cost to the groundfish fishery of a set of management measures to control bycatch because it is not known how each fishery would respond to a closure of a particular area. However, the costs are bounded by two polar cases: (1) vessels will be redirected to the remaining open areas in such a way that there will not be a change in the fishery's monthly or annual catch; and (2) vessels will not be redirected to other areas and, therefore, catch will be reduced by the amount that would have been taken in the closed time/areas.

In the first case, there will be an increase in harvesting cost if the time/area closures result in vessels being redirected to areas with lower groundfish catch rates. Such closures are not expected to redirect vessels to higher catch rate areas because such areas would be available with or without the closures imposed by PSC apportionments being taken. In the second case, groundfish catch would be foregone with an accompanying loss of gross revenue and profit.

Joint venture fishery catch rate data from the NMFS Foreign Observer Program were used together with projected catch by fishery, area, and quarter to estimate how the projected changes in catch by area would affect total effort and harvesting costs. Catch rate data in terms of metric tons of catch per hour of trawling are available for 1987, but are not yet available for 1988; currently only catch rate data in terms of catch per processing vessel day on grounds are available for 1988. Catch per hour is thought to provide a more uniform measure of effort and harvesting cost because the number of catcher boats delivering to each processing vessel and the amount of effort required for each delivery can differ significantly among time/areas. However, the 1988 fishery is thought to be more indicative of the 1989 fishery. Therefore, separate sets of estimates of the effects on effort and costs of the proposed PSC caps were made using the two types of catch rate data. The joint venture data on effort were also used to model DAP performance; no data are available with which to separately characterize the changes in effort of totally domestic operations.

Before reviewing the projected effects on effort and costs, it is important to note that in many cases the estimates of catch per hour or per processing vessel day were based on very small samples and that in

some instances catch per hour data were not available and had to be estimated using catch per day data. This means that the estimates of the changes in effort are subject to error. The direction of that error is not known. The transformations of the estimated changes in effort to changes in costs are subject to additional errors associated with identifying total cost in the absence of the changes in catch rates and the part of total cost affected by changes in catch rates. Therefore, in the absence of offsetting errors, the estimates of the changes in effort will tend to be more accurate than the estimates of the changes in costs.

Effort by fishery, area, and quarter was calculated for the unconstrained and constrained cases by dividing projected catch by the estimated catch rate. Total effort by fishery for each case was then calculated as the sum of effort across areas and quarters. This was done for each of the two types of catch rates. The catch rates used are presented in Table 2.19.

Four sets of estimates were made of the effects on harvesting cost because there was a set of effort changes for each of the two types of catch rates and because two different vessel cost structures were considered. The vessel cost structures are referred to as A and B and are defined separately for DAP and JVP fisheries (see Table 2.23). Total cost and the CPUE dependent variable cost for each fishery and cost structures A and B were calculated for the unconstrained scenario using the appropriate annual harvest, catch per vessel year, and cost per vessel year. The changes in variable cost were calculated using the estimated percentage change in effort and variable cost.

Valuation of groundfish catch and prohibited species bycatch

The results of the bycatch prediction and cost models can be combined to provide an overview of the possible dollar costs and benefits of the scenario examined. All groundfish values were computed at the level of transfer to the next market level; for DAP, where it is assumed most of the catch is taken by factory trawlers or mothership processors, wholesale blended prices were used. These prices are F.O.B. Dutch Harbor and assume mixed processing of fillets (pollock and cod) and blocks (pollock, cod, and flatfish). The overall blended price used is $1.00/lb wholesale, processed weight (Wiese and Burden, 1988). Joint venture product was evaluated at exvessel level in terms of round weight using an overall blended exvessel price of $162/mt (Wiese and Burden, 1988).

Bycatch was valued at the wholesale level using wholesale present (unit) values. For crab, these values account for the average age of the bycatch species taken as bycatch and taken in the directed fishery and annual natural mortality and growth. For halibut, the valuation procedure uses the IPHC mechanism of accounting for bycatch whereby 1.58 times the bycatch (landed weight equivalent) is subtracted from the next year's directed fishery quota.

Mortality is assumed to be 100% for all crab and trawl caught halibut. The exvessel and wholesale prices used, adjusted to round weight, are presented in Table 2.24a. All prices are assumed to remain constant, in real terms, and the yearly social discount rate applied to future harvest revenues is 5%.

In order to simplify the analysis for crab, an assumption of knife edge recruitment to both the bycatch and directed fisheries was used. That is, both bycatch and directed harvest was assumed to occur totally at the average age of those harvests. Also, directed harvest was assumed to be total, all crab at that age will be assumed to be taken in the directed fishery. The number of years between average age of the bycatch and targeted fisheries is 4, 4, and 2 years for C. bairdi, C. opilio, and red king crab, respectively (Figures 2.4 and 2.6). Natural mortality was estimated at 0.22 for C. bairdi and 0.30 for red king crab (D. Schmidt, pers. comm.). In lieu of a more specific natural mortality rate for other Tanner crabs, specifically C. opilio, the 0.22 rate for C. bairdi was used. During periods of low abundance, female crabs may be worth more, per crab, to the spawning population than in years of high abundance. In order to allow for this, a value to the future fishery was used for female crabs. For red king crab, Reeves and Terry (1986) used boundaries of 2.7 and 8.2 pounds based on estimated female mortality rates, past harvests, and optimal levels of spawners. The average of these two levels, 5.5 pounds, is similar to the average weight of directed harvest, 5.8 lb/crab

(ADF&G, 1988). Therefore, females were counted on an equal basis with males for impacts on future directed harvests. The same procedure was followed for Tanner crabs with an average weight for C. bairdi at time of directed harvest of 2.2 lb/crab and an average weight of 1.2 lb/crab for C. opilio (ADF&G, 1988).

For C. bairdi Tanner crab, for every 1,000 crab caught as bycatch, 22% would have died during each of the next 4 years due to natural mortality (see Section 2.3.1). The remaining 370 crabs would weigh a total of 814 pounds with discounted overall exvessel and wholesale values of $1,416 and $1,954, respectively (Table 2.24b). For C. opilio Tanner crab, for every 1,000 crab caught as bycatch, 22% would have died during each of the next four years due to natural mortality. The remaining 370 crabs would weigh a total of 444 pounds with discounted overall exvessel and wholesale values of $284 and $586, respectively. Lastly, for every 1,000 red king crab caught in the bycatch fishery, 30% would have died during each of the next 2 years due to natural mortality. The remaining 490 crabs would weigh a total of 2,842 pounds with discounted overall exvessel and wholesale values of $10,316 and $14,835, respectively.

For halibut, assuming 100% mortality, a recovery rate of 75%, and a conversion to adult equivalents of 1.58, implies exvessel and wholesale values of $4,145 and $5,469 per mt of halibut bycatch.

**Simulation Model -- Results**

Unconstrained prediction model

Using the groundfish apportionments shown in Table 2.17 and the bycatch rates shown in Table 2.18, bycatch by area and by quarter for each of the four fisheries (DAP flatfish; DAP other; JVP flatfish; JVP other) was calculated. The results of this unconstrained simulation are summarized in Table 2.20. The model predicted a total 1989 bycatch of 1,937,000 C. bairdi Tanner crab, 102,300 red king crab, and 9,400 mt of halibut. Since it is assumed that bycatch mortality for halibut in the Bering Sea/Aleutian Islands is 100%, 9,400 mt also represents total halibut mortality.

The relative share that each fishery took of the total predicted bycatch for each species was then used to equitably apportion the caps approved by the Council. The resulting apportionment of the caps by fishery is shown in Table 2.21. This implies that the determination of fishery PSC apportionments depends on the assumptions in the prediction model.

Prediction of 1989 bycatch under various assumptions about fishery performance

The simulation model was then rerun with individual fishery PSC apportionments, as specified in Table 2.20, in place. For each quarter, groundfish catch, by fishery and area, was multiplied by the matching bycatch rate to yield total bycatch. As in the unconstrained model described above, the bycatch rates used were those observed in 1988 in the joint venture fisheries; joint venture rates were used as a proxy for bycatch rates in the wholly domestic (DAP) fisheries, with bycatch rates in the other fishery category adjusted to reflect different distributions of pollock and cod catch in the cod/pollock bottom trawl fishery.

At the end of each time period the cumulative bycatch of C. bairdi, red king crab, and halibut in the relevant statistical area(s) was compared with the fishery's PSC apportionment. For red king crab, this was Zone 1 (Area 511); for C. bairdi, Zone 1 (Area 511) and Zone 2 (Areas 513 and 521); and for halibut Bering Sea wide. If the fishery had exceeded its prescribed PSC apportionment it was closed out of the relevant area(s) for the remainder of the fishing year. For halibut two caps were examined: if a fishery had attained its Zone 1 and 2H halibut cap then only Zone 1 and 2H were closed to the fishery; if, however, the fishery had attained its Bering Sea-wide PSC limit for halibut, the fishery was terminated for the remainder of the year. Except in the case of this last closure, the affected fishery was allowed to continue fishing in the remaining open areas in such a way that no groundfish catch was foregone. This was done by increasing catch in the open areas such that the original (pre-closure) catch would be exactly taken in each period.

Results of this first simulation are displayed in Table 2.22. As can be seen from examination of the rows labeled "Cap attained?" the JVP other fishery (pollock and cod bottom trawl) closes in the first quarter for attainment of the BSAI-wide halibut PSC apportionment. This means that joint venture fisheries that use bottom trawls and fish for cod and pollock are precluded from fishing for the remainder of the year. In the second quarter the simulation predicts attainment of the BSAI-wide cap for halibut in the DAP other fishery, and the JVP flatfish fishery, closing these fisheries for the remainder of the year. In the third quarter the only remaining open fishery, the DAP flatfish fishery, is expected to reach its BSAI-wide halibut PSC limit, thereby completely closing the BSAI to bottom trawling by the end of the third quarter.

Since every fishery is precluded from operating for the entire year, considerable groundfish catch is foregone (assuming the fleet does not reduce its bycatch rate for halibut from that used for prediction). Amounts of total groundfish not taken by virtue of the closures are:

for the DAP flatfish fishery, a shortfall in groundfish harvest of 17,800 mt (13% of unconstrained catch);

for the DAP other fishery, a catch foregone of 666,100 mt (66% of unconstrained catch);

for the JVP flatfish fishery, a loss of 46,900 mt (25% of unconstrained catch); and,

for the JVP other fishery, catch foregone of 171,500 mt (69% of unconstrained catch).

Overall, predicted bycatch is also greatly reduced relative to predicted under the unconstrained scenario. Results indicate

a decrease in C. bairdi bycatch from 1,937,000 animals to 1,167,000 animals (a 40% reduction),

a decrease in red king crab bycatch from 102,300 animals to 94,700 animals (an 8% reduction), and

a decrease in predicted halibut bycatch from 9,400 mt catch to 5,300 mt (a 44% reduction).

Comparing constraints imposed by the Council's preliminary PSC limits to an unconstrained fishery, the estimated change in total effort measured in trawl hours range from a 9% decrease for the domestic flatfish fishery to a 84% decrease for the domestic pollock/cod bottom trawl fishery (Table 2.23). With effort measured in processing vessel days on the fishing grounds, the range in decreased effort is from 20% for the domestic flatfish fishery to 49% for the domestic pollock/cod bottom trawl fishery. These dramatic declines in effort are a consequence of the relatively early closures of the Bering Sea to bottom trawling.

The estimated effects on total cost by fishery in percentage and absolute terms are also presented in Table 2.23. Total costs decrease because fishing effort ceases upon closure of the BSAI to bottom trawling. The total loss to the fishery (in terms of foregone profits) is the revenue lost less the decrease in costs (see Table 2.25). The estimated changes based on the catch per hour data range from a decrease of total cost of $3 million for the joint venture flatfish fishery to a decrease of $154 million for the domestic pollock/cod bottom trawl fishery. The estimated changes for the catch per day data range from a $3 million decrease in the joint venture flatfish fishery to a decrease of $115 million for the domestic pollock/cod bottom trawl fishery. Summing across fisheries, the ranges of decreased costs are from $168 to $170 million for the catch per hour data and from $120 to $130 million for the catch per day data.

A second scenario assumed that the management regime reflects the Council's action, but that 1988 observed halibut bycatch rates are anomalous and that in 1989 rates will be exactly one half of those observed in the joint venture fishery in 1988. Under these assumptions no groundfish catch is foregone as the predicted closures of the Bering Sea to bottom trawling occur simultaneously with the full attainment of groundfish apportionments. Bycatch saved is estimated as 2,800 red king crab, relative to the unconstrained case. Bycatch of C. bairdi is predicted to increase by 45,000 animals because the fleet is forced to fish in areas with relatively higher densities of C. bairdi than under the unconstrained scenario. The value of bycatch saved is predicted to be $42,000 for red king crab. The foregone value of C. bairdi to the directed fishery is estimated as $88,000.

An important assumption of the simulation model is the proportion of pollock that is taken by the DAP fisheries by bottom trawl, as opposed to mid-water trawl, since the bycatch rates observed for the former gear are two to three orders of magnitude greater than that observed in mid-water trawl operations. A simulation in which it was assumed that the DAP pollock fishery would take about 30% of its apportionment on bottom and 70% by mid-water trawling (as opposed to approximately 70% bottom trawl, 30% mid-water trawl under Scenarios 1 and 2), indicated diminished bycatch impacts. Groundfish catch foregone is estimated as 284,000 mt worth $169 million in lost gross revenue. Profits lost to the groundfish fleet are predicted to be between $94 and $120 million. Bycatch savings are estimated as 193,000 C. bairdi, 2,500 red king crab, and 1,200 mt of halibut. The present value of these bycatch savings is estimated as $376,000 for C. bairdi, $37,000 for red king crab, and $6.6 million for halibut.

A final scenario (Scenario 4) examined the impact of the combined assumption of a 30% share of pollock by DAP bottom trawl operations and halved halibut bycatch rates. Under these assumptions no closures were predicted to occur during the year, thus, the proposed management measure's result is no impact to the groundfish fleet relative to an unconstrained scenario.

Although these results are subject to a variety of sources of error discussed above, they indicate that the proposed bycatch caps could significantly alter the areas that are fished and, therefore, both the effort and cost associated with taking a given level of groundfish.

Conclusions of the analysis

Three critical factors in determining the appropriateness of a set of management measures to control bycatch in the groundfish fishery are: (1) the expected effect on bycatch; (2) the costs imposed on the groundfish fisheries; (3) the associated benefits to those who target on the species taken as bycatch in the groundfish fisheries; and, most importantly, (4) the response of target fisheries to imposition of bycatch management controls. The simulation model predicted effects on bycatch, and groundfish harvests, under various bycatch control scenarios. The effort/cost model applied catch per unit effort and cost assumptions to these same simulations to calculate costs imposed on the groundfish fleet. Benefits to those who target on crab and halibut were explored using discounted present value of bycatch savings applicable to future crab and halibut harvests. All of these simulation and modeling exercises depend upon a large set of assumptions, therefore results must be interpreted loosely as representing an order of magnitude estimate of actual impacts.

Crucial to the impact of the proposed rule is the fleet's ability to modify its behavior so as to approach the situation modeled under Scenario 4. This, of course, relates to the ability of the fleet to reduce the bycatch rates for crab and halibut. The Council heard considerable public testimony at its January 1989 meeting that, given imposition of these bycatch controls, the groundfish industry would use all available technology and techniques to reduce their bycatch of crab, and, particularly, halibut, to avoid costly closures. In light of this testimony and in recognition that a bycatch management regime imposed on the foreign fleet in 1983 and on the joint venture flatfish fishery in 1985 resulted in an immediate and significant decline in observed

bycatch rates for all species,[4] the Council believes that imposition of the preferred bycatch management regime will lead to significant declines in bycatch rates, particularly the incidental catch rates for halibut. To the extent that the groundfish fleet is able to modify its fishing pattern and practice to reduce bycatch rates and bycatch, any negative revenue and profit impacts will be mitigated, yet, at the same time, bycatch reductions will be realized.

Comparisons of prediction models and model sensitivity

The estimated bycatch that might occur in 1989 under Alternatives 1 through 5 has been presented above. To allow that prediction, five different models were used--each specific to the alternative being analyzed. This section is included to provide some additional insight regarding the sensitivity of those predictions to variations in assumed bycatch rates and to draw some contrasts between the predictive approaches used. All should be viewed as approximate as the fishery performance data used is highly variable and measured with some error.

Under Alternative 1 (do nothing) it was assumed that the fishing patterns and bycatch observed in 1985 just prior to the implementation of the bycatch emergency rule would reappear should that rule expire. This is an oversimplification of what would actually occur, given that over the last four years the fleet has not only greatly expanded but has also substantially modified the fishing patterns of 1985. In particular, in 1985 the yellowfin sole/other flatfish fishery was concentrated in the area that became Zone 1 and the fishery took place in the spring and early summer. Accordingly, the bycatch rates observed in 1985 for C. bairdi, C. opilio, and halibut, were lower than that observed in 1988 and the red king crab bycatch rate higher. This means that the model of Alternative 1 will tend to underestimate bycatch should the current fishing patterns and practice be carried over into an unregulated fishing situation.

To predict the bycatch under Alternatives 2, 4, and 5 (fixed PSC limits) it was necessary to simulate the fishery (by area and by season) so that zone closures could be appropriately accounted for. The models differ in that the Alternative 2 and 5 models use 1988 fishery performance and bycatch data while the Alternative 4 model uses 1987 performance and bycatch data. The most recent years' fishing patterns are most useful for predicting future bycatch, but in the case of Alternative 4, which includes an extension of the current Zone 1 area, it was necessary to examine an entire years' fishery and complete 1988 data were not yet available.

It was not necessary to simulate the fishery based on some prior years' fishery for Alternative 3, since the alternative does not include sequential zone closures (even though Zone 1 is still defined for the purposes of controlling red king crab bycatch and the 25 fm exemption for DAH cod trawling remains). In this case, 1988 bycatch rates and fishing patterns were used since, at the time of the analysis (August), the majority of the 1988 harvest had already occurred.

Collectively, this means that comparisons of the bycatch predictions should not be interpreted as a strict quantitative assessment of differences using one predictive model, but rather an approximation of differences given the different nature of the alternative solutions and given the different data bases used.

The sensitivity of the 1989 bycatch projections of Alternatives 2 and 3 was also examined by varying the bycatch rates used for calculations by plus or minus 25%. For the model used in Alternative 2, predicted bycatch also varied by approximately 25% with departures from this simple rule due to the complications caused by the Zone 1 closure. In particular, overall C. bairdi bycatch increased by 23%, given a 25% increase in all bycatch rates, and declined by 23%, assuming a 25% decrease in bycatch rates. Red king

[4] One should note that in both cases fishing companies employed internal controls to limit the bycatch of individual vessels.

crab bycatch varied by plus or minus 15%, given a 25% increase or decrease in bycatch rates, and halibut bycatch by plus or minus 24%, assuming the same variation in rates.

Sensitivity analysis for the model used in Alternative 3 is straightforward. This is because the prediction model examines all fisheries simultaneously (the catch in one fishery is not independent of another fishery) and determines the allowable mix of catches. Given this mix, the overall bycatch will vary exactly as the bycatch varies. Therefore, under Alternative 3, varying the bycatch rates by plus or minus 25% implies that bycatch would also vary by plus or minus 25%.

A formal sensitivity analysis of the bycatch prediction model used for analysis of Alternative 5 is not possible given current modeling tools in light of the extremely complex and non-linear calculation procedures contained in that model. As a next step, stochastic (Monte Carlo) simulation might prove instructive. In the interim, the range of estimated impacts under Scenarios 1-4 should be viewed as an approximation of the likely range of actual impacts.

### 2.4.2 Reporting costs

Current reporting practice, which includes reporting of bycatch by observers on joint venture processors and a requirement for weekly reporting of discards by domestic catcher/processors and mothership/processors, is not expected to change under Alternative 1 or 2. This is because Alternative 2 continues the present regime and should Alternative 1 be adopted, current reporting regulations would remain in place.

Implementation of Alternatives 3 through 5 will necessitate a more complete system of bycatch accounting; that is all DAP bycatch will need to be monitored. Possibilities include use of the existing discard section of the fish tickets, a mandatory logbook program, or onboard observers (either mandatory or voluntary).

Reporting of discards is currently required of all domestic vessels (50 CPR at 675.5(a)(2)) as the fish ticket form includes a space for discards but, for the most part, vessels are not completing this section of the form. One change, therefore, under Alternative 3, 4, or 5 would be to explicitly require that the discard section of the fish tickets be completed by all domestic vessels. The effectiveness of these two reporting methods is critically tied to the complete and accurate reporting of bycatch by the regulated vessel. A logbook program has not yet been investigated. The third option, reporting of bycatch by onboard observers, is discussed in the next section.

### 2.4.3 Administrative, Enforcement, and Information Costs

Administrative, enforcement, and information costs would all decrease if Alternative 1 is chosen as it will no longer be necessary to monitor fisheries inseason. Under Alternative 2 and, possibly, Alternative 4, administrative and enforcement costs would remain approximately at current levels. For Alternative 3 (and to some extent, Alternative 5), predicting the bycatch needs of each individual groundfish target fishery for each bycatch species, monitoring compliance with these prohibited species catch (PSC) limits, and deriving appropriate control of each target fishery as it approaches or is allowed to exceed its specific bycatch allowance would require a level of detail not yet incorporated in the current fishery management system. It would be necessary, preseason, to derive individual caps for halibut in two different target fisheries, caps for C. bairdi in eight different fisheries, and caps for red king crab in eight fisheries. These target fisheries do not correspond directly to monitored harvest limits such as total allowable catch (TAC). Instead, target fisheries are commonly understood to be operations fishing for specific species.

Inseason, it would be necessary to monitor, on a regular basis (e.g., weekly), the progress of the groundfish fishery toward the attainment of each of the 28 bycatch allowances. This would involve not only accounting for numbers of bycatch animals taken but also assigning bycatch to target fisheries. Such assignment of bycatch to the appropriate target fishery would additionally require accounting for the catch composition of each vessel on at least a weekly basis and comparing that to the target fishery definitions. The

administrative burden of this monitoring is several times larger than the current overhead required to monitor bycatch in the joint venture yellowfin sole/other flatfish fishery. NMFS estimates that additional staff would be needed to accomplish inseason oversight. Personnel costs are estimated to be two full time statistician/recorders and one part time programmer (approximately $65,000 to $85,000 per year).

Using more aggregated definitions of target fisheries under Alternative 3, it would be necessary to derive individual caps for C. bairdi in two fisheries, caps for red king crab in two smaller fisheries, and caps for halibut in four aggregated fisheries. Although these aggregated fisheries also do not correspond to species' TACs, they do correspond directly to gear type which should ease the enforcement burden. Preseason derivation of bycatch allowances and inseason monitoring would be greatly simplified in comparison to the use of more specific target fisheries.

The estimated cost of providing complete observer coverage for all domestic catcher processors and motherships in the BSAI is $6.25 million. This assumes 100% coverage; coverage of less than 100% would result in a proportional reduction in these estimates. For example, if coverage of 20% were required, as suggested in a recent ADF&G analysis and as suggested in the current agreement to accommodate monitoring of taking of marine mammals by the groundfish fishery, the total cost would be approximately $1.25 million. The optimal percent coverage for the fleet is not known, but it is likely less than 100%. Not knowing the appropriate level of coverage, the remainder of this section discusses the full coverage (100%) scenario. These estimates are based on several assumptions concerning the size and total fishing time of the fleet (number of days of coverage needed) and the cost of coverage including the necessary increase in observer support overhead and data processing requirements.

If logistical problems can be overcome and observers placed on catcher vessels delivering to shore-based plants, total costs of a domestic observer would increase accordingly to cover the 10-20 additional vessels.

The costs for observers, including all overhead and support services, are estimated at $250 per day. This is based on a budgeted cost of $200 per day for foreign observers (USDOC, MFCMA Operations Handbook, 1985) adjusted for expected inflation and other cost increases.

The number of vessels needing observer coverage (assuming 100% coverage of the at-sea processing fleet) under this program is estimated at 100 in 1989 with each vessel operating 250 days a year. Many of these vessels would be longline catcher/processors (Table 3.15, BSAI Amendment 12, SEIS). It is expected that the 32 catcher/processors present in 1987 will increase to 50 by 1989 as the longline seasons shorten and the need to stay on the grounds makes these larger vessels more cost efficient. The other major component of this at-sea processing fleet are factory trawlers and motherships. There were 24 of these active at the end of 1987 with 50 expected to be operational in 1989 (AFTA, letter dated Feb. 24, 1988). The 250 day operation schedule for these vessels would allow for steaming time between fishing grounds and trips to ports but would be the time necessary to have an observer onboard.

It is not known who would bear these costs. At present a government funded program is unlikely, and thus costs may be borne by industry. If this were true, an industry funded organization to hire, train, place and maintain observers may be necessary or industry could fund the existing observer program of the Northwest & Alaska Fisheries Center. One possibility for funding would be a per unit assessment on landed catch.

Enforcement costs under Alternatives 3 and 5 would also be expected to be larger than those occurring under Alternative 1, 2, or 4. Given the uncertainty with regard to certain options of Alternative 3 it is not known what manner and level of enforcement will be necessary. However, it is anticipated that enforcement costs for Option A would be substantially larger than for Option B due to the specificity of regulations to various distinct target fisheries.

For the one or two years of management under Alternative 5, the Council intends to rely upon a mixture of voluntary observer coverage being developed by the industry, observer coverage that may be provided

under reauthorization of the Marine Mammal Protection Act, and calculations based upon previously observed ratios of bycatch to groundfish catch obtained from observer coverage of the JVP processing fleet.

### 2.4.4 Redistribution of Costs and Benefits

The management of incidental catch attempts to minimize losses to those who target on the species and to minimize the cost of avoiding the bycatch species to those who harvest groundfish. Bycatch management is therefore, above all, an allocation of certain amounts of bycatch species to those who target on the species and to those who catch it incidentally while prosecuting other fisheries.

Using this fundamental view of bycatch the five proposed alternatives are characterized below. Table 2.26 presents a brief outline of the alternatives and their likely impacts.

Alternative 1: Do nothing.

This alternative would allow unconstrained bycatch of crab and halibut to occur in domestic and joint venture fisheries. Adoption of the alternative affords no protection to the harvester of crab and halibut and imposes no costs on the groundfish harvester. Unless the amount of bycatch in this situation is by some chance circumstance "optimal," the lack of accountability and control under Alternative 1 does not accomplish rational bycatch management.

Alternative 2: Extend the specific bycatch provisions established in Amendment 10.

This alternative would continue the present management regime. Currently the DAH yellowfin sole/other flatfish fishery operates under bycatch controls while other fisheries do not. DAP bycatch is not adequately accounted for although it would be possible to set DAP apportionments so as not to exceed a desired bycatch amount or to require DAP reporting of discards. Regardless, the lessons learned from Amendment 10 apply. The joint venture fishery would bear increased operational costs due to early closure of Zone 1 and relocation to more distant grounds.

The DAP yellowfin sole/other flatfish fishery would be constrained under Alternative 2 as it is currently constrained: operators would be closed out of Zone 1 should JVP take the crab cap. As DAP replaces JVP in this fishery, this constraint would become more costly should the JVP bycatch amount close the fishery. Of course, when DAP fully replaces JVP in this fishery, lack of bycatch accountability implies that the DAP fishery may not be so constrained.

With respect to the harvesters of crab and halibut, Alternative 2 provides partial bycatch control; it limits the harvest of red king and C. bairdi Tanner crab in Zone 1 and halibut in trawl fisheries throughout the BSAI area for a portion of the fleet. If 1987 crab population projections are borne out such bycatch mortality will represent a small fraction of the total crab biomass. However, at low crab stock sizes, these bycatch limits would cause a proportionately higher impact.

Alternative 3: Establish a framework management procedure to control bycatch of Tanner crab, red king crab, and Pacific halibut.

This alternative would implement a bycatch management framework that, if successful, would more fully account for and potentially limit all crab and halibut bycatch in domestic Bering Sea groundfish fisheries. The alternative includes a provision for inseason monitoring of bycatch and a comprehensive definition for regulated groundfish fisheries. The two options (A and B) provide specific and more general definitions of groundfish target fisheries, respectively, in order to address various aspects of estimation, monitoring, and enforcement.

Further, the alternative would provide for the primary allocation decision--how much crab and halibut should go to the target fishery and how much should go to the groundfish fishery. The upper limits of allowed PSC limits represent approximately 1% of the total C. bairdi crab biomass, and thus, as discussed in Section 2.3 of this chapter, some 5% of the legal sized biomass that will recruit to the directed crab fishery.

Whether this allocation is "correct" depends not only on the accuracy of the data used for bycatch estimation but also on the relative value of the species as bycatch and as target catch, the importance of the affected fisheries to the local and national economy, and the cost of implementing the allocation. Determination of the marginal value of bycatch is difficult and somewhat controversial and has not been satisfactorily resolved.

Indications of relative valuations of crab and groundfish were part of the analysis contained in the EA/RIR/IRFA for Amendment 10. Without repeating the analysis, the conclusion in that document was that exvessel revenue in the joint venture fishery did not fall (although costs increased some unknown amount), but that some $9 million in bycatch savings were realized (present value of exvessel revenue for crab using a 10% discount rate). Total value to the industry harvesting and processing crab and halibut, accounting for the value generated in the processing, wholesale, and retail markets would increase this estimate.

The overall PSC limits of Alternative 3 are negotiated limits with participation from all affected parts of the fishing industry. Assuming that all parties to the negotiations were fairly represented, the allocation can be viewed as optimal. That is, the agreed to PSC limits are optimal in the biological, economic, social and political context in which they were negotiated and thus represent the best allocation decision that could be determined at that point in time.

One potentially large cost under Alternative 3 is the lost revenue and increased operational costs engendered by a closure of a part of the Bering Sea to a specific target fishery. The essential conclusion of the analysis of Alternative 3 is, however, that, for the next year or two, predicted bycatch, with the exception of halibut, is likely to fall below the negotiated limits and thus the fishery will remain relatively unburdened. The costs of Alternative 3 depend on the option chosen. Much of those costs relate to administration and enforcement, as discussed above. These latter costs are higher for specifically defined target fisheries than for aggregated definitions.

Alternative 4: Establish fixed, but increasingly restrictive, bycatch limits for particular zones.

Imposition of Alternative 4 would include a more restrictive bycatch regime on the groundfish fishery than that imposed under Alternatives 1 through 3. This is because the Alternative 4 PSC limits are more restrictive than those specified under Alternative 2 and because those caps are to be applied against the entire groundfish fishery, not only the joint venture flatfish fishery.

This alternative, as well as Alternative 2, suffers from the inflexibility of fixed numerical limits on bycatch, and hence cannot be adjusted for changes in the status of groundfish, crab and, halibut stocks.

This alternative provides the greatest protection to the fishermen who target crab and halibut, among the alternatives considered, but, not surprisingly, restrictions on groundfish fishing--restrictions that will increase operational costs and, should catch rates in Zone 3 not improve, also diminish groundfish harvest and revenue.

Alternative 5 (Preferred): Establish aggregate PSC limits, apportioned by "target fishery" and area.

Imposition of Alternative 5 could be at great cost to the groundfish fishery if the four target fisheries are unable to reduce their bycatch rates for halibut. The issue is whether or not the fleet would adjust its behavior so as to reduce its bycatch rates and, hence, overall bycatch. Public testimony and past performance by industry when faced with bycatch controls indicate that immediate and significant reductions

in bycatch rates are possible. To the extent that this occurs costs will be reduced towards zero (Table 2.25, final scenario) while bycatch savings will be maintained (Table 2.25, first scenario).

### 2.4.5 Cost/Benefit Conclusions

The bycatch of crabs and halibut in groundfish fisheries results in a reduction in future harvestable populations of crab and halibut. Some of the crab and halibut taken as bycatch would, over time, have grown and become available to their respective target fisheries while others would have died due to natural mortality. By accounting for natural mortality rates, an estimate can be made of the percentage of bycatch that would otherwise have been available to directed crab and halibut fisheries.

The impacts of each alternative would, theoretically, include changes in revenue, costs, and profits affecting harvesters, processors, wholesales, retailers, and consumers. The change in future product flow would be estimated and the revenue change at each level measured and added across levels. Such an analysis would compare the total changes associated with each of the alternatives; however, such an indepth and comprehensive analysis is beyond the scope of available data, and, moreover, the dissimilarities of the prediction models (in terms of both technique and data used) make such comparisons suspect.

The analyses, except for Alternative 5, examine only the effect on the bycatch species, crab and halibut, without distinction being made as to the change in cost to groundfish harvesters associated with the different alternatives. It is apparent that the alternatives would each have a different effect on groundfish harvesters by forcing them to fish in areas of (potentially) lower catch per unit effort. When the harvesters move due to bycatch constraints, their costs would increase for the same amount of catch, resulting in decreased profits of some unknown magnitude. These increased costs, although unknown at this time, need to be balanced against the gains to crab and halibut fishermen.

Only Alternatives 4 and 5 may actually restrict groundfish harvests. As suggested in Section 2.4.1, such a drastic potential reduction in harvest would be expected to change harvest patterns and bycatch rates. Further consideration also needs to be given to the market implications of such a large decrease in landings should fishermen be unable or unwilling to modify their fishing behavior. The reduction in the landings of yellowfin sole, other flatfish, pollock and cod could have the effect of reducing world supplies and possibly increasing prices. Data are not available at this time to analyze such implications.

## 2.5 References


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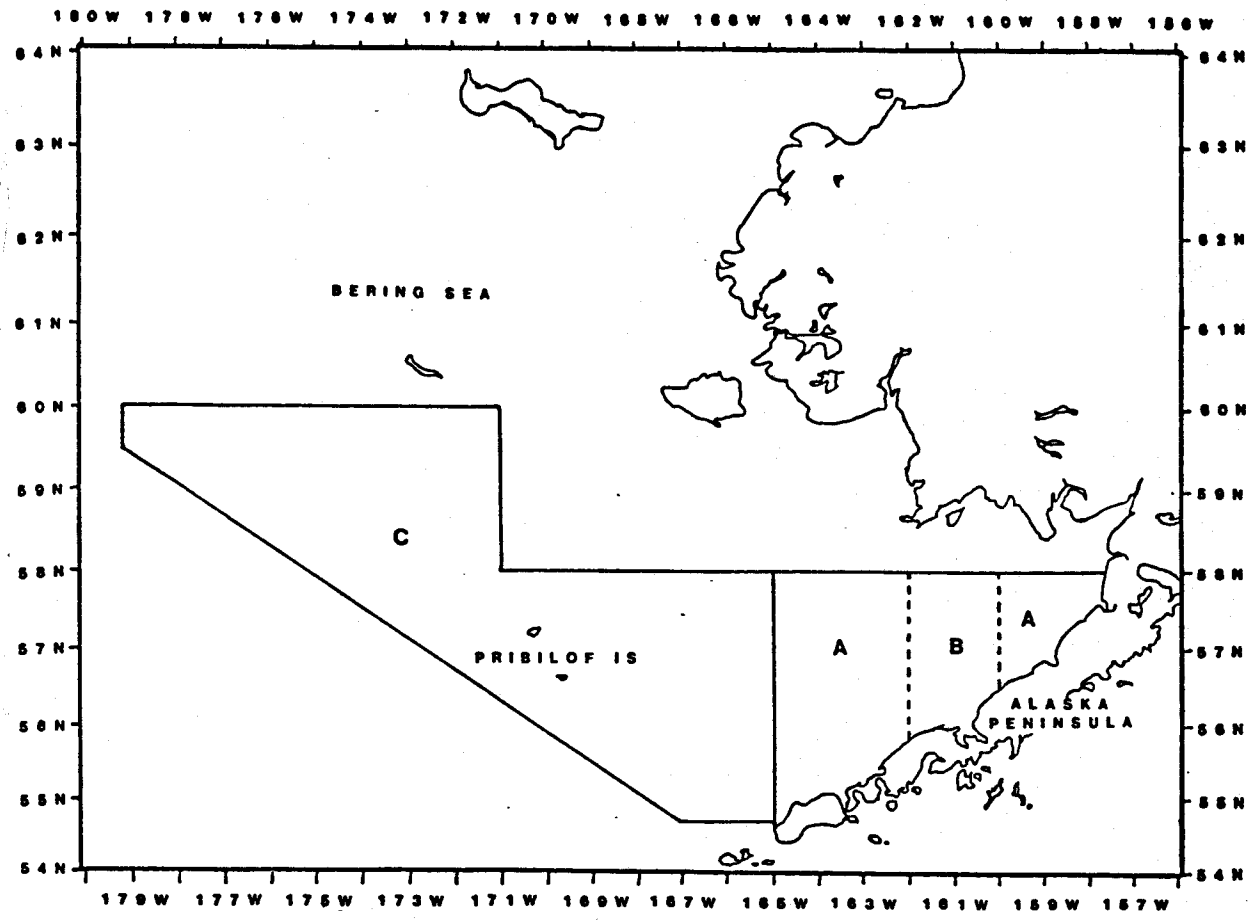


Figure 2.1 Bering Sea/Aleutian Islands:

A = Zone 1
B = Closed area defined at 50 CFR 675.22(a)
C = Zone 2
Rest of BS/AI is considered Zone 3.

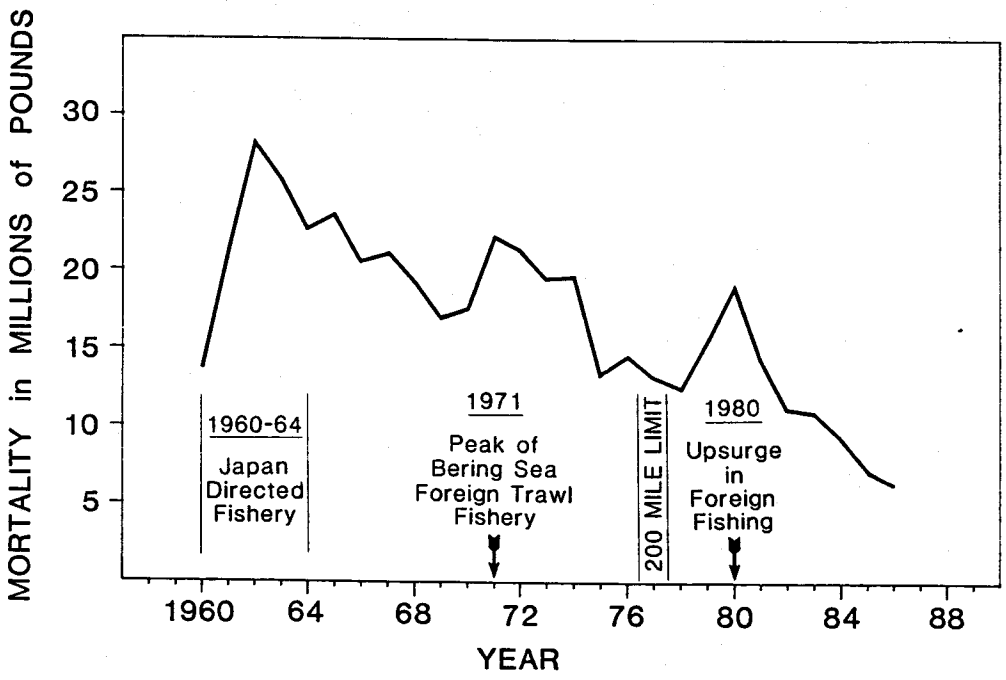


Figure 2.2 Trend in incidental (bycatch) mortality of halibut coastwide. Source: IPHC (1987).

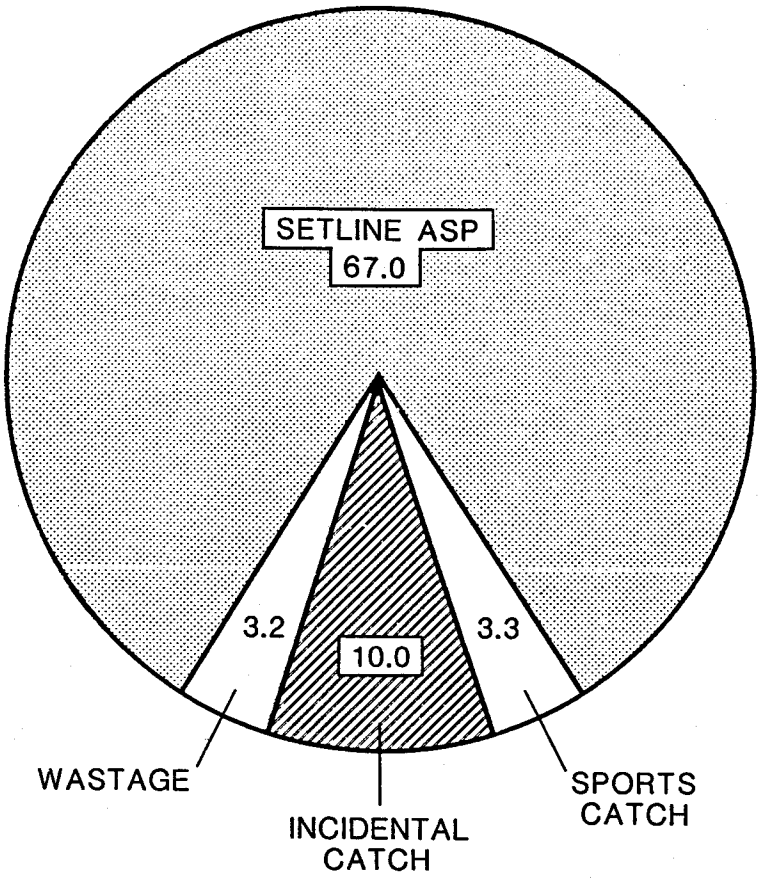


Figure 2.3 Breakdown of halibut annual surplus production coastwide for 1986 (millions of pounds). Source: IPHC (1987).

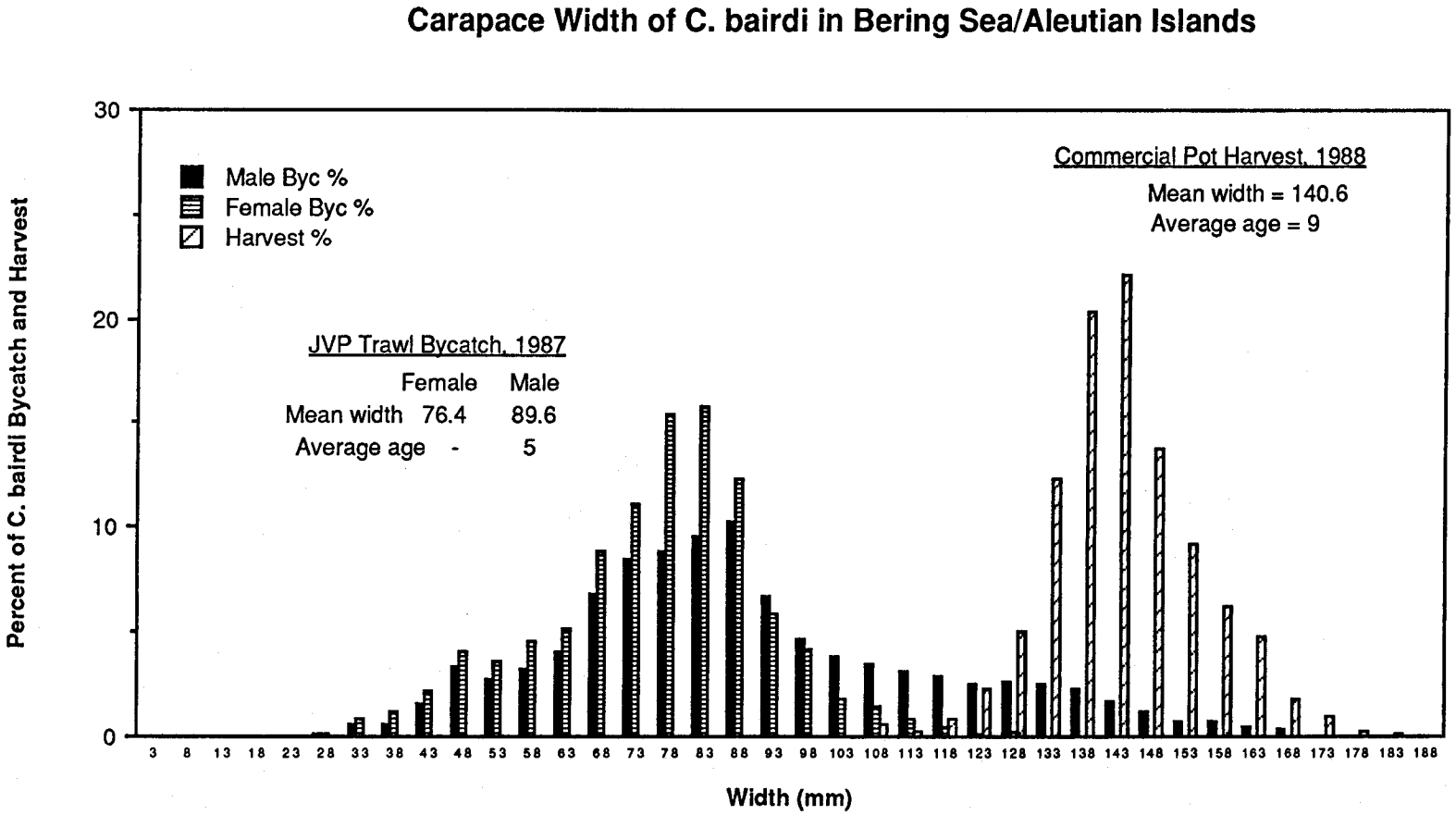


Figure 2.4 Size distribution of C. bairdi in trawl bycatch and commercial harvest. Sources: Russ Nelson (NWAFC); Ken Griffin (ADF&G).

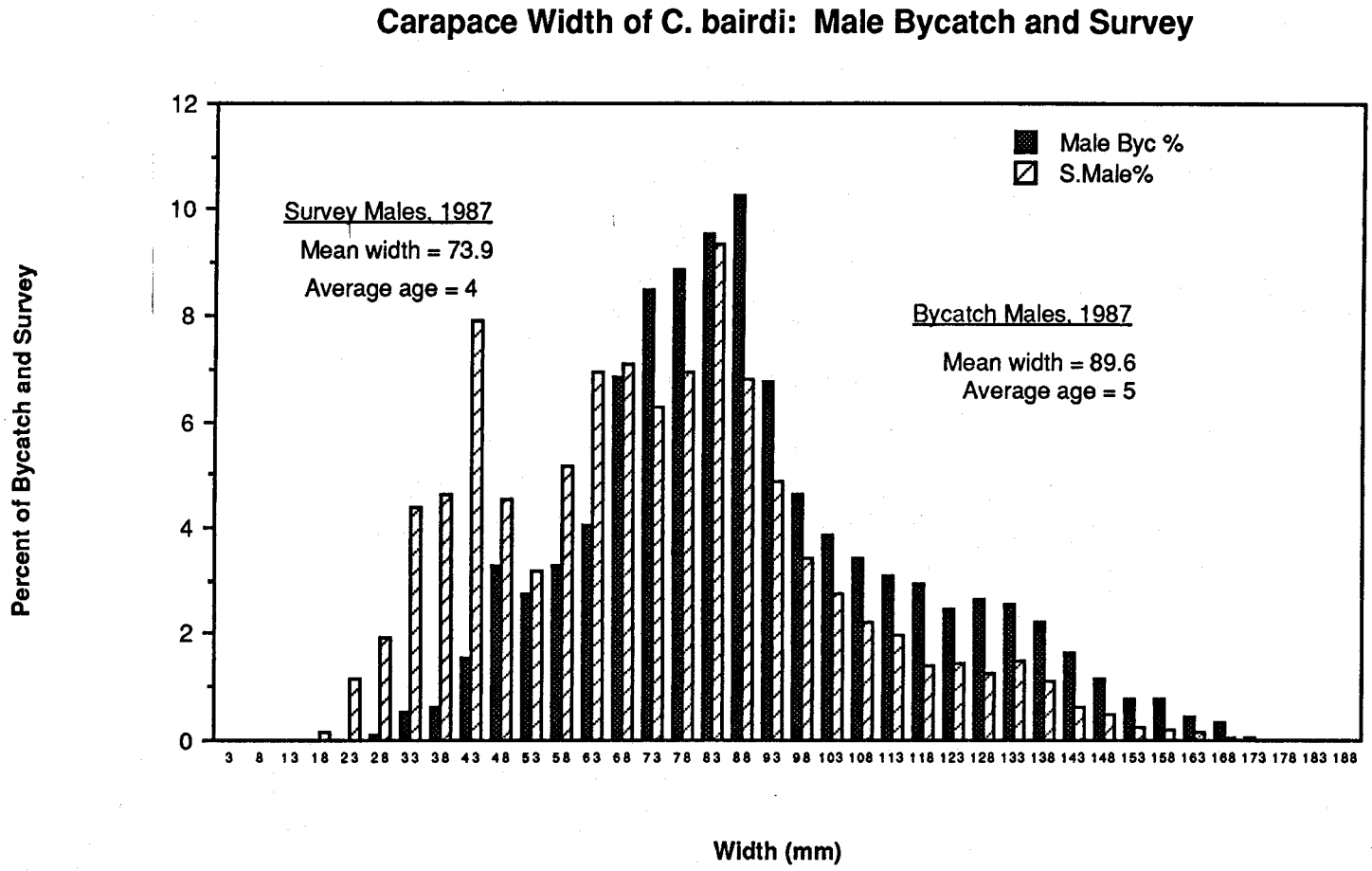


Figure 2.5 Size distribution of C. bairdi in population trawl surveys and trawl bycatch. Sources: Brad Stevens (NWAFC); Russ Nelson (NWAFC).

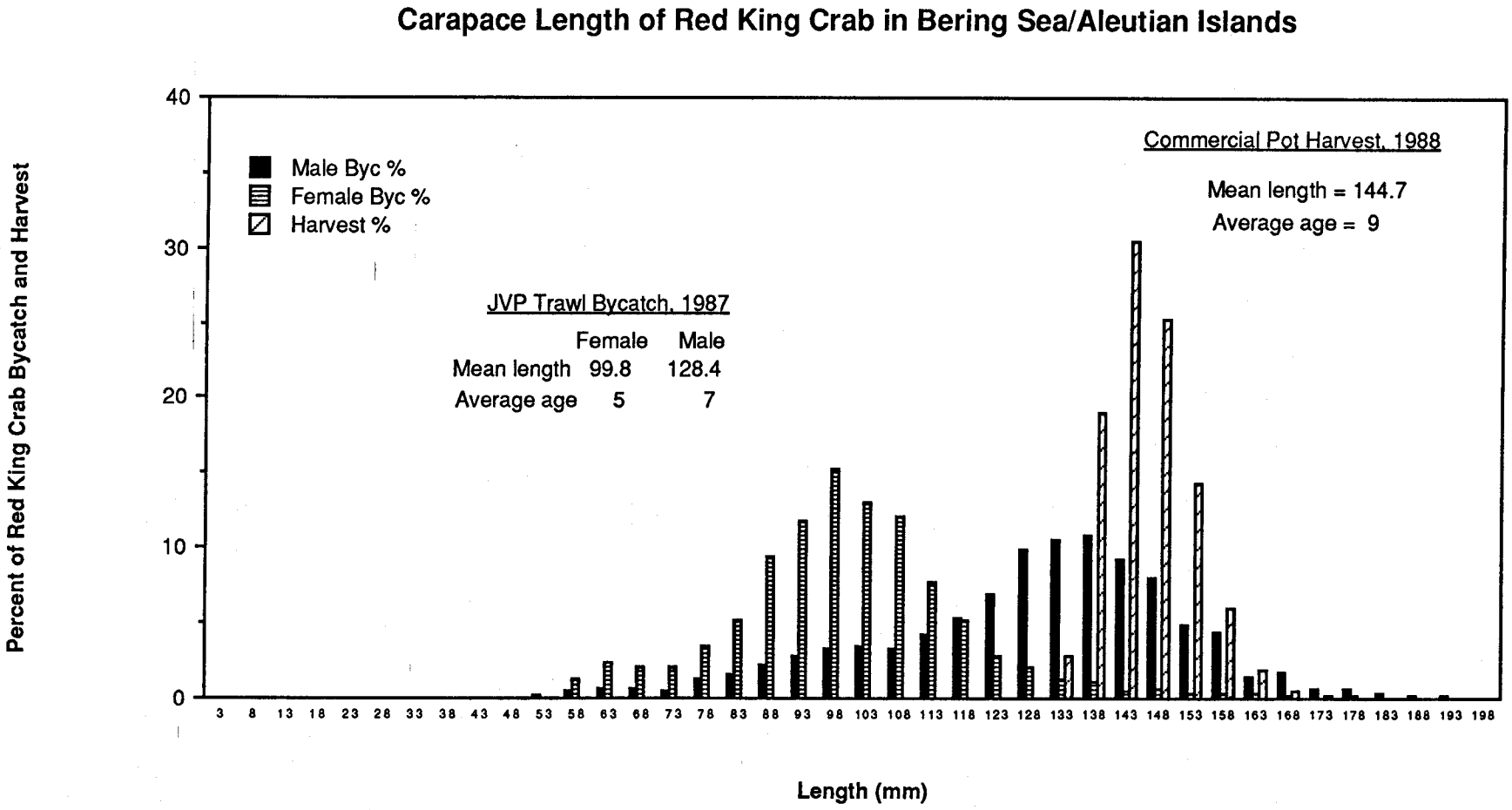


Figure 2.6 Size distribution of red king crab in trawl bycatch and commercial harvest. Sources: Russ Nelson (NWAFC); Ken Griffin (ADF&G).

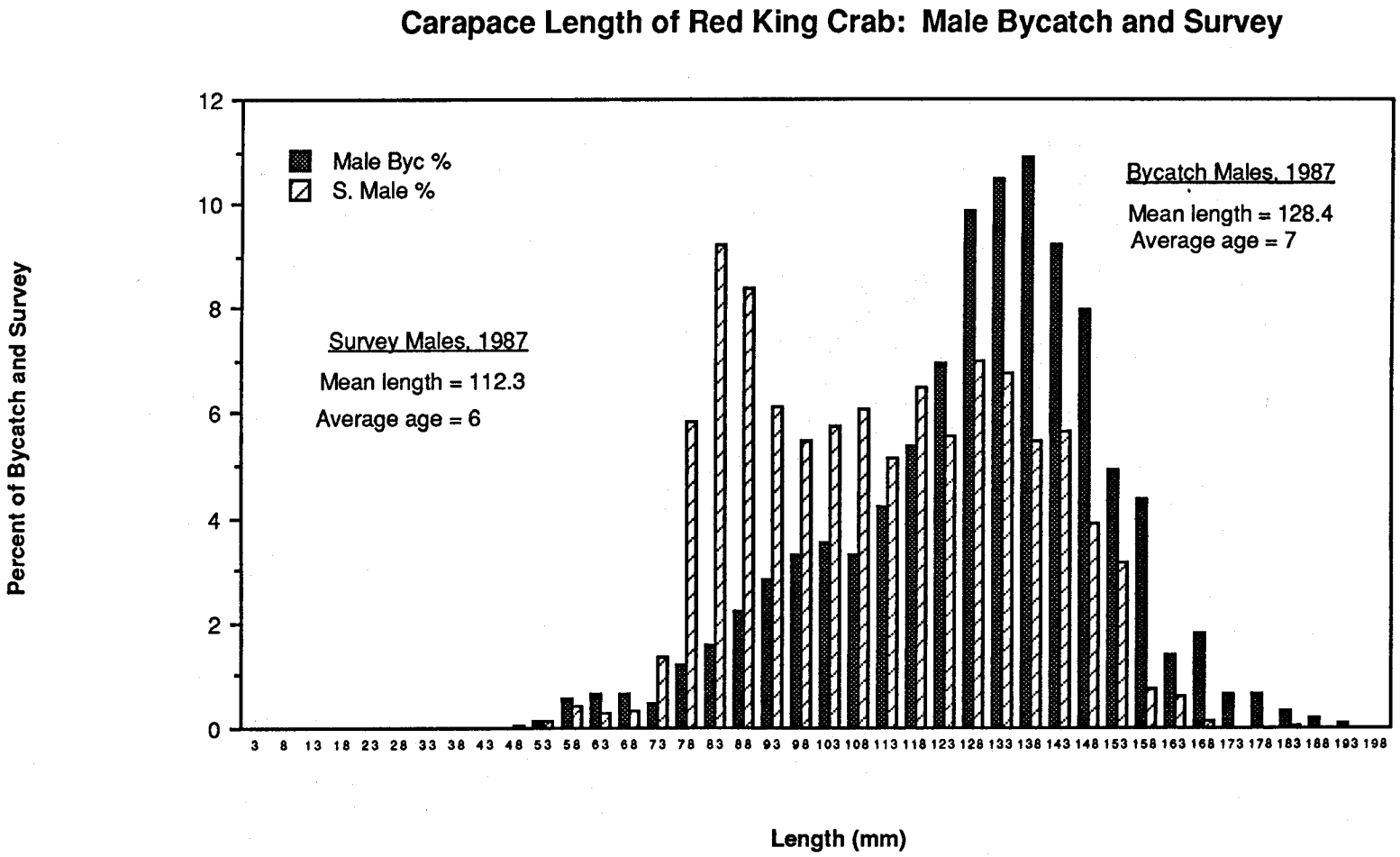


Figure 2.7 Size distribution of red king crab in population trawl surveys and trawl bycatch. Sources: Brad Stevens (NWAFC); Russ Nelson (NWAFC).

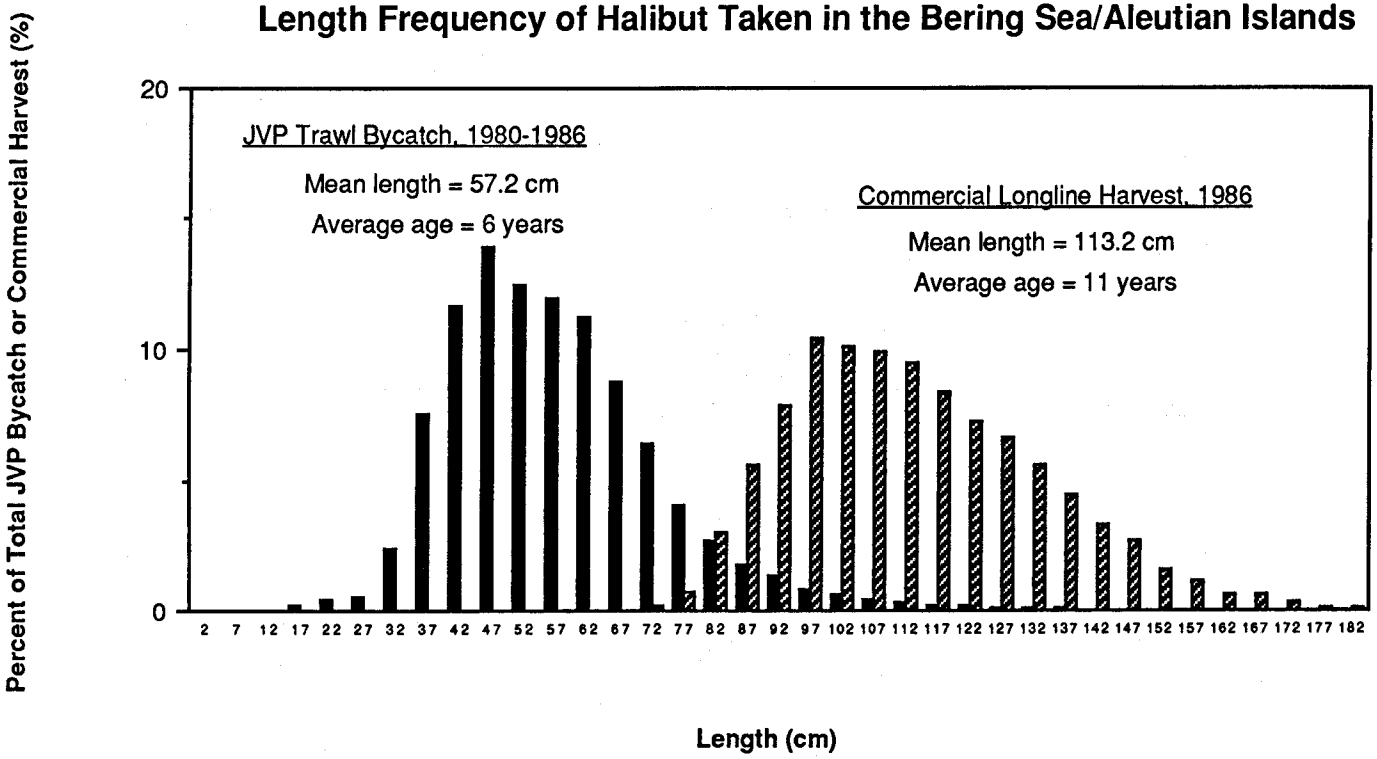


Figure 2.8 Size distribution of halibut in trawl bycatch and commercial harvest. Source: Williams (IPHC).

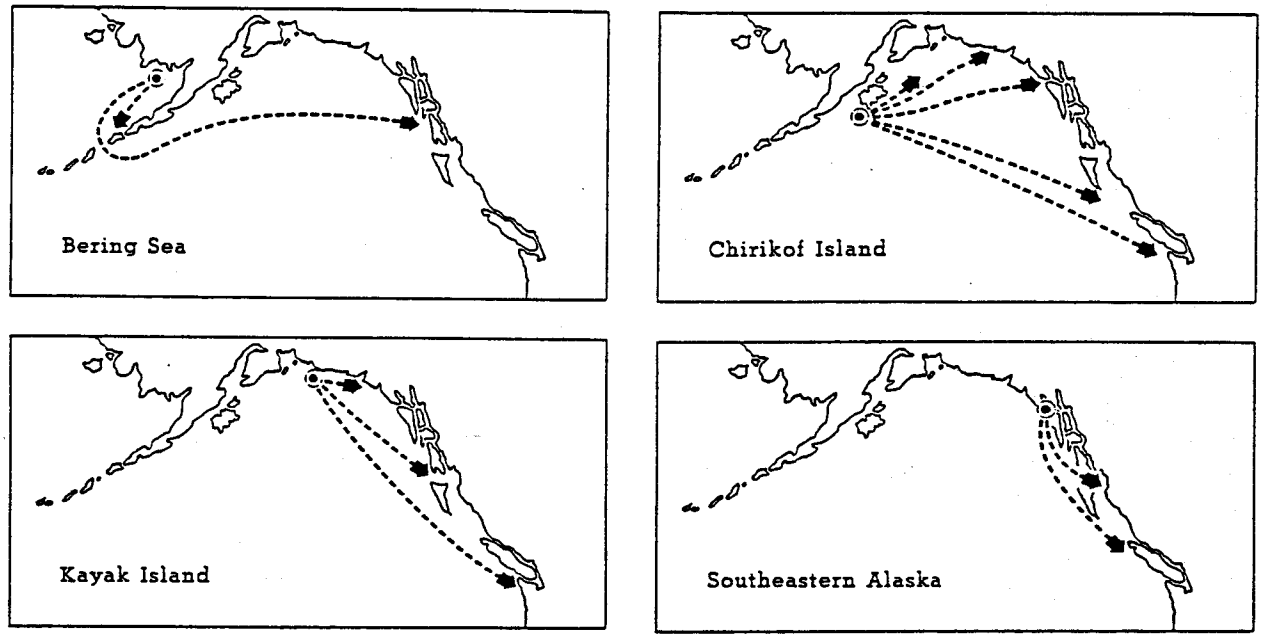


Figure 2.9 Migratory patterns of juvenile Pacific halibut from different tagging sites. Source: IPHC.

Table 2.1 Individual target fishery / bycatch allowances required under Alternative 3.

| Target fishery (definition) | Bycatch species | | |
|---|---|---|---|
| | C. bairdi | Red king crab | Halibut |
| Pollock - bottom trawl (≥50% pollock) | | | |
| DAP | x | x | x |
| JVP | x | x | x |
| Pacific cod - bottom trawl (≥60% P.cod) | | | |
| DAP | x | x | x |
| JVP | x | x | x |
| Yellowfin sole/other flatfish (default bottom trawl) | | | |
| DAP | x | x | x |
| JVP | x | x | x |
| Rock sole - bottom trawl (≥35% rock sole) | | | |
| DAP | x | x | x |
| JVP | x | x | x |
| Greenland turbot - bottom trawl (≥35% G.turbot) | | | |
| DAP | | | x |
| JVP | | | x |
| Pacific cod - longline (≥70% P.cod) | | | |
| DAP | | | x |
| JVP | | | x |
| Aggregate bycatch limits | | | |
| Initiating active management | 0.75% of pop. | 0.75% of pop. | 2925 mt |
| Ultimate ceiling | 1% of pop. | 1% of pop. | 3900 mt |

Note: Twenty-eight (28) individual target fishery/bycatch allowances are required.

Table 2.2 Aggregated target fishery / bycatch allowances required under Alternative 3.

| Target fishery (as gear type) | Bycatch species | | |
|---|---|---|---|
| | C. bairdi | Red king crab | Halibut |
| Trawl | | | |
| DAP | x | x | x |
| JVP | x | x | x |
| Longline | | | |
| DAP | | | x |
| JVP | | | x |
| Aggregate bycatch limits | | | |
| Initiating active management | 0.75% of pop. | 0.75% of pop. | 2925 mt |
| Ultimate ceiling | 1% of pop. | 1% of pop. | 3900 mt |

Note: Eight (8) individual target fishery/bycatch allowances are required.

Table 2.3 Bering Sea population estimates of C. bairdi Tanner crab, estimated foreign and joint venture bycatch and bycatch expressed as a percentage of the population, 1978-1987.

| | Population (millions) | | | | | Bycatch | |
|---|---|---|---|---|---|---|---|
| Year | Legal Males | Other Males | Total Males | Females | Total Crabs | Number (millions) | % of Pop. |
| 1978 | 45.9 | 279.2 | 325.1 | 318.4 | 643.5 | 4.1 | 0.64 |
| 1979 | 31.6 | 211.4 | 242.9 | 216.2 | 459.1 | 7.5 | 1.63 |
| 1980 | 31.1 | 572.7 | 603.7 | 543.3 | 1147.0 | 3.7 | 0.32 |
| 1981 | 14.2 | 375.7 | 389.9 | 458.3 | 848.2 | 1.6 | 0.19 |
| 1982 | 11.4 | 188.9 | 200.3 | 513.8 | 714.1 | 0.4 | 0.05 |
| 1983 | 7.1 | 211.7 | 218.8 | 280.6 | 499.4 | 0.6 | 0.12 |
| 1984 | 6.0 | 121.2 | 127.1 | 154.4 | 281.5 | 0.7 | 0.25 |
| 1985 | 4.5 | 56.9 | 61.3 | 58.1 | 119.4 | 0.9 | 0.75 |
| 1986 | 3.2 | 134.9 | 138.0 | 87.6 | 225.6 | 0.6 | 0.27 |
| 1987 | 8.3 | 279.8 | 288.1 | 250.6 | 538.7 | 0.5 | 0.09 |

Source: NWAFC, J. Reeves, personal communication.

Table 2.4 Bering Sea population estimates of red king crab, estimated foreign and joint venture bycatch and bycatch expressed as a percentage of the population, 1977-1987.

| | Population (millions) | | | | | Bycatch | |
|---|---|---|---|---|---|---|---|
| Year | Legal Males | Other Males | Total Males | Females | Total Crabs | Number (millions) | % of Pop. |
| 1977 | 37.6 | 144.1 | 181.7 | 183.6 | 365.3 | - | - |
| 1978 | 46.6 | 110.8 | 157.4 | 166.6 | 324.0 | 0.32 | 0.10 |
| 1979 | 43.9 | 85.3 | 129.2 | 156.0 | 285.2 | 0.08 | 0.03 |
| 1980 | 36.1 | 80.7 | 116.8 | 112.5 | 229.3 | 0.34 | 0.15 |
| 1981 | 11.3 | 75.0 | 86.3 | 103.6 | 189.9 | 1.14 | 0.60 |
| 1982 | 4.7 | 124.6 | 129.3 | 132.0 | 261.3 | 0.27 | 0.10 |
| 1983 | 1.5 | 53.7 | 55.2 | 34.0 | 89.2 | 0.81 | 0.91 |
| 1984 | 3.1 | 94.5 | 97.6 | 75.1 | 172.7 | 0.49 | 0.28 |
| 1985 | 2.5 | 23.8 | 26.3 | 13.7 | 40.0 | 1.17 | 2.92 |
| 1986 | 5.9 | 24.1 | 30.0 | 9.8 | 39.8 | 0.26 | 0.65 |
| 1987 | 7.9 | 32.7 | 40.6 | 35.1 | 75.7 | 0.13 | 0.17 |

Source: NWAFC, J. Reeves, personal communication.

Table 2.5 Bering Sea Pacific halibut bycatch mortality, 1977-1986.

| Year | Metric Tons |
|---|---|
| 1977 | 1,758 |
| 1978 | 3,029 |
| 1979 | 3,269 |
| 1980 | 5,570 |
| 1981 | 3,865 |
| 1982 | 2,869 |
| 1983 | 2,137 |
| 1984 | 2,830 |
| 1985 | 2,538 |
| 1986[1/] | 2,697 |

1/ Preliminary.

Source: IPHC, R. Trumble, personal communication.

Table 2.6 Pacific halibut removals (all areas), 1977-1986.

| | Thousand Metric Tons, Round Weight | | | |
|---|---|---|---|---|
| Year | Catch | Bycatch[1/] | Sport | Total Removals |
| 1977 | 13.2 | 10.9 | 0.3 | 24.4 |
| 1978 | 13.3 | 11.2 | 0.2 | 24.7 |
| 1979 | 13.6 | 14.0 | 0.4 | 28.0 |
| 1980 | 13.2 | 17.3 | 0.5 | 31.0 |
| 1981 | 15.5 | 13.7 | 0.6 | 24.8 |
| 1982 | 17.5 | 11.4 | 0.8 | 29.7 |
| 1983 | 23.2 | 9.4 | 1.2 | 33.8 |
| 1984 | 29.1 | 9.4 | 1.3 | 37.8 |
| 1985 | 33.8 | 6.9 | 2.0 | 42.7 |
| 1986 | 42.0 | 6.8 | 2.4 | 51.2 |

1/ Expressed in adult equivalents (bycatch mortality x 1.58).

Source: IPHC, R. Trumble, personal communication.

Table 2.7 Joint venture bycatch summary, prohibited species, Bering Sea, 1987 and 1988[1/], by target fishery.

| Prohibited Species | Target Fishery | Incidental Catch (1000s of animals) 1987 | Incidental Catch (1000s of animals) 1988[1/] | Bycatch rate[2/] (animals/mt of groundfish) 1987 | Bycatch rate[2/] (animals/mt of groundfish) 1988[1/] |
|---|---|---|---|---|---|
| C. bairdi | JV, flounder | 216 | 368 | 0.88 | 1.07 |
| | JV, other | 161 | 228 | 0.15 | 0.29 |
| | Foreign | 90 | 0 | 1.31 | 0.00 |
| | TOTAL | 467 | 596 | 0.33 | 0.53 |
| Other Tanner Crab | JV, flounder | 6,146 | 1,814 | 25.04 | 5.25 |
| | JV, other | 341 | 134 | 0.31 | 0.17 |
| | Foreign | 265 | 0 | 3.83 | 0.00 |
| | TOTAL | 6,751 | 1,948 | 4.78 | 1.72 |
| Red King Crab | JV, flounder | 76 | 51 | 0.31 | 0.15 |
| | JV, other | 48 | 22 | 0.04 | 0.03 |
| | Foreign | 1 | 0 | 0.02 | 0.00 |
| | TOTAL | 125 | 73 | 0.09 | 0.06 |
| Halibut | JV, flounder | 222 | 547 | 0.90 | 1.58 |
| | JV, other | 314 | 945 | 0.29 | 1.17 |
| | Foreign | 271 | 0 | 3.93 | 0.00 |
| | TOTAL | 807 | 1,492 | 0.57 | 1.31 |

Source: Report from foreign observer program, NWAFC, February 1988 and August 1988.

1/ As of August 1988.

2/ Totals are overall bycatch rates (weighted average).

Table 2.8 Joint venture bycatch summary, prohibited species, Bering Sea, 1987 and 1988[1/], by zone.

| Prohibited Species | Zone | Incidental Catch (1000s of animals) 1987 | Incidental Catch (1000s of animals) 1988[1/] | Bycatch Rate (animals/mt of groundfish) 1987 | Bycatch Rate (animals/mt of groundfish) 1988[1/] |
|---|---|---|---|---|---|
| C. bairdi | 1 | 121 | 92 | 0.61 | 0.36 |
| | 2 | 281 | 383 | 0.43 | 0.63 |
| | 3 | 65 | 29 | 0.11 | 0.11 |
| Other Tanner crab | 1 | 45 | 17 | 0.23 | 0.06 |
| | 2 | 3,139 | 915 | 4.84 | 1.49 |
| | 3 | 3,567 | 1,006 | 6.32 | 3.83 |
| Red king crab | 1 | 104 | 51 | 0.52 | 0.20 |
| | 2 | 10 | 4 | 0.02 | 0.01 |
| | 3 | 12 | 10 | 0.02 | 0.04 |
| Halibut | 1 | 140 | 306 | 0.70 | 0.57 |
| | 2 | 463 | 1,089 | 0.71 | 1.78 |
| | 3 | 205 | 97 | 0.36 | 0.37 |

Source: Report from foreign observer program, NWAFC, February 1988 and August 1988.

1/ As of August 1988.

Table 2.9 Incidental catch and bycatch rates in joint venture yellowfin sole/ flatfish fishery, and other foreign and joint venture groundfish fisheries, in 1985.

1985 Harvest

JVP Yellowfin sole/flatfish (total groundfish) 216,000 mt

1985 Bycatch

| Species | Animals | Bycatch Rate (#/mt groundfish) |
|---|---|---|
| C. bairdi | 344,000 | 1.6 |
| C. opilio | 321,000 | 1.5 |
| Red king crab | 886,000 | 4.1 |
| Halibut | 266,000 | 1.2 |

Source: EA/RIR/IRFA for Amendment 10 to the BSAI FMP, 1986.

1985 Harvest

All other JVP fisheries, total groundfish 448,123 mt

1985 Bycatch

| Species | Animals | Bycatch Rate (#/mt groundfish) |
|---|---|---|
| Tanner crab | 226,437 | 0.51 |
| King crab | 119,290 | 0.27 |
| Halibut | 181,370 | 0.40 |

1985 Harvest

All foreign fisheries, total groundfish 1,035,000 mt

1985 Bycatch

| Species | Animals | Bycatch Rate (#/mt groundfish) |
|---|---|---|
| Tanner crab | 1,757,520 | 1.70 |
| King crab | 219,783 | 0.21 |
| Halibut | 485,311 | 0.47 |

Source: Berger et al., 1986. Summary of U.S. observer sampling of foreign and joint venture fisheries in the northeast Pacific Ocean and eastern Bering Sea, 1985. NWAFC.

Table 2.10 Predicted bycatch under Alternative 1 for 1989-1990 BS/AI groundfish fisheries without PSC limits.

| | JVP yellowfin sole/ other flatfish | | All other fisheries[1/] | | Total | |
|---|---|---|---|---|---|---|
| | 1989 | 1990 | 1989 | 1990 | 1989 | 1990 |
| Groundfish harvest (mt) | 280,000 | 200,000 | 1,720,000 | 1,800,000 | 2,000,000 | 2,000,000 |
| Predicted bycatch (thousands of animals) | | | | | | |
| Tanner crab | 862 | 616 | 877 | 918 | 1,739 | 1,534 |
| King crab | 1,148 | 820 | 464 | 486 | 1,612 | 1,306 |
| Halibut | 336 | 240 | 688 | 720 | 1,024 | 960 |

1/ All other DAH fisheries. Observed JVP bycatch rate is applied to DAP harvest.

Table 2.11. Simulation of Alternative 2, continuation of the Amendment 10 PSC limits, 1989-1990.

| | | JVP Yellowfin sole/other flatfish | | All other DAH | | Foreign | | TOTAL | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1989 | 1990 | 1989 | 1990 | 1989 | 1990 | 1989 | 1990 |
| Groundfish harvest (mt) | | 280,000 | 200,000 | 1,720,000 | 1,800,000 | 0 | 0 | 2,000,000 | 2,000,000 |
| Amendent 10 PSC limits: | Bairdi - Zone 1 | 80,000 | 80,000 | N/A | N/A | N/A | N/A | | |
| | Bairdi - Zone 2 | 326,000 | 326,000 | N/A | N/A | N/A | N/A | | |
| | Red king crab - Zone 1 | 135,000 | 135,000 | N/A | N/A | N/A | N/A | | |
| | Halibut | 828,000 | 828,000 | N/A | N/A | N/A | N/A | | |
| Predicted Zone 1 bycatch: (animals) | Bairdi | 74,800 | 74,800 | 236,651 | 247,658 | 0 | 0 | 311,451 | 322,458 |
| | Red king crab | 39,000 | 39,000 | 46,554 | 48,720 | 0 | 0 | 85,554 | 87,720 |
| | Halibut | 137,500 | 137,500 | 368,555 | 385,698 | 0 | 0 | 506,055 | 523,198 |
| Predicted groundfish harvest, Zone 1 (mt) | | 81,500 | 81,500 | 387,953 | 405,997 | 0 | 0 | 469,453 | 487,497 |
| Predicted bycatch, all other zones (animals) | Bairdi | 220,687 | 131,745 | 260,528 | 272,645 | 0 | 0 | 481,214 | 404,390 |
| | Red king crab | 8,849 | 5,283 | 5,293 | 5,539 | 0 | 0 | 14,142 | 10,822 |
| | Halibut | 308,260 | 184,024 | 1,692,159 | 1,770,864 | 0 | 0 | 2,000,419 | 1,954,889 |
| Predicted bycatch, all zones (animals) | Bairdi | 295,487 | 206,545 | 497,179 | 520,304 | 0 | 0 | 792,666 | 726,848 |
| | Red king crab | 47,849 | 44,283 | 51,848 | 54,259 | 0 | 0 | 99,696 | 98,542 |
| | Halibut | 445,760 | 321,524 | 2,060,715 | 2,156,562 | 0 | 0 | 2,506,475 | 2,478,086 |

**Notes:** Predicted Zone 1 bycatch and groundfish harvest for JVP yellowfin sole/other flatfish fishery is that observed in 1988 fishery. Bycatch in all other fisheries is predicted using the bycatch rates shown in Table 2.12.

Table 2.12. Bycatch rates used for projecting bycatch under Alternative 2 (Table 2.11) in animals per mt of groundfish.

| | | TARGET FISHERY | |
|---|---|---|---|
| Species | Zone | JVP-Flounder | JVP-other |
| C. bairdi | 1 | 0.92 | 0.61 |
| | 2 | 1.51 | 0.27 |
| | 3 | 0.32 | 0.01 |
| | All Zones | 1.07 | 0.29 |
| Other Tanner crab | 1 | 0.16 | 0.08 |
| | 2 | 4.59 | 0.25 |
| | 3 | 11.28 | 0.06 |
| | All Zones | 5.25 | 0.17 |
| Red king crab | 1 | 0.48 | 0.12 |
| | 2 | 0.01 | <0.01 |
| | 3 | 0.10 | 0.01 |
| | All Zones | 0.15 | 0.03 |
| Halibut | 1 | 1.69 | 0.95 |
| | 2 | 2.07 | 1.66 |
| | 3 | 0.53 | 0.29 |
| | All Zones | 1.58 | 1.17 |

Source: Bycatch summary for 1988 (as of August, 1988), foreign observer program, NWAFC, NMFS.

Table 2.13. Overall guidelines for prohibited species catch limits under Alternative 3, 1988.

| SPECIES | LOWER LIMIT | | UPPER LIMIT | |
|---|---|---|---|---|
| | Type | Amount | Type | Amount |
| C. bairdi Tanner crab, animals | 0.75% | 4,040,250 | 1.00% | 5,387,000 |
| Red king crab, animals | 0.75% | 567,750 | 1.00% | 757,000 |
| Halibut, weight, mt | mortality | 2,925 | mortality | 3,900 |
| Halibut, animals | mortality | 928,571 | mortality | 1,238,095 |

Notes: C. bairdi and red king crab percentages are applied to current population estimates (1987) derived from summer population survey. Halibut bycatch (not mortality) will depend on assumed bycatch mortality rates. For the purposes of this analysis 100% mortality to trawl and 25% mortality to longline was assumed.

Table 2.14. Predicted bycatch for 1989 under Alternative 3.

ANTICIPATED GROUNDFISH APPORTIONMENTS

| Species | Area | TAC | DAP | JVP | TALFF |
|---|---|---|---|---|---|
| Pollock | BS | 1,275,000 | 925,000 | 350,000 | 0 |
| | AI | 78,000 | 36,000 | 42,000 | 0 |
| Pacific cod | | 200,000 | 100,000 | 100,000 | 0 |
| Yellowfin sole | | 230,000 | 50,000 | 180,000 | 0 |
| Greenland turbot | | 13,100 | 13,100 | 0 | 0 |
| Arrowtooth flounder | | 5,000 | 5,000 | 0 | 0 |
| Other flatfish | | 150,000 | 50,000 | 100,000 | 0 |
| Sablefish | BS | 3,400 | 3,300 | 100 | 0 |
| | AI | 5,800 | 5,700 | 100 | 0 |
| Pacific ocean perch | BS | 5,200 | 5,170 | 30 | 0 |
| | AI | 6,000 | 5,550 | 450 | 0 |
| Other rockfish | BS | 400 | 370 | 30 | 0 |
| | AI | 1,100 | 870 | 230 | 0 |
| Atka mackerel | | 21,000 | 100 | 20,900 | 0 |
| Squid | | 2,000 | 2,000 | 0 | 0 |
| Other species | | 4,000 | 2,000 | 2,000 | 0 |
| BS/AI TOTAL | | 2,000,000 | 1,204,160 | 795,840 | 0 |

Notes: Each species TAC is reduced by 15% to provide for 300,000 tons of nonspecific reserves.
JVP for pollock is apportioned over two seasons: Part One is applicable to Jan. 15 to April 15.
Bycatch rates are per mt of target and are taken from a report summarizing 1988 bycatch rates (NWAFC, 1988).
Observed joint venture bycatch rates are used to estimate bycatch for all user groups
except sablefish, rockfish and longline cod where observed foreign rates are used.
Bycatch rates in the other flatfish fishery are used for arrowthooth flounder, trubot and other flatfish.

Table 2.14. (cont.) Predicted bycatch for 1989 under Alternative 3.

GEAR SHARE ASSUMPTIONS

| Species | Area | Bottom trawl DAP | Bottom trawl JVP | Bottom trawl TALFF | Midwater trawl DAP | Midwater trawl JVP | Midwater trawl TALFF | Longline DAP | Longline JVP | Longline TALFF |
|---|---|---|---|---|---|---|---|---|---|---|
| Pollock | BS | 20% | 20% | 20% | 80% | 80% | 80% | 0% | 0% | 0% |
| | AI | 20% | 20% | 20% | 80% | 80% | 80% | 0% | 0% | 0% |
| Pacific cod | | 96% | 100% | 0% | 0% | 0% | 0% | 4% | 0% | 100% |
| Yellowfin sole | | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% |
| Greenland turbot | | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% |
| Arrowtooth flounder | | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% |
| Other flatfish | | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% |
| Sablefish | BS | 50% | 50% | 50% | 0% | 0% | 0% | 50% | 50% | 50% |
| | AI | 30% | 30% | 30% | 0% | 0% | 0% | 70% | 70% | 70% |
| Pacific ocean perch | BS | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% |
| | AI | 97% | 97% | 97% | 0% | 0% | 0% | 3% | 3% | 3% |
| Other rockfish | BS | 85% | 85% | 85% | 0% | 0% | 0% | 15% | 15% | 15% |
| | AI | 20% | 20% | 20% | 0% | 0% | 0% | 80% | 80% | 80% |
| Atka mackerel | | 0% | 0% | 0% | 100% | 100% | 100% | 0% | 0% | 0% |

Table 2.14. (cont.) Predicted bycatch for 1989 under Alternative 3.

CATCHES BY GEAR (mt)

| Species | Area | Bottom trawl DAP | Bottom trawl JVP | Bottom trawl TALFF | Midwater trawl DAP | Midwater trawl JVP | Midwater trawl TALFF | Longline DAP | Longline JVP | Longline TALFF |
|---|---|---|---|---|---|---|---|---|---|---|
| Pollock | BS | 185,000 | 70,000 | 0 | 740,000 | 280,000 | 0 | 0 | 0 | 0 |
| | AI | 7,200 | 8,400 | 0 | 28,800 | 33,600 | 0 | 0 | 0 | 0 |
| Pacific cod | | 96,000 | 100,000 | 0 | 0 | 0 | 0 | 4,000 | 0 | 0 |
| Yellowfin sole | | 50,000 | 180,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Greenland turbot | | 13,100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Arrowtooth flounder | | 5,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other flatfish | | 50,000 | 100,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sablefish | BS | 1,650 | 50 | 0 | 0 | 0 | 0 | 1,650 | 50 | 0 |
| | AI | 1,710 | 30 | 0 | 0 | 0 | 0 | 3,990 | 70 | 0 |
| Pacific ocean perch | BS | 5,170 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | AI | 5,384 | 437 | 0 | 0 | 0 | 0 | 167 | 14 | 0 |
| Other rockfish | BS | 315 | 26 | 0 | 0 | 0 | 0 | 56 | 5 | 0 |
| | AI | 174 | 46 | 0 | 0 | 0 | 0 | 696 | 184 | 0 |
| Atka mackerel | | 0 | 0 | 0 | 100 | 20,900 | 0 | 0 | 0 | 0 |

Table 2.14. (cont.) Predicted bycatch for 1989 under Alternative 3.

C. bairdi TANNER CRAB

| Species | Bycatch Rate (#/mt-target) B. trawl | M. trawl | Longline |
|---|---|---|---|
| Pollock | 3.16 | 0.01 | - |
| | 3.16 | 0.01 | - |
| Pacific cod | 1.17 | - | 0.01 |
| Yellowfin sole | 0.96 | - | - |
| Greenland turbot | 3.63 | - | - |
| Arrowtooth flounder | 3.63 | - | - |
| Other flatfish | 3.63 | - | - |
| Sablefish | - | | 0.00 |
| | - | | 0.00 |
| Pacific ocean perch | - | | 0.00 |
| | - | | 0.00 |
| Other rockfish | - | | 0.00 |
| | - | | 0.00 |
| Atka mackerel | - | 0.00 | - |

Bycatch Amount (animals)

Bottom Trawl

| Fishery | Area | DAP | JVP | TALFF | Total |
|---|---|---|---|---|---|
| Pollock | BS | 505,074 | 69,366 | 0 | 574,439 |
| | AI | 19,657 | 8,324 | 0 | 27,981 |
| Cod | | 57,854 | 82,811 | 0 | 140,665 |
| Y. sole | | 30,860 | 153,530 | 0 | 184,390 |
| O. flatfish | | 172,721 | 214,233 | 0 | 386,953 |
| TOTAL | | 786,165 | 528,263 | 0 | 1,314,429 |

Longline

| Fishery | Area | DAP | JVP | TALFF | Total |
|---|---|---|---|---|---|
| P. cod | | 39 | 0 | 0 | 39 |
| Sablefish | BS | 0 | 0 | 0 | 0 |
| | AI | 0 | 0 | 0 | 0 |
| Rockfish | BS | 0 | 0 | 0 | 0 |
| | AI | 0 | 0 | 0 | 0 |
| TOTAL | | 39 | 0 | 0 | 39 |

Midwater Trawl

| Fishery | Area | DAP | JVP | TALFF | Total |
|---|---|---|---|---|---|
| Pollock | BS | 7,400 | 2,800 | 0 | 10,200 |
| | AI | 288 | 336 | 0 | 624 |
| A. mackerel | | 0 | 0 | 0 | 0 |
| TOTAL | | 7,688 | 3,136 | 0 | 10,824 |

| | | | | | |
|---|---|---|---|---|---|
| GRAND TOTAL | | 793,892 | 531,399 | 0 | 1,325,291 |

Table 2.14. (cont.) Predicted bycatch for 1989 under Alternative 3.

OTHER TANNER CRAB

| Species | Bycatch Rate (#/mt-target) B. trawl | M. trawl | Longline |
|---|---|---|---|
| Pollock | 0.70 | 0.01 | - |
| | 0.70 | 0.01 | - |
| Pacific cod | 0.45 | - | 1.32 |
| Yellowfin sole | 2.41 | - | - |
| Greenland turbot | 12.20 | - | - |
| Arrowtooth flounder | 12.20 | - | - |
| Other flatfish | 12.20 | - | - |
| Sablefish | - | | 0.00 |
| | - | | 0.00 |
| Pacific ocean perch | - | | 0.00 |
| | - | | 0.00 |
| Other rockfish | - | | 0.00 |
| | - | | 0.00 |
| Atka mackerel | - | 0.00 | - |

Bycatch Amount (animals)

Bottom Trawl

| Fishery | Area | DAP | JVP | TALFF | Total |
|---|---|---|---|---|---|
| Pollock | BS | 111,883 | 15,366 | 0 | 127,249 |
| | AI | 4,354 | 1,844 | 0 | 6,198 |
| Cod | | 22,251 | 31,850 | 0 | 54,102 |
| Y. sole | | 77,473 | 385,423 | 0 | 462,896 |
| O. flatfish | | 580,494 | 720,011 | 0 | 1,300,505 |
| TOTAL | | 796,456 | 1,154,495 | 0 | 1,950,950 |

Longline

| Fishery | Area | DAP | JVP | TALFF | Total |
|---|---|---|---|---|---|
| P. cod | | 5,110 | 4 | 0 | 5,114 |
| Sablefish | BS | 0 | 0 | 0 | 0 |
| | AI | 0 | 0 | 0 | 0 |
| Rockfish | BS | 0 | 0 | 0 | 0 |
| | AI | 0 | 0 | 0 | 0 |
| TOTAL | | 5,110 | 4 | 0 | 5,114 |

Midwater Trawl

| Fishery | Area | DAP | JVP | TALFF | Total |
|---|---|---|---|---|---|
| Pollock | BS | 7,400 | 2,800 | 0 | 10,200 |
| | AI | 288 | 336 | 0 | 624 |
| A. mackerel | | 0 | 0 | 0 | 0 |
| TOTAL | | 7,688 | 3,136 | 0 | 10,824 |

| GRAND TOTAL | 809,253 | 1,157,635 | 0 | 1,966,888 |
|---|---|---|---|---|

Table 2.14. (cont.) Predicted bycatch for 1989 under Alternative 3.

RED KING CRAB

| Species | Bycatch Rate (#/mt-target) B. trawl | M. trawl | Longline |
|---|---|---|---|
| Pollock | 0.27 | 0.00 | - |
| | 0.27 | 0.00 | - |
| Pacific cod | 0.00 | - | 0.00 |
| Yellowfin sole | 0.32 | - | - |
| Greenland turbot | 0.12 | - | - |
| Arrowtooth flounder | 0.12 | - | - |
| Other flatfish | 0.12 | - | - |
| Sablefish | - | | 0.00 |
| | - | | 0.00 |
| Pacific ocean perch | - | | 0.00 |
| | - | | 0.00 |
| Other rockfish | - | | 0.00 |
| | - | | 0.00 |
| Atka mackerel | - | 0.00 | - |

Bycatch Amount (animals)

Bottom Trawl

| Fishery | Area | DAP | JVP | TALFF | Total |
|---|---|---|---|---|---|
| Pollock | BS | 43,155 | 5,927 | 0 | 49,082 |
| | AI | 1,680 | 711 | 0 | 2,391 |
| Cod | | 0 | 0 | 0 | 0 |
| Y. sole | | 10,287 | 51,177 | 0 | 61,463 |
| O. flatfish | | 5,710 | 7,082 | 0 | 12,792 |
| TOTAL | | 60,831 | 64,897 | 0 | 125,728 |

Longline

| Fishery | Area | DAP | JVP | TALFF | Total |
|---|---|---|---|---|---|
| P. cod | | 0 | 0 | 0 | 0 |
| Sablefish | BS | 0 | 0 | 0 | 0 |
| | AI | 0 | 0 | 0 | 0 |
| Rockfish | BS | 0 | 0 | 0 | 0 |
| | AI | 0 | 0 | 0 | 0 |
| TOTAL | | 0 | 0 | 0 | 0 |

Midwater Trawl

| Fishery | Area | DAP | JVP | TALFF | Total |
|---|---|---|---|---|---|
| Pollock | BS | 0 | 0 | 0 | 0 |
| | AI | 0 | 0 | 0 | 0 |
| A. mackerel | | 0 | 0 | 0 | 0 |
| TOTAL | | 0 | 0 | 0 | 0 |

| GRAND TOTAL | | 60,831 | 64,897 | 0 | 125,728 |
|---|---|---|---|---|---|

Table 2.14. (cont.) Predicted bycatch for 1989 under Alternative 3.

| Species | Bycatch Rate (#/mt-target) B. trawl | M. trawl | Longline |
|---|---|---|---|
| Pollock | 4.20 | 0.02 | - |
| | 4.20 | 0.02 | - |
| Pacific cod | 12.61 | - | 4.96 |
| Yellowfin sole | 0.57 | - | - |
| Greenland turbot | 6.30 | - | - |
| Arrowtooth flounder | 6.30 | - | - |
| Other flatfish | 6.30 | - | - |
| Sablefish | - | | 0.00 |
| | - | | 0.00 |
| Pacific ocean perch | - | | 0.00 |
| | - | | 0.00 |
| Other rockfish | - | | 0.00 |
| | - | | 0.00 |
| Atka mackerel | - | 0.27 | - |

HALIBUT
Bycatch Amount (animals)

Bottom Trawl

| Fishery | Area | DAP | JVP | TALFF | Total |
|---|---|---|---|---|---|
| Pollock | BS | 671,300 | 92,195 | 0 | 763,495 |
| | AI | 26,126 | 11,063 | 0 | 37,190 |
| Cod | | 623,534 | 892,520 | 0 | 1,516,055 |
| Yellowfin sole | | 18,323 | 91,158 | 0 | 109,482 |
| Other flatfish | | 299,763 | 371,809 | 0 | 671,572 |
| TOTAL | | 1,639,047 | 1,458,746 | 0 | 3,097,793 |

Longline

| Fishery | Area | DAP | JVP | TALFF | Total |
|---|---|---|---|---|---|
| P. cod | | 19,200 | 16 | 0 | 19,216 |
| Sablefish | BS | 0 | 0 | 0 | 0 |
| | AI | 0 | 0 | 0 | 0 |
| Rockfish | BS | 0 | 0 | 0 | 0 |
| | AI | 0 | 0 | 0 | 0 |
| TOTAL | | 19,200 | 16 | 0 | 19,216 |

Midwater Trawl

| Fishery | Area | DAP | JVP | TALFF | Total |
|---|---|---|---|---|---|
| Pollock | BS | 14,800 | 5,600 | 0 | 20,400 |
| | AI | 576 | 672 | 0 | 1,248 |
| A. mackerel | | 27 | 5,643 | 0 | 5,670 |
| TOTAL | | 15,403 | 11,915 | 0 | 27,318 |

| GRAND TOTAL | 1,673,651 | 1,470,677 | 0 | 3,144,327 |
|---|---|---|---|---|

Table 2.15 A Comparison of 1987 actual prohibited species bycatch with bycatch expected to occur under Alternative 4 regulations.

| | C. bairdi (1,000's) | C. opilio (1,000's) | King Crab (1,000's) | Halibut (mt. tons) |
|---|---|---|---|---|
| Zone 1 | | | | |
| 1987 JVP | 116.0 | 45.1 | 105.1 | 288.8 |
| Sim JVP | 104.6 | 27.5 | 86.7 | 256.2 |
| Sim DAH | 113.9 | 30.7 | 90.5 | 272.5 |
| Zone 2 | | | | |
| 1987 JVP | 221.7 | 2978.5 | 10.1 | 593.6 |
| Sim JVP | 109.9 | 742.9 | 0.5 | 251.7 |
| Sim DAH | 122.2 | 797.1 | 0.6 | 276.5 |
| Zone 3 | | | | |
| 1987 JVP | 38.7 | 3462.7 | 15.9 | 589.5 |
| Sim JVP | 12.2 | 1041.8 | 0.1 | 4.6 |
| Sim DAH | 13.0 | 1108.9 | 0.1 | 33.3 |
| Bering Sea | | | | |
| 1987 JVP | 376.3 | 6486.3 | 131.1 | 1471.9 |
| Sim JVP | 226.6 | 1812.2 | 87.4 | 512.5 |
| Sim DAH | 249.1 | 1936.8 | 91.2 | 582.3 |

Table 2.16 A comparison of 1987 groundfish harvest with simulated harvest under Alternative 4 regulations (catch in thousands of metric tons).

| | JV Groundfish | DAP Groundfish | JV Y/F Complex | JV P. Cod | JV Pollock |
|---|---|---|---|---|---|
| Zone 1 | | | | | |
| 1987 Actual | 199.0 | -- | 59.7 | 6.6 | 131.6 |
| Simulation | 188.9 | 18.2 | 59.0 | 5.7 | 123.4 |
| Zone 2 | | | | | |
| 1987 Actual | 588.9 | -- | 17.0 | 33.0 | 535.4 |
| Simulation | 297.9 | 26.6 | 10.4 | 24.7 | 261.8 |
| Zone 3 | | | | | |
| 1987 Actual | 554.2 | -- | 136.4 | 17.8 | 365.4 |
| Simulation | 336.9 | 27.1 | 2.8 | 0.2 | 333.9 |
| Bering Sea | | | | | |
| 1987 Actual | 1342.2 | 298.6 | 213.0 | 57.5 | 1032.4 |
| Simulation | 823.7 | 71.9 | 72.2 | 30.5 | 719.0 |

Note: DAP harvests not recorded by zone.

Table 2.17. Annual groundfish apportionments for the Bering Sea/Aleutian Islands for 1989; Assumptions on species catch and gear share, by quarter.



ANTICIPATED ANNUAL GROUNDFISH APPORTIONMENTS

| Species | Area | ABC | TAC | DAP | JVP |
|---|---|---|---|---|---|
| Pollock | BS | 1,340,000 | 1,340,000 | 1,045,585 | 294,415 |
| | AI | 117,900 | 13,450 | 13,450 | 0 |
| Pacific cod | | 370,600 | 230,681 | 158,613 | 72,068 |
| Yellowfin sole | | 241,000 | 182,675 | 72,675 | 110,000 |
| Greenland turbot | | 20,300 | 8,000 | 7,974 | 26 |
| Arrowtooth flounder | | 163,700 | 6,000 | 6,000 | 0 |
| Rock sole | | 171,000 | 90,762 | 81,157 | 9,605 |
| Other flatfish | | 155,900 | 75,183 | 35,183 | 40,000 |
| Sablefish | BS | 2,800 | 2,800 | 2,800 | 0 |
| | AI | 3,400 | 3,400 | 3,400 | 0 |
| Pacific ocean perch | BS | 6,000 | 5,000 | 5,000 | 0 |
| | AI | 16,600 | 6,000 | 6,000 | 0 |
| Other rockfish | BS | 400 | 400 | 400 | 0 |
| | AI | 1,100 | 1,100 | 1,100 | 0 |
| Atka mackerel | | 21,000 | 20,285 | 20,285 | 0 |
| Squid | | 10,000 | 1,000 | 1,000 | 0 |
| Other species | | 59,000 | 13,264 | 13,264 | 0 |
| BS/AI TOTAL | | 2,700,700 | 2,000,000 | 1,473,886 | 526,114 |

ASSUMPTIONS CONCERNING SPECIES CATCH, BY QUARTER 1/

| | | DAP | | | | JVP | | | |
|---|---|---|---|---|---|---|---|---|---|
| Species | Area | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
| Pollock | BS | 26% | 21% | 23% | 30% | 50% | 4% | 46% | 0% |
| | AI | 0% | 40% | 40% | 20% | 83% | 4% | 13% | 0% |
| Pacific cod | | 12% | 22% | 28% | 38% | 50% | 20% | 30% | 0% |
| Yellowfin sole | | 0% | 35% | 35% | 30% | 50% | 25% | 25% | 0% |
| Greenland turbot | | 0% | 43% | 43% | 14% | 33% | 33% | 33% | 0% |
| Arrowtooth flounder | | 25% | 25% | 25% | 25% | 33% | 33% | 33% | 0% |
| Rock sole | | 80% | 5% | 5% | 10% | 50% | 25% | 25% | 0% |
| Other flatfish | | 0% | 33% | 33% | 33% | 50% | 25% | 25% | 0% |
| Sablefish | BS | 25% | 25% | 25% | 25% | 33% | 33% | 33% | 0% |
| | AI | 0% | 42% | 42% | 16% | 33% | 33% | 33% | 0% |
| Pacific ocean perch | BS | 0% | 40% | 40% | 20% | 33% | 33% | 33% | 0% |
| | AI | 0% | 42% | 42% | 16% | 33% | 33% | 33% | 0% |
| Other rockfish | BS | 0% | 40% | 40% | 20% | 25% | 25% | 25% | 25% |
| | AI | 0% | 42% | 42% | 16% | 25% | 25% | 25% | 25% |
| Atka mackerel | | 0% | 40% | 40% | 20% | 0% | 69% | 31% | 0% |

/ 1 Estimates of catch by quarter and fishery provided by L. Alverson, M. Stevens, and P. Chitwood, Oct. 21, 1988.

ASSUMPTIONS ON FISHING PATTERNS, BY QUARTER
Percentage of catch, by gear



DAP

| Species | Area | Bottom Trawl 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | Midwater Trawl 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | Fixed Gear (Longline and pot) 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollock | BS | 33% | 70% | 90% | 90% | 67% | 30% | 10% | 10% | 0% | 0% | 0% | 0% |
| | AI | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Pacific cod | | 97% | 97% | 97% | 97% | 0% | 0% | 0% | 0% | 3% | 3% | 3% | 3% |
| Yellowfin sole | | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Greenland turbot | | 74% | 74% | 74% | 74% | 0% | 0% | 0% | 0% | 26% | 26% | 26% | 26% |
| Arrowtooth flounder | | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Rock sole | | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Other flatfish | | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Sablefish | BS | 50% | 50% | 50% | 50% | 0% | 0% | 0% | 0% | 50% | 50% | 50% | 50% |
| | AI | 30% | 30% | 30% | 30% | 0% | 0% | 0% | 0% | 70% | 70% | 70% | 70% |
| Pacific ocean perch | BS | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| | AI | 97% | 97% | 97% | 97% | 0% | 0% | 0% | 0% | 3% | 3% | 3% | 3% |
| Other rockfish | BS | 95% | 95% | 95% | 95% | 0% | 0% | 0% | 0% | 5% | 5% | 5% | 5% |
| | AI | 85% | 85% | 85% | 85% | 0% | 0% | 0% | 0% | 15% | 15% | 15% | 15% |
| Atka mackerel | | 0% | 0% | 0% | 0% | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% |

JVP

| Species | Area | Bottom Trawl 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | Midwater Trawl 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | Fixed Gear (Longline and pot) 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollock | BS | 40% | 100% | 100% | 100% | 60% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| | AI | 0% | 100% | 25% | 100% | 100% | 0% | 75% | 0% | 0% | 0% | 0% | 0% |
| Pacific cod | | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Yellowfin sole | | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Greenland turbot | | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Arrowtooth flounder | | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Rock sole | | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Other flatfish | | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Sablefish | BS | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| | AI | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Pacific ocean perch | BS | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| | AI | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Other rockfish | BS | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| | AI | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| Atka mackerel | | 0% | 0% | 0% | 0% | 100% | 100% | 100% | 100% | 0% | 0% | 0% | 0% |

/ 1 Estimates of catch by quarter and fishery provided by L. Alverson, M. Stevens, and P. Chitwood, Oct. 21, 1988.

Table 2.17 (continued)

UNCONSTRAINED CATCH, BY QUARTER AND GEAR, MT

DAP

| Species | Bottom Trawl 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | Midwater Trawl 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | Fixed Gear (Longline and pot) 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollock | 89,711 | 153,701 | 216,436 | 282,308 | 182,141 | 65,872 | 24,048 | 31,368 | 0 | 0 | 0 | 0 |
| | 0 | 5,380 | 5,380 | 2,690 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pacific cod | 18,463 | 33,848 | 43,079 | 58,465 | 0 | 0 | 0 | 0 | 571 | 1,047 | 1,332 | 1,808 |
| Yellowfin sole | 0 | 25,436 | 25,436 | 21,803 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Greenland turbot | 0 | 2,537 | 2,537 | 826 | 0 | 0 | 0 | 0 | 0 | 891 | 891 | 290 |
| Arrowtooth flounder | 1,500 | 1,500 | 1,500 | 1,500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rock sole | 64,926 | 4,058 | 4,058 | 8,116 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other flatfish | 0 | 11,726 | 11,726 | 11,716 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sablefish | 350 | 350 | 350 | 350 | 0 | 0 | 0 | 0 | 350 | 350 | 350 | 350 |
| | 0 | 428 | 428 | 163 | 0 | 0 | 0 | 0 | 0 | 1,000 | 1,000 | 381 |
| Pacific ocean perch | 0 | 2,000 | 2,000 | 1,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 2,444 | 2,444 | 931 | 0 | 0 | 0 | 0 | 0 | 76 | 76 | 29 |
| Other rockfish | 0 | 152 | 152 | 76 | 0 | 0 | 0 | 0 | 0 | 8 | 8 | 4 |
| | 0 | 393 | 393 | 150 | 0 | 0 | 0 | 0 | 0 | 69 | 69 | 26 |
| Atka mackerel | 0 | 0 | 0 | 0 | 0 | 8,114 | 8,114 | 4,057 | 0 | 0 | 0 | 0 |
| | 174,949 | 243,954 | 315,921 | 390,093 | 182,141 | 73,986 | 32,162 | 35,425 | 921 | 3,441 | 3,726 | 2,888 |

JVP

| Species | Bottom Trawl 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | Midwater Trawl 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter | Fixed Gear (Longline and pot) 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pollock | 58,883 | 11,777 | 135,431 | 0 | 88,325 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pacific cod | 36,034 | 14,414 | 21,620 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Yellowfin sole | 55,000 | 27,500 | 27,500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Greenland turbot | 9 | 9 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Arrowtooth flounder | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rock sole | 4,803 | 2,401 | 2,401 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other flatfish | 20,000 | 10,000 | 10,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sablefish | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pacific ocean perch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other rockfish | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Atka mackerel | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 174,728 | 66,100 | 196,961 | 0 | 88,325 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 2.18. Bycatch rates used for predicting bycatch in the Bering Sea flatfish and other fisheries under Alternative 5.

BYCATCH RATE SUMMARY, ALTERNATIVE 5 BYCATCH PREDICTION MODEL

JANUARY-MARCH, 1989

| | SPECIES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | C. bairdi (animals/mt) | | Other Tanner crab (animals/mt) | | Red King crab (animals/mt) | | Halibut (mt/mt) | |
| FLATFISH | DAP | JVP | DAP | JVP | DAP | JVP | DAP | JVP |
| Zone 1- 511 | 0.91 | 0.91 | 0.15 | 0.15 | 0.506 | 0.506 | 0.0013 | 0.0013 |
| 513A | 2.03 | 2.03 | 6.33 | 6.33 | 0.001 | 0.001 | 0.0025 | 0.0025 |
| 513B | 0.50 | 0.50 | 1.03 | 1.03 | 0.004 | 0.004 | 0.0017 | 0.0017 |
| 515 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0000 | 0.0000 |
| 521 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0000 | 0.0000 |
| All other BS | 0.29 | 0.29 | 0.24 | 0.24 | 0.000 | 0.000 | 0.0027 | 0.0027 |
| AI - 540 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0000 | 0.0000 |
| OTHER | | | | | | | | |
| Zone 1- 511 | 1.06 | 1.09 | 0.26 | 0.28 | 0.4405 | 0.3498 | 0.0061 | 0.0069 |
| 513A | 0.33 | 0.23 | 0.31 | 0.20 | 0.0009 | 0.0006 | 0.0015 | 0.0028 |
| 513B | 1.21 | 1.27 | 0.56 | 0.59 | 0.0010 | 0.0010 | 0.0148 | 0.0125 |
| 515 | 0.42 | 0.42 | 0.03 | 0.03 | 0.0035 | 0.0035 | 0.0106 | 0.0117 |
| 521 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| All other BS | 0.00 | 0.00 | 0.00 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| AI - 540 | 0.00 | 0.00 | 0.00 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

APRIL-JUNE, 1989

| | SPECIES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | C. bairdi (animals/mt) | | Other Tanner crab (animals/mt) | | Red King crab (animals/mt) | | Halibut (mt/mt) | |
| | DAP | JVP | DAP | JVP | DAP | JVP | DAP | JVP |
| | 2.00 | 2.00 | 0.60 | 0.60 | 1.000 | 1.000 | 0.0013 | 0.0013 |
| | 2.37 | 2.37 | 10.33 | 10.33 | 0.034 | 0.034 | 0.0073 | 0.0073 |
| | 0.36 | 0.36 | 0.17 | 0.17 | 0.001 | 0.001 | 0.0023 | 0.0023 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.006 | 0.006 | 0.0002 | 0.0002 |
| | 8.16 | 8.16 | 2.67 | 2.67 | 0.282 | 0.282 | 0.0166 | 0.0166 |
| | 0.08 | 0.08 | 1.49 | 1.49 | 0.121 | 0.121 | 0.0010 | 0.0010 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0000 | 0.0000 |
| | | | | | | | | |
| | 1.72 | 1.72 | 0.31 | 0.31 | 0.030 | 0.030 | 0.0043 | 0.0043 |
| | 4.78 | 3.87 | 13.40 | 8.81 | 0.028 | 0.018 | 0.0163 | 0.0122 |
| | 1.84 | 1.17 | 0.22 | 0.07 | 0.047 | 0.013 | 0.0354 | 0.0182 |
| | 0.14 | 0.14 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0142 | 0.0142 |
| | 7.32 | 4.53 | 0.19 | 0.41 | 0.010 | 0.020 | 0.0026 | 0.0056 |
| | 0.67 | 0.97 | 24.08 | 36.56 | 0.003 | 0.004 | 0.0037 | 0.0066 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0053 | 0.0053 |

JULY-SEPTEMBER, 1989

| | SPECIES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | C. bairdi (animals/mt) | | Other Tanner crab (animals/mt) | | Red King crab (animals/mt) | | Halibut (mt/mt) | |
| FLATFISH | DAP | JVP | DAP | JVP | DAP | JVP | DAP | JVP |
| Zone 1- 511 | 2.00 | 2.00 | 0.60 | 0.60 | 1.000 | 1.000 | 0.0025 | 0.0025 |
| 513A | 1.62 | 1.62 | 2.75 | 2.75 | 0.275 | 0.275 | 0.0032 | 0.0032 |
| 513B | 2.31 | 2.31 | 2.32 | 2.32 | 0.000 | 0.000 | 0.0000 | 0.0000 |
| 515 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0000 | 0.0000 |
| 521 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0000 | 0.0000 |
| All other BS | 1.91 | 1.91 | 109.47 | 109.47 | 0.041 | 0.041 | 0.0031 | 0.0031 |
| AI - 540 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0000 | 0.0000 |
| OTHER | | | | | | | | |
| *Area* | | | | | | | | |
| Zone 1- 511 | 2.34 | 2.34 | 0.10 | 0.10 | 0.020 | 0.020 | 0.0037 | 0.0037 |
| 513A | 1.05 | 2.85 | 98.55 | 16.86 | 0.000 | 0.000 | 0.0003 | 0.0013 |
| 513B | 0.64 | 1.77 | 42.65 | 5.93 | 0.015 | 0.015 | 0.0005 | 0.0028 |
| 515 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0000 | 0.0000 |
| 521 | 1.56 | 1.56 | 0.75 | 0.75 | 0.000 | 0.000 | 0.0028 | 0.0028 |
| All other BS | 0.33 | 0.34 | 9.84 | 7.53 | 0.000 | 0.000 | 0.0014 | 0.0013 |
| AI - 540 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0000 | 0.0053 |

OCTOBER-DECEMBER, 1989

| | SPECIES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | C. bairdi (animals/mt) | | Other Tanner crab (animals/mt) | | Red King crab (animals/mt) | | Halibut (mt/mt) | |
| | DAP | JVP | DAP | JVP | DAP | JVP | DAP | JVP |
| | 2.00 | 2.00 | 0.04 | 0.04 | 1.000 | 1.000 | 0.0025 | 0.0025 |
| | 2.58 | 2.58 | 4.35 | 4.35 | 0.595 | 0.595 | 0.0059 | 0.0059 |
| | 11.99 | 11.99 | 2.51 | 2.51 | 0.000 | 0.000 | 0.0141 | 0.0141 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0000 | 0.0000 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0000 | 0.0000 |
| | 1.84 | 1.84 | 7.05 | 7.05 | 0.077 | 0.077 | 0.0081 | 0.0081 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0000 | 0.0000 |
| | | | | | | | | |
| | 1.18 | 1.18 | 1.20 | 1.20 | 0.339 | 0.339 | 0.0039 | 0.0039 |
| | 2.76 | 3.28 | 57.28 | 57.28 | 0.002 | 0.002 | 0.0037 | 0.0059 |
| | 1.21 | 1.59 | 4.27 | 4.27 | 0.579 | 0.579 | 0.0056 | 0.0110 |
| | 0.15 | 0.15 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0216 | 0.0216 |
| | 2.29 | 2.29 | 2.97 | 2.97 | 0.000 | 0.000 | 0.0073 | 0.0073 |
| | 0.33 | 0.34 | 9.80 | 7.53 | 0.000 | 0.000 | 0.0014 | 0.0013 |
| | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 | 0.000 | 0.0000 | 0.0000 |

Table 2.19 Estimated catch per unit effort by area, fishery, and quarter.

Metric tons per hour, 1987

| Fishery/ Quarter | Areas 511 | 513a | 513b | 514 | 515 | 521 | 522 | 540 |
|---|---|---|---|---|---|---|---|---|
| Flatfish | | | | | | | | |
| 1 | 7.8 | 11.5 | 2.8 | 6.7 | - | - | - | - |
| 2 | 0.1 | 4.0 | - | 7.5 | 8.9 | 2.8 | 2.3 | - |
| 3 | - | 7.5 | - | 7.2 | - | 4.0 | 3.3 | - |
| 4 | - | 7.5 | - | 7.2 | - | - | - | - |
| Pollock-Cod Bottom Trawl | | | | | | | | |
| 1 | 7.6 | 5.5 | 6.3 | 0.0 | 4.5 | 0.0 | 0.0 | 0.0 |
| 2 | 0.4 | 5.0 | 9.4 | 9.1 | 7.8 | 12.4 | 1.0 | 1.2 |
| 3 | 6.3 | 13.8 | 9.0 | 7.5 | 6.7 | 9.5 | 2.9 | 2.3 |
| 4 | 0.0 | 10.7 | 9.7 | 1.1 | 9.5 | 6.8 | 0.0 | 0.0 |

Metric tons per day, 1988

| Fishery/ Quarter | Areas 511 | 513a | 513b | 514 | 515 | 521 | 522 | 540 |
|---|---|---|---|---|---|---|---|---|
| Flatfish | | | | | | | | |
| 1 | 73.6 | 66.4 | 78.0 | 48.0 | - | - | - | - |
| 2 | 55.3 | 50.8 | 87.6 | 52.1 | 64.2 | 39.3 | 44.3 | - |
| 3 | - | 80.8 | - | 55.6 | - | 51.7 | 65.3 | - |
| 4 | 72.5 | 77.8 | 9.8 | 47.2 | - | - | - | - |
| Pollock-Cod Bottom Trawl | | | | | | | | |
| 1 | 52.1 | 94.0 | 47.4 | - | 34.7 | - | - | - |
| 2 | 110.0 | 36.1 | 48.8 | 96.5 | 51.5 | 74.9 | 20.3 | 25.8 |
| 3 | 66.2 | 90.5 | 83.8 | 88.7 | 62.6 | 91.3 | 61.1 | 45.6 |
| 4 | 405.1 | 33.4 | 40.2 | 12.5 | 44.8 | 71.5 | - | - |

**Notes:** Both measures of catch per unit of effort were generated using NMFS Observer Program data for the joint venture fisheries. The catch per hour trawled data are for 1987; however, if no data were available for an area, quarter, and fishery, estimates were made by adjusting 1987 data for other cells using 1988 catch per day on grounds data. The catch per processing vessel day on grounds data are for 1988. A "-" appears in each cell for which no fishing occurred in 1988.

Table 2.20. Predicted groundfish catch and prohibited species catch for 1989 assuming that no PSC limits are in place, by period and fishery.

BYCATCH SUMMARY

JANUARY-MARCH, 1989

| | FISHERY | | | |
|---|---|---|---|---|
| | DAP | | JVP | |
| Cumulative catch | Flatfish | Other | Flatfish | Other |
| Total groundfish, mt | 74,366 | 100,584 | 97,130 | 77,598 |
| "Target" catch, mt | 55,577 | 91,235 | 72,590 | 70,386 |
| Percent of annual catch | 50% | 10% | 52% | 31% |
| C. bairdi bycatch, Zone 1 | 34,385 | 0 | 89,821 | 25,025 |
| C. bairdi bycatch, Zone 2 | 36,713 | 139,260 | 0 | 57,616 |
| C. bairdi bycatch, all areas | 71,097 | 140,514 | 89,821 | 82,642 |
| Red king crab bycatch, Zone 1 | 19,102 | 0 | 49,900 | 4,268 |
| Red king crab bycatch, all areas | 19,221 | 72 | 49,900 | 4,320 |
| Halibut bycatch, mt, BSAI | 122 | 806 | 126 | 780 |

APRIL-JUNE, 1989

| | FISHERY | | | |
|---|---|---|---|---|
| | DAP | | JVP | |
| Cumulative catch | Flatfish | Other | Flatfish | Other |
| Total groundfish, mt | 75,492 | 342,198 | 141,726 | 99,102 |
| "Target" catch, mt | 56,497 | 293,763 | 109,013 | 88,411 |
| Percent of annual catch | 50% | 35% | 76% | 39% |
| C. bairdi bycatch, Zone 1 | 36,411 | 27,612 | 89,821 | 44,200 |
| C. bairdi bycatch, Zone 2 | 36,713 | 718,127 | 0 | 73,243 |
| C. bairdi bycatch, all areas | 73,136 | 747,359 | 94,549 | 117,945 |
| Red king crab bycatch, Zone 1 | 20,116 | 1,330 | 49,900 | 5,702 |
| Red king crab bycatch, all areas | 20,248 | 4,442 | 55,229 | 5,814 |
| Halibut bycatch, mt, BSAI | 123 | 4,863 | 174 | 1,089 |

JULY-SEPTEMBER, 1989

| | FISHERY | | | |
|---|---|---|---|---|
| | DAP | | JVP | |
| Cumulative catch | Flatfish | Other | Flatfish | Other |
| Total groundfish, mt | 108,952 | 623,445 | 186,323 | 251,466 |
| "Target" catch, mt | 79,538 | 558,044 | 139,723 | 231,584 |
| Percent of annual catch | 73% | 64% | 100% | 100% |
| C. bairdi bycatch, Zone 1 | 36,411 | 27,612 | 89,821 | 116,116 |
| C. bairdi bycatch, Zone 2 | 64,089 | 906,184 | 0 | 207,323 |
| C. bairdi bycatch, all areas | 134,213 | 936,054 | 184,383 | 323,941 |
| Red king crab bycatch, Zone 1 | 20,116 | 1,330 | 49,900 | 6,311 |
| Red king crab bycatch, all areas | 25,235 | 6,719 | 57,219 | 7,033 |
| Halibut bycatch, mt, BSAI | 228 | 8,364 | 313 | 1,452 |

OCTOBER-DECEMBER, 1989

| | FISHERY | | | |
|---|---|---|---|---|
| | DAP | | JVP | |
| Cumulative catch | Flatfish | Other | Flatfish | Other |
| Total groundfish, mt | 149,635 | 975,275 | 186,323 | 251,466 |
| "Target" catch, mt | 108,759 | 895,040 | 139,723 | 231,584 |
| Percent of annual catch | 100% | 100% | 100% | 100% |
| C. bairdi bycatch, Zone 1 | 36,411 | 27,612 | 89,821 | 116,116 |
| C. bairdi bycatch, Zone 2 | 64,089 | 906,184 | 0 | 207,323 |
| C. bairdi bycatch, all areas | 228,569 | 1,060,884 | 184,383 | 323,941 |
| Red king crab bycatch, Zone 1 | 20,116 | 1,330 | 49,900 | 6,311 |
| Red king crab bycatch, all areas | 28,056 | 6,719 | 57,219 | 7,033 |
| Halibut bycatch, mt, BSAI | 444 | 8,889 | 313 | 1,452 |

Table 2.21 PSC limits (caps) as suggested by the Council and apportionment of those caps to the four fisheries in proportion to predicted annual bycatch.

**Caps and Allocation of Caps**

Overall PSC Limits

| Species | Zone 1 | Zone 2 or 1 & 2H | BSAI-wide |
|---|---|---|---|
| C. bairdi, # | 1,000,000 | 3,000,000 | - |
| Red king crab, # | 200,000 | - | - |
| Halibut, mt | - | 4,400 | 5,333 |

Fishery PSC Limits

| Species | | Zone 1 | Zone 2 | BSAI-wide |
|---|---|---|---|---|
| C. bairdi (animals) | DAP-flatfish | 87,104 | 261,312 | - |
| | DAP-other | 609,226 | 1,827,679 | - |
| | JVP-flatfish | 93,408 | 280,223 | - |
| | JVP-other | 210,262 | 630,786 | - |
| | | 1,000,000 | 3,000,000 | |
| Red king crab (animals) | DAP-flatfish | 52,685 | - | - |
| | DAP-other | 20,557 | - | - |
| | JVP-flatfish | 110,305 | - | - |
| | JVP-other | 16,453 | - | - |
| | | 200,000 | | |

| Halibut (metric tons) | | 1 & 2H | BSAI-wide |
|---|---|---|---|
| | DAP-flatfish | - | 173 | 210 |
| | DAP-other | - | 3,414 | 4,138 |
| | JVP-flatfish | - | 146 | 177 |
| | JVP-other | - | 666 | 808 |
| | | | 4,400 | 5,333 |

PSC Limit Share, by Fishery

| | C. bairdi | Red king crab | Halibut |
|---|---|---|---|
| DAP flatfish | 8.71% | 26.34% | 3.94% |
| DAP other | 60.92% | 10.28% | 77.60% |
| JVP flatfish | 9.34% | 55.15% | 3.32% |
| JVP other | 21.03% | 8.23% | 15.14% |
| | 100.00% | 100.00% | 100.00% |

Table 2.22. Predicted groundfish catch and prohibited species catch for 1989 assuming that the Council approved PSC limits are in place, by period and fishery.

JANUARY-MARCH, 1989

| Cumulative catch | FISHERY: DAP Flatfish | DAP Other | JVP Flatfish | JVP Other |
|---|---|---|---|---|
| Total groundfish, mt | 74,830 | 100,120 | 97,326 | 77,403 |
| "Target" catch, mt | 56,127 | 91,321 | 73,000 | 70,600 |
| Percent of annual catch | 58% | 10% | 52% | 31% |
| C. bairdi cap, Zone 1 | 87,104 | 609,226 | 93,408 | 210,262 |
| C. bairdi bycatch, Zone 1 | 34,035 | 0 | 88,534 | 21,155 |
| Cap attained? | No | No | Qtr end | No |
| C. bairdi cap, Zone 2 | 261,312 | 1,827,679 | 280,223 | 630,786 |
| C. bairdi bycatch, Zone 2 | 38,260 | 92,964 | 0 | 61,424 |
| Cap attained? | No | No | No | No |
| C. bairdi bycatch, all areas | 72,295 | 97,184 | 88,534 | 82,579 |
| Red king crab cap, Zone 1 | 52,685 | 20,557 | 110,305 | 16,453 |
| Red king crab bycatch, Zone 1 | 18,925 | 0 | 49,227 | 6,769 |
| Cap attained? | No | No | No | No |
| Red king crab bycatch, all areas | 19,043 | 119 | 49,227 | 6,822 |
| Halibut Zone 1 & 2H cap, mt | 173 | 3,414 | 146 | 666 |
| Halibut BSAI-wide cap, mt | 210 | 4,138 | 177 | 808 |
| Halibut bycatch, mt, BSAI | 122 | 1,195 | 123 | 747 |
| Zone 1 & 2H cap attained? | No | No | No | Yes |
| BSAI-wide cap attained? | No | No | No | Qtr end |

APRIL-JUNE, 1989

| Cumulative catch | FISHERY: DAP Flatfish | DAP Other | JVP Flatfish | JVP Other |
|---|---|---|---|---|
| Total groundfish, mt | 75,747 | 343,157 | 140,759 | 77,403 |
| "Target" catch, mt | 56,890 | 293,901 | 109,128 | 70,600 |
| Percent of annual catch | 59% | 34% | 75% | 31% |
| C. bairdi cap, Zone 1 | 87,104 | 609,226 | 93,408 | 93,408 |
| C. bairdi bycatch, Zone 1 | 35,685 | 12,562 | 88,534 | 21,155 |
| Cap attained? | No | No | Qtr end | No |
| C. bairdi cap, Zone 2 | 261,312 | 1,827,679 | 280,223 | 630,786 |
| C. bairdi bycatch, Zone 2 | 38,260 | 832,912 | 0 | 61,424 |
| Cap attained? | No | No | No | No |
| C. bairdi bycatch, all areas | 73,952 | 853,646 | 91,947 | 82,579 |
| Red king crab cap, Zone 1 | 52,685 | 20,557 | 110,305 | 16,453 |
| Red king crab bycatch, Zone 1 | 19,750 | 217 | 49,227 | 6,769 |
| Cap attained? | No | No | No | No |
| Red king crab bycatch, all areas | 19,880 | 7,766 | 54,474 | 6,822 |
| Halibut Zone 1 & 2H cap, mt | 173 | 3,414 | 146 | 666 |
| Halibut BSAI-wide cap, mt | 210 | 4,138 | 177 | 808 |
| Halibut bycatch, mt, BSAI | 123 | 6,614 | 168 | 747 |
| Zone 1 & 2H cap attained? | No | Yes | Yes | Yes |
| BSAI-wide cap attained? | No | Yes | Qtr end | Qtr end |

JULY-SEPTEMBER, 1989

| Cumulative catch | FISHERY: DAP Flatfish | DAP Other | JVP Flatfish | JVP Other |
|---|---|---|---|---|
| Total groundfish, mt | 112,428 | 343,157 | 140,759 | 77,403 |
| "Target" catch, mt | 81,140 | 293,901 | 109,128 | 70,600 |
| Percent of annual catch | 87% | 34% | 75% | 31% |
| C. bairdi cap, Zone 1 | 87,104 | 609,226 | 93,408 | 210,262 |
| C. bairdi bycatch, Zone 1 | 35,685 | 12,562 | 88,534 | 21,155 |
| Cap attained? | No | No | Qtr end | No |
| C. bairdi cap, Zone 2 | 261,312 | 1,827,679 | 280,223 | 630,786 |
| C. bairdi bycatch, Zone 2 | 67,943 | 832,912 | 0 | 61,424 |
| Cap attained? | No | No | No | No |
| C. bairdi bycatch, all areas | 138,729 | 853,646 | 91,947 | 82,579 |
| Red king crab cap, Zone 1 | 52,685 | 20,557 | 110,305 | 16,453 |
| Red king crab bycatch, Zone 1 | 19,750 | 217 | 49,227 | 6,769 |
| Cap attained? | No | No | No | No |
| Red king crab bycatch, all areas | 25,672 | 7,766 | 54,474 | 6,822 |
| Halibut Zone 1 & 2H cap, mt | 173 | 3,414 | 146 | 666 |
| Halibut BSAI-wide cap, mt | 210 | 4,138 | 177 | 808 |
| Halibut bycatch, mt, BSAI | 238 | 6,614 | 168 | 747 |
| Zone 1 & 2H cap attained? | Yes | Yes | Yes | Yes |
| BSAI-wide cap attained? | Yes | Yes | Qtr end | Qtr end |

OCTOBER-DECEMBER, 1989

| Cumulative catch | FISHERY: DAP Flatfish | DAP Other | JVP Flatfish | JVP Other |
|---|---|---|---|---|
| Total groundfish, mt | 112,428 | 343,157 | 140,759 | 77,403 |
| "Target" catch, mt | 81,140 | 293,901 | 109,128 | 70,600 |
| Percent of annual catch | 87% | 34% | 75% | 31% |
| C. bairdi cap, Zone 1 | 87,104 | 609,226 | 93,408 | 210,262 |
| C. bairdi bycatch, Zone 1 | 35,685 | 12,562 | 88,534 | 21,155 |
| Cap attained? | No | No | Qtr end | No |
| C. bairdi cap, Zone 2 | 261,312 | 1,827,679 | 280,223 | 630,786 |
| C. bairdi bycatch, Zone 2 | 67,943 | 832,912 | 0 | 61,424 |
| Cap attained? | No | No | No | No |
| C. bairdi bycatch, all areas | 138,729 | 853,646 | 91,947 | 82,579 |
| Red king crab cap, Zone 1 | 52,685 | 20,557 | 110,305 | 16,453 |
| Red king crab bycatch, Zone 1 | 19,750 | 217 | 49,227 | 6,769 |
| Cap attained? | No | No | No | No |
| Red king crab bycatch, all areas | 25,672 | 7,766 | 54,474 | 6,822 |
| Halibut Zone 1 & 2H cap, mt | 173 | 3,414 | 146 | 666 |
| Halibut BSAI-wide cap, mt | 210 | 4,138 | 177 | 808 |
| Halibut bycatch, mt, BSAI | 238 | 6,614 | 168 | 747 |
| Zone 1 & 2H cap attained? | Yes | Yes | Yes | Yes |
| BSAI-wide cap attained? | Yes | Yes | Qtr end | Qtr end |

Table 2.23 Estimated effects on effort and harvesting cost by fishery, measure of effort, and harvest cost, for Scenario 1.

Estimated effects based on catch per hour data

| | Percentage Change | | | Change in Total Cost ($ million) | |
|---|---|---|---|---|---|
| Fishery | Effort | TC A | TC B | A | B |
| Joint Venture Flatfish | -26.1 | -9.3 | -9.9 | -2.6 | -2.7 |
| Joint Venture Other BT | -75.7 | -26.8 | -28.5 | -9.9 | -10.5 |
| Domestic Flatfish | -8.7 | -3.9 | -3.5 | -2.9 | -2.6 |
| Domestic Other BT | -83.6 | -26.4 | -26.4 | -154.4 | -151.8 |
| Total | | | | -169.7 | -167.6 |

Estimated effects based on catch per day data

| | Percentage Change | | | Change in Total Cost ($ million) | |
|---|---|---|---|---|---|
| Fishery | Effort | TC A | TC B | A | B |
| Joint Venture Flatfish | -28.1 | -9.9 | -10.5 | -2.7 | -2.9 |
| Joint Venture Other BT | -60.1 | -22.1 | -23.9 | -8.1 | -8.8 |
| Domestic Flatfish | -20.0 | -6.1 | -6.2 | -4.6 | -4.5 |
| Domestic Other BT | -49.0 | -19.7 | -18.1 | -115.0 | -104.4 |
| Total | | | | -130.4 | -120.7 |

**Notes:** TC denotes total harvesting and processing costs. The two base case cost scenarios are A and B. With case A for domestic fisheries, catch, the portion of variable cost assumed to depend on CPUE, and total cost per vessel year are 12,300 mt, $1.41 million, and $7.22 million, respectively. The corresponding values for case B in domestic fisheries are 7,400 mt, $1.02 million, and $4.27 million. For joint ventures, case A catch, portion of variable cost dependent upon CPUE, and total cost per vessel year are 11,100 mt, $0.5 million, and $1.63 million, respectively. Joint venture case B values are 7,600 mt, $0.33 million, and $1.12 million. Specific effects on percentage change in effort and total cost and absolute change in total cost for Scenarios 2-4 are summarized in Table 2.25.

Table 2.24a Exvessel and wholesale prices, converted to round weight, used to value crab and halibut bycatch.

| | Conversion Factor[1/] | Present Price[2/] | Discounted price/lb |
|---|---|---|---|
| Bairdi Tanner Crab | | | (4 years) |
| Exvessel | 1.00 | $2.11 | $1.74 |
| Wholesale | 0.47 | 2.92 | 2.40 |
| Other Tanner Crab (opilio) | | | (4 years) |
| Exvessel | 1.00 | $0.78 | $0.64 |
| Wholesale | 0.47 | 1.60 | 1.32 |
| Red King Crab | | | (2 years) |
| Exvessel | 1.00 | $4.00 | $3.63 |
| Wholesale | 0.57 | 5.75 | 5.22 |
| Halibut | | | (1 year) |
| Exvessel | 0.75 | $1.25 | $1.19 |
| Wholesale | 0.75 | 1.67 | 1.57 |

1/ Conversion factors are percentage conversions from round to processed weight. Thomas, B.G., 1979. Conversion factors for fishery products. NMFS memorandum, Washington, D.C.

2/ Fishery Market News, NMFS, February 1988 and previous issues.

Table 2.24b Estimated exvessel and wholesale prices used for bycatch valuation.

| | | |
|---|---|---|
| Bairdi Tanner Crab | | |
| Exvessel | $1,416/1,000 crab | $1.42/crab |
| Wholesale | 1,954/1,000 crab | 1.95/crab |
| Other Tanner Crab (opilio) | | |
| Exvessel | $284/1,000 crab | $0.28/crab |
| Wholesale | 586/1,000 crab | 0.59/crab |
| Red King Crab | | |
| Exvessel | $10,316/1,000 crab | $10.32/crab |
| Wholesale | 14,835/1,000 crab | 14.84/crab |
| Halibut | | |
| Exvessel | $4,145/mt | $1.88/lb |
| Wholesale | 5,469/mt | 2.48/lb |

Table 2.25. Summary of simulation results: predicted total groundfish catch and predicted total prohibited species catch; predicted change in total groundfish catch and prohibited species catch, relative to unconstrained simulation; and, predicted change in total groundfish gross revenue and profit and prohibited species catch wholesale value, relative to unconstrained simulation.

| | *Total groundfish* | | *Total bycatch* | | |
|---|---|---|---|---|---|
| | *catch 1/* (mt) | *gross revenue 2/* ($millions) | C. bairdi (animals) | Red king crab (animals) | Halibut (mt) |
| Unconstrained | 1,562,700 | 741 | 1,937,000 | 102,300 | 9,400 |
| Constrained by Council PSC limits | 673,700 | 307 | 1,167,000 | 94,700 | 5,300 |
| Unconstrained, halibut bycatch rates halved | 1,562,700 | 741 | 1,937,000 | 102,300 | 5,000 |
| Constrained, halibut bycatch rates halved, PSC limits | 1,562,700 | 741 | 1,982,000 | 99,500 | 5,000 |
| Unconstrained, DAP pollock bottom trawl share at 30% | 1,142,400 | 490 | 1,520,000 | 120,600 | 6,500 |
| Constrained, DAP pollock bottom trawl share at 30% | 858,000 | 321 | 1,327,000 | 118,100 | 5,300 |
| Unconstrained, DAP pollock bottom trawl share at 30%, halibut rates halved | 1,142,000 | 490 | 1,520,000 | 120,600 | 3,400 |
| Constrained, DAP pollock bottom trawl share at 30%, halibut rates halved | 1,142,400 | 490 | 1,520,000 | 120,600 | 3,400 |

1 / Excludes mid-water pollock, Atka mackerel, and groundfish taken with fixed gear.
2 / DAP groundfish valued at $1.00/lb, wholesale, processed weight, using an overall conversion factor of 27% (Wiese and Burden, 1988).
JVP groundfish valued at $162/mt, ex-vessel, round weight (Wiese and Burden, 1988).

**Catch - Change Relative to the Unconstrained Simulation**

| | Groundfish catch (mt) | Bycatch saved C. bairdi (animals) | Red king crab (animals) | Halibut (mt) |
|---|---|---|---|---|
| Council PSC limits | (889,000) | 770,000 | 7,600 | 4,100 |
| Halibut bycatch rates halved | - | (45,000) | 2,800 | 0 |
| DAP pollock bottom trawl share at 30% | (284,400) | 193,000 | 2,500 | 1,200 |
| DAP pollock bottom trawl share at 30%, halibut rates halved | - | 0 | 0 | 0 |

**Value - Change Relative to the Unconstrained Simulation**

| | *Groundfish value lost, millions of dollars* | | | | *Bycatch value saved, thousands of dollars* | | |
|---|---|---|---|---|---|---|---|
| | DAP | | JVP | | | | |
| | Gross revenue | Profits or Cost | Gross revenue | Profits or Cost | C. bairdi | Red king crab | Halibut |
| Council PSC limits | $398 | $241-$289 | $36 | $23-$25 | $1,502 | $113 | $22,423 |
| Halibut bycatch rates halved | $0 | NS | $0 | NS | ($88) | $42 | $0 |
| DAP pollock bottom trawl share at 30% | $169 | $94-$120 | $0 | NS | $376 | $37 | $6,563 |
| DAP pollock bottom trawl share at 30%, halibut rates halved | $0 | NS | $0 | NS | $0 | $0 | $0 |

Notes: NS means estimate is not significantly different from zero.
Change in profits is relevant when groundfish catch is foregone. It it computed as revenue minus change in cost.
Change in cost is relevant when no groundfish catch is foregone. It is defined as the change in variable costs associated with the displacement of fishing operations.
Values for halibut and crab are wholesale present values; unit values are from Table 2.24b.

Table 2.26 Summary of the 1989 DAH bycatch implications of each suggested management alternative.

| | Anticipated bycatch (and bycatch limits) for total BSAI area | | | | | Effects on groundfish fishery |
|---|---|---|---|---|---|---|
| | | | | Halibut | | |
| | C. bairdi (1000s) | Other Tanner crab (1000s) | Red king crab (1000s) | Bycatch (mt) | Mortality (mt) | |
| Alternative 1: Status quo | - | 1,739 1/ | 1,612 | 1,024 | - | Least restrictive: no constraints on full harvest of groundfish TACs. No limit on potential bycatch. |
| Alternative 2: Continue Amendment 10 | 793 (406) | - | 100 (135) | 2,506 (1,225)4/ | - | Moderately restrictive, all restrictions placed upon DAH yellowfin sole/other flatfish fishery: increased operational costs but no likely constraint to full harvest of TACs. No limit on potential bycatch in other groundfish fisheries. |
| Alternative 3: Bycatch framework | 1,325 (5,387) | 1,967 - | 126 (757) | 4,654 - | 4,647 (3,900) | Most responsive to individual target fisheries: increased operational, administrative, and enforcement costs; possible constraints on full harvest of flatfish and Pacific cod TACs. Restrictions on bycatch in all groundfish fisheries. |
| Alternative 4: Numerical limits | 249 (380) | 1,937 (1,000)2/ | 91 (80)3/ | 582 - | 582 (2,000) | Most restrictive: increased operational, administrative, and enforcement costs; constraints on full harvest of TACs (45% of all groundfish cannot be harvested). |
| Alternative 5: Time/area controls | 1,167 (3,000) | - | 95 (200) | 5,300 (4,400; 5,333) | 5,300 | Maybe costly to the groundfish fishery if fleet cannot reduce halibut bycatch rates, triggering a BS/AI wide closure; large savings in predicted bycatch relative to unconstrained operation; increased operational, administrative, and enforcement costs. |

1/ Includes all Tanner crab. May be underestimated because 1985 fishing patterns are assumed to occur in 1989.
2/ C. opilio in Zone 2 and Zone 3.
3/ Zone 1 only.
4/ Assumes 1.48 kg/animal for 828,000 animals.

## 3.0 EFFECTS ON ENDANGERED SPECIES AND THE ALASKA COASTAL ZONE

None of the alternatives would constitute actions that "may affect" endangered species or their habitat within the meaning of the regulations implementing Section 7 of the Endangered Species Act of 1973. Thus, consultation procedures under Section 7 on the final actions and their alternatives will not be necessary.

Also each of the alternatives would be conducted in a manner consistent, to the maximum extent practicable, with the Alaska Coastal Management Program within the meaning of Section 307(c)(1) of the Coastal Zone Management Act of 1972 and its implementing regulations.

## 4.0 OTHER EXECUTIVE ORDER 12291 REQUIREMENTS

Executive Order 12291 requires that the following three issues be considered:

(a) Will the amendment have an annual effect on the economy of $100 million or more?

(b) Will the amendment lead to an increase in the costs or prices for consumers, individual industries, Federal, State, or local government agencies or geographic regions?

(c) Will the amendment have significant adverse effects on competition, employment, investment, productivity, innovation, or on the ability of U.S. based enterprises to compete with foreign enterprises in domestic or export markets?

Regulations do impose costs and cause redistribution of costs and benefits. If the proposed regulations are implemented to the extent anticipated, these costs are not expected to significant relative to total operational costs.

The fishery simulation model used to examine the possible consequences of imposition of the proposed bycatch management regime on the Bering Sea/Aleutian Islands groundfish fishery indicates, under some sets of assumptions of fleet distribution and performance, potential profit declines in excess of $100 million. These substantial potential losses are predicted only for the case where a fishery attains its BSAI-wide halibut PSC apportionment prior to the end of the fishing year. When faced with possible losses of this magnitude the groundfish fleet will use every possible technique to reduce bycatch rates and bycatch so as to avoid closure.

Modification of existing fishing practice is borne out by recent fleet behavior. In 1983 the Secretary adopted a fixed bycatch rate management system in the foreign fisheries in the Bering Sea. In each subsequent year the established rates were reduced, by regulation, by a fixed percentage. Following imposition of these controls the fishery immediately reduced bycatch rates from those observed in the previous year and continued to reduce bycatch rates each year thereafter. In 1985 the Secretary adopted PSC limit controls with area closures in the DAP and JVP flatfish fisheries by emergency rule followed by Amendment 10 the BSAI FMP. Subsequently, bycatch rates for C.bairdi Tanner crab, and red king crab have substantially declined.

Adoption of the preferred alternative will have a similar influence on the behavior of the groundfish fleet. To the extent that the fleet is successful in reducing bycatch rates actual profit losses in the groundfish fishery will approach zero.

The amendment will not have significant adverse effects on competition, employment, investment, productivity, innovation, or on the ability of U.S. based enterprises to compete with foreign enterprises in domestic or export markets.

The amendment should not lead to a substantial increase in the price paid by consumers, local governments, or geographic regions since no significant quantity changes are expected in the groundfish markets. Where more enforcement and management effort are required, costs to state and federal fishery management agencies will increase.

This amendment should not have an annual effect of $100 million, since although the total value of the domestic catch of all groundfish species is over $100 million, this amendment is not expected to substantially alter the amount or distribution of this catch.

## 5.0 IMPACTS RELATIVE TO THE REGULATORY FLEXIBILITY ACT

The Regulatory Flexibility Act (RFA) requires that impacts of regulatory measures imposed on small entities (i.e., small businesses, small organizations, and small governmental jurisdictions with limited resources) be examined to determine whether a substantial number of such small entities will be significantly impacted by the measures. Fishing vessels are considered to be small businesses. A total of 1,421 vessels may fish for groundfish off Alaska in 1988, based on Federal groundfish permits issued by NMFS through March 12, 1988. In addition, 3,893 U.S. vessels landed Pacific halibut in 1987. While these numbers of vessels are considered substantial, regulatory measures will only affect a smaller proportion of the fleet.

In 1988 there were about 150 domestic trawlers delivering to shore-based processing plants or processing at sea. Additionally there were a maximum of 123 trawlers operating in the joint venture mode (these two vessels categories overlap to some unknown extent). All of these vessels would be affected should an area close to bottom trawling because of attainment of the fishery's PSC apportionment. However, based on the arguments presented in the preceding chapter and in the chapter analyzing the Council's preferred alternative, fleet behavior will be modified to avoid these potentially costly closures.

To the extent that the fleet is successful in avoiding closures of portions of the Bering Sea/Aleutian Islands management areas to bottom trawling no adverse impacts related to the competitive position or longer term viability of the industry are expected. There remains a remote possibility that closures will occur for some portion of the trawler fleet, disadvantaging those vessels. The potential costs of closure are viewed as necessary in controlling the bycatch of crab and halibut in the groundfish fisheries and in striking a more appropriate balance of costs and benefits to the two competing user groups.

## 6.0 FINDINGS OF NO SIGNIFICANT IMPACT

For the reasons discussed above, neither implementation of the status quo nor any of the alternatives would significantly affect the quality of the human environment, and the preparation of an environmental impact statement on the final action is not required by Section 102(2)(c) of the National Environmental Policy Act or its implementing regulations.

_____ _____

Assistant Administrator for Fisheries Date

## 7.0 COORDINATION WITH OTHERS

The Bering Sea/Aleutian Islands Groundfish Plan Team consulted with representatives of the Alaska Department of Fish and Game, National Marine Fisheries Service, members of the Scientific and Statistical Committee and Advisory Panel of the Council, and members of the academic and fishing community. Data were provided by the Northwest and Alaska Fisheries Center's Foreign Observer Program with particular help from Russ Nelson and Joe Terry.

## 8.0 LIST OF PREPARERS

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## 9.0 CHANGES TO THE FMP

### 9.1 Summary

Amendment 12A was approved by the Council at its January 1989 meeting. The amendment establishes a bycatch control procedure to limit the incidental take of Tanner crab, king crab, and Pacific halibut in groundfish fisheries.

### 9.2 Changes to Relevant Sections of the Bering Sea/Aleutian Islands FMP

In Chapter 2.0, Section 2.1, entitled, "History and Summary of Amendments," add the following:

> Amendment 12a, on _____, 1989:
>
> Established a bycatch control procedure to limit the incidental take of C. bairdi Tanner crab, red king crab, and halibut in groundfish fisheries.

In Chapter 14 entitled "Management Regime" in Section 14.4.2, "Prohibited Species" replace the text in subsection E, PSC Limits and Time/Area Closures for DAH Fisheries with:

> The PSC limits and area closures for DAH fisheries expire on December 31, 1990.

In Chapter 14, entitled, "Management Regime" in Section 14.4.2.1 "Bycatch Limitation Zones" replace the text in subsection C with:

> Crab and Halibut Protection Zone. Domestic and foreign trawl fishing is not permitted in the Crab and Halibut Protection Zone. For the periods January 1 - March 14 and June 16 - December 31 of each fishing year the Crab and Halibut Protection Zone is defined as that portion of the EEZ north of the Alaska Peninsula, south of 58° N. latitude, west of 160° W. longitude and east of 162° W. longitude. For the period March 15 - June 15 of each fishing year the Crab and Halibut Protection Zone is defined as that portion of the EEZ north of the Alaska Peninsula, south of 58° N. latitude, west of 160° W. longitude and east of 163° W. longitude (Figure 27a).

In Chapter 14, entitled, "Management Regime" in Section 14.4.2.1 "Bycatch Limitation Zones" append a new subsection D, Halibut Protection Zone:

> D. The Halibut Protection Zone (Zone 2H) is that portion of Zone 2 south of 56° 30" N. latitude, west of 165° W. longitude and east of 170° W. longitude.

In Chapter 14, entitled, "Management Regime" replace Section 14.4.4.2, "Prohibited Species Catch Limits" with:

> 14.4.4.2 Prohibited Species Catch Limits
>
> A. The DAH fishery for Pacific cod south of a straight line approximating the 25-fathom depth contour in the Crab and Halibut Protection Zone identified in 14.4.2.1 C is limited to a PSC of 12,000 red king crab.
>
> B. The DAH trawl fisheries are limited to a PSC of 1,000,000 C. bairdi Tanner crab and to a PSC of 200,000 red king crab in Zone 1 in any fishing year.
>
> C. The DAH trawl fisheries are limited to a PSC of 3,000,000 C. bairdi Tanner crab in Zone 2 in any fishing year.

D. Two PSC limits for Pacific halibut for DAH trawl fisheries are established: a Zone 1 & 2H limit of 4,400 mt and a BSAI-wide limit of 5,333 mt.

14.4.4.3 Apportionment of PSC Limits to Target Fisheries

A. The PSC limits for C. bairdi Tanner crab, red king crab and halibut apply to DAH (DAP and JVP) trawl fisheries for groundfish categorized by target species or species group as:

(1) DAP flatfish - yellowfin sole, other flatfish, and rock sole.
(2) DAP other species - all other target fisheries.
(3) JVP flatfish - yellowfin sole, other flatfish, and rock sole.
(4) JVP other species - all other target fisheries.

B. The overall PSC limits described in 14.4.4.2 will be apportioned by the Secretary, after consultation with the North Pacific Fishery Management Council (Council), to the four target fisheries defined in 14.4.4.3 (A) in proportion to the amount of anticipated annual incidental catch in each fishery.

In Chapter 14, entitled, "Management Regime" replace Section 14.4.3.4, "Implementation of Time and Area Limitations" with:

A. Attainment of a PSC apportionment for C. bairdi Tanner crab or red king crab in a zone for a flatfish fishery defined in 14.4.4.3 (DAP or JVP flatfish) will close the zone to further directed fishing for flatfish for the remainder of the fishing year.

B. Attainment of a PSC apportionment for C. bairdi Tanner crab or red king crab in a zone for an other species fishery defined in 14.4.4.3 (DAP or JVP other species) will close the zone to further directed fishing using bottom trawls for pollock or Pacific cod in the aggregate for that fishery for the remainder of the fishing year.

C. Attainment of a Zone 1 & 2H PSC apportionment for Pacific halibut for a flatfish fishery defined in 14.4.4.3 (DAP or JVP flatfish) will close Zone 1 and Zone 2H to further directed fishing for flatfish for the remainder of the fishing year.

F. Attainment of a Zone 1 & 2H PSC apportionment for Pacific halibut for an other species fishery defined in 14.4.4.3 (DAP or JVP other species) will close Zone 1 and Zone 2H to further directed fishing using bottom trawls for pollock or Pacific cod in the aggregate for that fishery for the remainder of the fishing year.

G. Attainment of a BSAI-wide PSC apportionment for Pacific halibut for a flatfish fishery defined in 14.4.4.3 (DAP or JVP flatfish) will close the BSAI management area to directed fishing for flatfish for the remainder of the fishing year.

H. Attainment of a BSAI-wide PSC apportionment for Pacific halibut for an other species fishery defined in 14.4.4.3 (DAP or JVP other species) will close the BSAI management area to further fishing using bottom trawls for pollock and Pacific cod in the aggregate for that fishery for the remainder of the fishing year.

In Chapter 14, entitled, "Management Regime" delete Section 14.4.3.5, "Discretionary Authority of the Secretary".

In Appendix III, entitled, "Descriptions of Closed Areas" replace paragraph 5 with:

> 5. For the periods January 1 - March 14 and June 16 - December 31 of each fishing year the Crab and Halibut Protection Zone is defined as that portion of the EEZ north of the Alaska Peninsula, south of 58° N. latitude, west of 160° W. longitude and east of 162° W. longitude. For the period March 15 -June 15 of each fishing year the Crab and Halibut Protection Zone is defined as that portion of the EEZ north of the Alaska Peninsula, south of 58° N. latitude, west of 160° W. longitude and east of 163° W. longitude (Figure 27a).

In Appendix III, entitled, "Descriptions of Closed Areas" append a new paragraph 6.

> The Halibut Protection Zone (Zone 2H) is that portion of Zone 2, south of 56° 30" N. latitude, west of 165° W. longitude and east of 170° W. longitude.