MEMORANDUM

TO: Council, SSC and AP Members

FROM: Clarence Pautzke
Executive Director

DATE: November 26, 2001

SUBJECT: Groundfish Management Issues

ESTIMATED TIME
10 HOURS
(for all D-1 items)

ACTION REQUIRED

(d) Review tasking and Problem Statement for differential gear impact analysis (zonal approach).
(e) Receive discussion paper on salmon bycatch implications for the 2002 Steller sea lion measures.
(f) Organize the independent review panel to examine the existing harvest strategy.

BACKGROUND

(d) Pacific Cod Zonal Approach

At the October meeting, the Council considered a zonal approach for Gulf of Alaska Pacific cod fisheries as Alternative 4, Option 3, of the Steller sea lion protection measures EIS. Option 3 would have established a zonal approach for GOA Pacific cod as proposed by the Alaska Marine Conservation Council during the RPA Committee process (original proposal attached as Item D-1(d)). Essentially, this approach would establish buffer zones as measured from land, from which vessels of certain sizes, and using certain listed gear types could participate. The zones are as follows:

0-3 nm	3-12 nm	12-20 nm	outside 20 nm
pot vessels with 60 pot limit, jig vessels with a 5 machine limit	pot vessels with 60 pot limit, jig vessels with a 5 machine limit, and longline vessels < 60'	all pot vessels, all jig vessels, all longline vessels	all vessels and gears

The Council decided that this option was better considered outside of the sea lion protection measures package, and agreed to bring the issue back in December to develop a problem statement for future analysis.

(e) Salmon Bycatch

The Council requested that staff bring forward information regarding salmon bycatch implications resulting from the 2002 Steller sea lion measures. Staff has prepared a draft discussion paper that reviews salmon bycatch and projections for 2002 (Item D-1(e)(1)). Section 4.5 from the Steller sea lion SEIS is attached as Item D-1(e)(2).

(f) Independent F40 Review

The Council passed a motion in October requesting an independent review of our current harvest strategy policy. At this meeting, the Council will want to better define the terms of reference for the review panel, including composition, objectives, and schedule for completion. Of particular importance will be the advice of the SSC on how to conduct the review, and its scope.

A workshop on the Pacific Council's harvest strategy was held in 2000, and their report is attached (Item D-1(f)).

Proposal for the Pacific Cod Fishery in the Gulf of Alaska:
A Zonal Approach for the 2002 RPA
May 9, 2001

Name of Proposer: Alaska Marine Conservation Council

Statement of proposal: The goal of the Zonal Approach for Gulf of Alaska Pacific cod is to achieve Steller sea lion conservation through modified fishing opportunities for coastal community fleets using lower impact fishing gears and practices. The Zonal Approach minimizes competition for cod between fisheries and Steller sea lions by dispersing the fishery over area and time and thus protecting the integrity of the Steller sea lion prey field (food available for sea lions).

The Zonal Approach is based on the following elements:

- Coast wide zones from 0 to 20 nm as an approximation of critical habitat designed to be enforceable by NMFS and easy for the fleet to comply with.
- Reduction of large-scale removals of cod by allowing fishing with pot, jig and longline gears within 20 nm from shore. This will enable coastal community fleets to fish in a modified way that does not disrupt Steller sea lion critical habitat.
- Opportunity for vessels using trawl gear to convert to pots in order to fish inside 20 nm from shore.
- Incorporation of measures to reduce bycatch of species that have been determined important food for Steller sea lions.
- Safeguards against overfishing through application and strengthening of the global control rule.

Jeopardy and Adverse Modification

Based on the stipulations laid out in the Biological Opinion (November 30, 2000), dispersing the cod fishery over area and time and using gear types and fishing practices at appropriate levels will prevent jeopardy and adverse modification of Steller sea lion critical habitat.

Social and Economic Impacts

The Zonal Approach enables the coastal community fleets the opportunity to fish in a modified way at appropriate levels. In addition, the Zonal Approach attempts to minimize negative impacts on the trawl sector by providing the opportunity for gear conversion from trawls to pots.

Minimizing Bycatch of PSC

Gear conversion from trawl to pots will reduce halibut bycatch. A summer season for cod using pots and jigs will achieve temporal dispersion without creating more bycatch.

Adaptation to a sound experimental design for monitoring

An experimental design can be overlaid on this cod management program. AMCC recommends selecting discrete areas where a scientific hypothesis can be tested to derive statistically useful results.

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Proposal for the Pacific Cod Fishery in the Gulf of Alaska:

A Zonal Approach for the 2002 RPA

The goal of the Zonal Approach is to achieve Steller sea lion conservation through modified fishing opportunities for coastal community fleets using lower impact fishing gears and practices. Because food stress is the National Marine Fisheries Service's prevailing hypothesis for why Steller sea lions are failing to recover, the Zonal Approach attempts to minimize vessel-sea lion competition for cod by dispersing the fishery temporally and spatially. The Zonal Approach is based on the following elements:

- Coast wide zones from 0 to 20 nm as an approximation of critical habitat designed to be enforceable by NMFS and easy for the fleet to comply with.
- Reduction of large-scale removals of cod by allowing fishing with pot, jig and longline gears within 20 nm from shore. This will enable coastal community fleets to fish in a modified way that does not disrupt Steller sea lion critical habitat.
- Opportunity for vessels using trawl gear to convert to pots in order to fish inside 20 nm from shore.
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- Safeguards against overfishing through application and strengthening of the global control rule.

Spatial Dispersion

The intent of the spatial dispersion element is to slow the rate of removals of Pacific cod from within the 20 nm zone.

> *The fisheries effects that give rise to these determinations include both large scale removals of Steller sea lion forage over time, and reduced availability of prey on the fishing grounds at scales of importance to individual foraging Steller sea lions, particularly in critical habitat.* (Nov 30 BiOp page 271).

We propose coast wide zones from 0 to 20 nm as an approximation of critical habitat designed to be enforceable by NMFS and easy for the fleet to comply with. Fixed gear types are permitted inside 20 nm and trawl gear is permitted outside 20 nm based on findings in the Biological Opinion.

> *The possible effects of these other gear types are dwarfed by the magnitude of biomass removals by the trawl sector.* (Nov. 30 BiOp page 217).

Table 1: Recommended Management Action for Gulf of Alaska Pacific Cod Fisheries qSpatial Dispersion				
Zone	**1**	**2**	**3**	**4**
Area of Zone	0 nm from shore and beyond	3 nm from shore and beyond	12 nm (Territorial Sea Boundary) from shore and beyond	20 nm from shore and beyond
Vessels eligible to fish within zone	Vessels with a maximum of 60 pots or 5 jig machines, as per State rules	Vessels with a maximum of 60 pots or 5 jig machines plus all longliners <60 ft. LOA	Zone 2 and 3 vessels, plus vessels using pot and jig gear with no gear restrictions plus longliners >60 ft. LOA	Zone 1, 2 and 3 vessels, plus vessels using trawl gear
Intent of Action	The intent of Zone 1 is not to preempt State rules.	The intent of the 60-pot limit in Zone 1 and 2 is to have no more than 60 pots per vessel at one time.		

Temporal Dispersion

The intent of temporal dispersion is to reduce the likelihood of localized depletion occurring in critical habitat according to requirements contained in the Nov. 30 BiOp (page 274, 9.2.3 Temporal Apportionment of TACs).

> *"Establishing summer and winter seasons for all these species would be important to preventing localized depletion"* (Nov.30 BiOp, p. 260)

AMCC proposes that vessels fishing with fixed gear open on the first day of each quarter, and vessels fishing with trawl gear start on the 20th day of each quarter except the C season. This mirrors the current regulatory framework for fixed/trawl gear starting dates.

Table 2: Recommended Management Action to Temporally Disperse the GOA Pacific Cod Fishery

Season	% TAC	Fixed Gear Start/End Dates	Trawl Gear Start/End Dates
A	25%	Jan 1/March 31	Jan 20/March 31
B	25%	April 1/June 30	April 20/June 30
C	25%	July 1/Sept 30 (pots & jigs only)*	N/A*
D	25%	Oct 1/Dec 31	Oct 20/Oct 31

*** Note: We recognize that the summer season will have increased bycatch in some gear types. Our goal is to maximize dispersion of the cod fishery by allowing opportunity for those gears without bycatch problems to fish cod in the summer. TAC not taken in the summer season could be rolled over to the D season.**

Global Control Rule

The global control rule should apply to the cod fishery to safeguard against overfishing. We recommend that NMFS consider strengthening the formula to require conservation action sooner than the BiOp measure.

Other Provisions for the Zonal Approach

AMCC recognizes that the Zonal Approach has consequences for the fleets and conservation considerations. The following are recommended management actions intended to build in flexibility for the various cod fleets, address bycatch issues, and meet requirements in the Biological Opinion.

1. Enable Gear Conversion from Trawls to Pots

Intent:
- Enable LLP qualified cod trawl vessels to convert to pots so they are eligible to fish for cod within 20 nm.

Action:
- Issue LLP pot cod endorsements to LLP qualified cod trawl vessels.
- Vessels are not allowed to target Pacific cod with trawl gear and pot gear under this provision in the same quarter.

Rationale:
- Conversion from trawls to pots should slow down harvest rates and make it possible to allow those vessels to operate inside 20 nm.

2. Prohibit Retention of Octopus in the Pacific Cod Fishery

NMFS data shows that octopus is important prey for Steller sea lions. With the possibility of the cod trawl sector converting to pot gear and fishing throughout the year, octopus bycatch is likely to increase.

Intent:
- Address the potential increase in octopus bycatch in the cod fishery.
- Encourage live discard of octopus.
- Prevent a bycatch fishery for octopus from developing.

Action:
- Prohibit retention of octopus in the cod fishery.

Rationale:
- Action applies to entire cod fishery because of the enforcement difficulties outlined in the NMFS Draft Discussion Paper.

3. Roll Over of TAC Across Seasons

Intent:
- To maintain temporal dispersion while allowing a level of flexibility for the fleets if TAC is not completely caught in a quarter.

Action:
- In 2002, allow unfished TAC, at a maximum of one quarterly seasonal amount, to be rolled over to the next quarterly season within that year as a phase-in measure for a limited roll over of TAC starting in 2003.
- Starting in 2003, allow a maximum 1/5 of a quarterly season's TAC to be rolled over to the next quarterly season within that year. A higher percentage rollover may be appropriate from the C season to the D season.

Rationale:
- Temporal dispersion is maintained by allowing a maximum percentage of any quarterly seasonal TAC to be rolled over to the next quarter.

4. Seasonal Apportionment of Halibut PSC

Intent:

- Prevent the yearly PSC for halibut from being taken all in one quarter.

Action:

- Split the yearly PSC by season according to seasonal apportionment of TAC. Consideration should be given to those seasons in which gear types with the highest use of halibut bycatch participate. (Since the C season would be open only to pots and jigs, a corresponding apportionment of the PSC cap would be made to that season.)

Rationale:

- The yearly PSC of halibut allocated to longline gear for 2001 was mostly caught in the cod " A" season, effectively closing the cod longline fishery in the "B" season. By splitting the PSC cap among quarters, the opportunity for vessels using longline gear to fish later in the year is increased.

5. Reduce the Maximum Retainable Bycatch of Pacific Cod

Intent:

- Prevent a "ballast" fishery for cod from occurring within 20 nm from shore.

Action:

- Reduce the MRB for cod from 20% to 5% within 20 nm from shore.

Rationale:

- The 20% MRB for cod is an economic incentive for a ballast fishery. Bycatch of cod should be minimized inside 20 nm to help control the total removals of cod from the prey field.

NOTE: The intent is to lower the MRB to an appropriate level such that more at-sea discards are not created. Therefore, the recommended 5% MRB may need to be adjusted by the agency to reflect a true 'intrinsic' bycatch rate. However, if the intrinsic bycatch rate or volume were high enough to disrupt the Steller sea lion prey field, further action would be needed.

6. Improve Data Collection and Enforcement

Observer Coverage

Action:

- Increase observer coverage, especially on vessels with high extraction rates, to monitor catch effectively both inside the 20 nm zone and beyond. NMFS should prioritize where increased observer coverage should be placed to maximize benefit and utility of greater data collection.
- A funding mechanism using Steller sea lion moneys should be used to increase observer coverage equitably.

VMS

Action:

Install VMS on those vessels deemed necessary by NMFS as a tool to improve fishery data and enforce new fishery regulations.

- The cost of implementing VMS for Steller sea lion protection measures should be funded by NMFS (as the agency has done in certain other fisheries).

Rationale:

- NMFS has stated, *"VMS combined with observer data improves NMFS's ability to determine where catch was made"* (NMFS Draft Discussion Paper, Revised May 4, 2001, page 7).

7. Weekly Delivery Limits

Because the Zonal Approach spreads the cod fishery over time and area through gear restrictions, fishing zones and seasonal splits, weekly delivery limits may not be necessary to prevent large scale removals and localized depletion. However, analysis of the full RPA package should be conducted before excluding this element since the possibility exists for fishing to exceed acceptable rates inside 20 nm. Delivery limits may be needed as a tool to further slow down the fishery.

A Review of Salmon Bycatch in Alaska Groundfish Fisheries and an Outlook for 2002

by
David Witherell and David Ackley

DRAFT

Abstract - Chinook and chum salmon are caught incidentally in Alaska groundfish fisheries, primarily in the pollock trawl fishery. On average 1990-2001, 37,500 chinook salmon and 69,000 other salmon species (> 95% are chum salmon) were caught annually in Bering Sea groundfish trawl fisheries and 21,000 chinook salmon and 20,500 other salmon were caught annually in Gulf of Alaska trawl fisheries. In 1999 and 2000, chinook salmon bycatch was reduced in the Bering Sea, but increased in the Gulf of Alaska. Chum salmon bycatch has remained relatively stable in recent years. Bycatch is primarily juvenile salmon that are one or two years away from returning to the river of origin as adults. The origin of salmon taken as bycatch includes rivers in western Alaska, central and southeast Alaska, Asia, and British Columbia. About 60% of the chinook salmon and 27% of the chum salmon taken as bycatch in Bering Sea trawl fisheries originate from western Alaska streams; the percentage taken in Gulf of Alaska trawl fisheries is likely smaller but no data are available. Analysis indicates that a Bering Sea trawl fisheries bycatch level of 30,000 chinook salmon equates to about 9,000 adult fish from western Alaska. Similarly, a bycatch of 60,000 chum salmon in Bering Sea trawl fisheries equates to about 16,000 adult chum salmon from western Alaska. Management measures to control salmon bycatch in trawl fisheries include area closures and bycatch limits. No significant changes in salmon bycatch are expected to result from new fishery management measures designed to protect Steller sea lions, that are scheduled to be implemented in January 2002.

Introduction

Five species of Pacific salmon, pink (*Oncorhynchus gorbuscha*), chum (*O. keta*), sockeye (*O. nerka*), coho (*O. kisutch*), and chinook (*O. tschawtscha*) salmon as well as steelhead trout (*O. Mykiss*) occur in the marine waters off Alaska. Alaska commercial salmon harvests generally increased over the last three decades but appear to have peaked in 1995 (Wertheimer 1997) and are now declining. Alaska salmon run sizes have exhibited wide variations throughout their known history and have generally been strongly correlated to environmental factors (Hare and Francis 1995).

In 2000, salmon returns throughout the Yukon and Kuskokwim River drainages and the entirety of Norton Sound were less than 50 percent of the mean 20-year average which resulted in severe constraints on commercial, sport, and subsistence harvest. The State of Alaska declared that an emergency disaster existed in the area, prompting fisheries managers to re-examine any and all factors that may have contributed to the decline.

This paper reviews available information regarding salmon taken incidentally in U.S. North Pacific groundfish fisheries of the Bering Sea and Aleutian Islands (BSAI) and Gulf of Alaska (GOA) areas. We also provide estimates of salmon bycatch for 2002 as a result of new fishery management measures designed to protect Steller sea lions.

How much salmon is bycaught?

Pacific salmon bycatch is estimated through the observer program and is normally classified into the two major groups of chinook salmon and other salmon. In both the BSAI and GOA groundfish fisheries, about 95 % of other salmon bycatch is chum salmon (Table 1). Bycatch of coho, pink, and sockeye salmon is relatively rare. Nearly all (>99%) salmon bycatch is attributable to trawl fisheries, with most taken in the pollock trawl fishery (Table 2). The average size of salmon taken as bycatch has been about 4.5 pounds (22 inches) for chum salmon and 6.5 pounds (23 inches) for chinook salmon (1993 NMFS Observer Program data).

Bycatch of salmon has fluctuated through the years. On average 1990-2001, 37,500 chinook salmon and 68,600 chum salmon were bycaught annually in BSAI groundfish fisheries, and 21,000 chinook salmon and 20,500 chum salmon in GOA groundfish fisheries (Table 1). Much lower chinook salmon bycatch was recorded in 1999 and 2000 BSAI groundfish fisheries, but increased to 38,000 salmon in 2001. Chum salmon bycatch in the BSAI has been fairly consistant over the last 5 years. In the GOA, chinook salmon and chum salmon bycatch has been fluctuated in recent years. Reductions in BSAI chinook salmon bycatch are likely to be attributable, in part, to changes in salmon abundance, reduction in salmon bycatch limits, regulatory changes (particularly those associated with Steller sea lion protection measures), bycatch avoidance measures by the fleet, and changes in fishery operations due to the formation of cooperatives allowed under the American Fisheries Act of 1998.

Table 1. Catch of Pacific salmon in North Pacific groundfish fisheries, 1990-2001.

Bering Sea and Aleutian Islands Area

Year	Chinook	Chum	Coho	Sockeye	Pink
1990	14,085	16,202	153	30	31
1991	48,873	29,706	396	79	79
1992	41,955	40,090	1,266	14	80
1993	45,964	242,895	321	22	8
1994	44,380	95,978	231	20	202
1995	23,079	20,901	858	0	21
1996	63,205	77,771	218	5	1
1997	50,218	67,349	114	3	69
1998	58,966	69,237	(combined with chum)		
1999	12,924	46,295	(combined with chum)		
2000	7,470	57,600	(combined with chum)		
2001	38,363	58,953	(catch through 11/10)		

Gulf of Alaska Area

Year	Chinook	Chum	Coho	Sockeye	Pink
1990	16,913	2,541	1,482	85	64
1991	38,894	13,713	1,129	51	57
1992	20,462	17,727	86	33	0
1993	24,465	55,268	306	15	799
1994	13,973	40,033	46	103	331
1995	14,647	64,067	668	41	16
1996	15,761	3,969	194	2	11
1997	15,119	3,349	41	7	23
1998	16,941	13,539	(combined with chum)		
1999	30,600	7,529	(combined with chum)		
2000	26,705	10,995	(combined with chum)		
2001	15,108	5,989	(catch through 11/10)		

Table 2. Incidental take of salmon in BSAI trawl fisheries, 2000.

Fishery	Chinook	Others
Pollock	3,968	56,715
Pacific cod	2,688	128
Yellowfin sole	75	188
Other Flatfish	462	108
Other targets	278	460
Total	7,470	57,600

What is their stream of origin?

Information on the origins of chinook salmon caught incidentally in BSAI fisheries comes primarily from salmon scale pattern analysis. Salmon scales collected by groundfish observers have been analyzed in a number of studies (Table 3). The Myers and Rogers (1988) analysis of chinook salmon bycatch in joint venture trawl fisheries indicated about 60% of the chinook salmon bycatch came from western Alaska, 17 % from south central Alaska, 14% from Asia, and 9% from southeast Alaska and Canada. These results should be interpreted with some caution, however, as the information is over 15 years old.

More recent studies have examined the stock composition of chum salmon taken as bycatch in BSAI fisheries. On average, about 27% of the chum salmon bycatch originated from western Alaska, 5% from south central Alaska, 38% from Asia, 12% from southeast Alaska and 18% from Canada and Washington, based on data from Wilmot et al.(1998) and Kondzela et al. (1999) as cited in NMFS (2001a). To date, no studies have examined the stock composition of salmon bycatch from GOA trawl fisheries.

What are the impacts to western Alaska stocks?

Because of the poor returns of chinook salmon and chum salmon to western Alaska rivers in recent years, it is useful to consider the impacts of incidental bycatch from trawl fisheries on these stocks. Previous analysis regarding the impacts of chinook salmon bycatch from BSAI trawl fisheries concluded that salmon bycatch equated to < 1% of the adult chum population and 2-4 % of the adult chinook salmon population in western Alaska (NPFMC 1999).

The methodology incorporated mortality associated with age at incidental capture so as to express bycatch as adult equivalents. Myers and Rogers (1988) had estimated that 56% of the chinook included in their analysis were age 1.2 fish and that 26% of the chinook were age 1.3 (years in fresh water, years in salt water). If we assume that all bycatch is age 1.2 or 1.3, then the numbers are adjusted accordingly such that 68.3% are age 1.2 and 31.7% are age 1.3. Annual at-sea natural mortality rates between ages 1.2 and 1.3 were set at 20%, and the natural mortality rate over the year between ages 1.3 and 1.4 was set at 10% (Pacific Salmon Commission 1988). The returns would occur over a number of years. Of the 1.2 age fish, some will return the next year (with a 20% mortality) and some in 2 years with a 10% mortality. Some of the 1.3 age fish will return the same year and some in another year at 10% mortality (NPFMC 1995).

As a rough estimate, approximately 60% of the bycaught chinook salmon in any given year would be expected to return to western Alaskan systems as adults had they not been intercepted (NPFMC 1999). Using this approximation, a BSAI trawl bycatch of 30,000 juvenile chinook salmon would be comprised of about 18,000 fish from western Alaska. Using fairly general assumptions based on chinook salmon return information (NPFMC 1995), and assuming that all fish return as age 1.3 or 1.4, a rough approximation can be made that 38% of chinook salmon return to the Yukon and Nushagak systems as age 1.3, and approximately 62% as age 1.4. Given the above natural mortality rates and age proportions (NPFMC 1995), and assuming that the majority of returns from the following year would be affected, approximately 9,000 chinook would have been removed as adult equivalents. For comparison, this amount of adult equivalent bycatch equates to about 4.5% of the average (1997-99) western Alaska catch of 200,000 chinook salmon (NMFS 1999a).

The same age-specific information for chum salmon was not available for this paper, however, the impacts are believed to be smaller due to the larger population size and lower bycatch composition from western Alaska (27%). A bycatch of 60,000 juvenile chum salmon in BSAI trawl fisheries would reduce the numbers of returning adults by about 16,000 fish. This number would be spread out in impacts across two or more years in unknown proportions. For rough comparison, an adult equivalent bycatch of 16,000 western Alaska chum salmon equates to about 1.9% of the average (1997-99) western Alaska catch of 830,000 chum salmon.

It is not known what proportion, if any, of the chinook salmon or chum salmon taken in GOA trawl fisheries originate from western Alaska, so no assessment of impacts can be made.

What has been done to control salmon bycatch?

Salmon are listed as a prohibited species in the groundfish fishery management plans, meaning that they cannot be kept, and must be returned to the sea as soon as possible with a minimum of injury. However, regulations implemented in 1994 prohibited the discard of salmon taken as bycatch in BSAI groundfish trawl fisheries until the number of salmon has been determined by a NMFS certified observer. Additional regulations were adopted to allow voluntary retention and processing of salmon for donation to foodbanks.

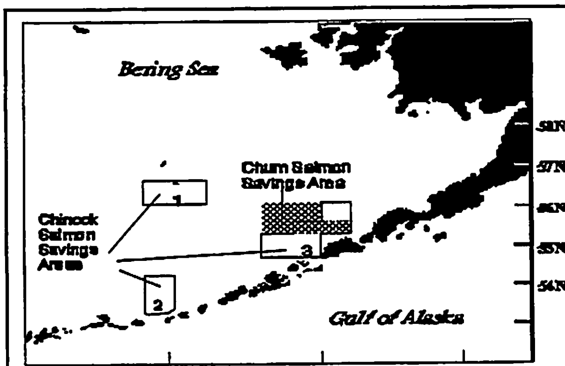

Figure 1. Location of the salmon savings areas in the Bering Sea.

The Council has taken measures over the years to control the bycatch of salmon in trawl fisheries (Witherell and Pautzke 1997). Several bycatch "hotspot" areas have been closed to trawl fishing if too many salmon are encountered (Figure 1). Beginning in 1995, the Chum Salmon Savings Area has been closed to all trawling from August 1 through August 31. Additionally, the area remains closed if a bycatch limit of 42,000 chum salmon is taken within the catcher vessel operational area. Although more than 42,000 chum salmon were taken over the course of a year from 1995 through 1999, additional closures had not been triggered because the bycatch limit was not attained within the area prior to the accounting period (August 15 to October 14).

From 1996 through 1999, regulations were in place to prohibit trawling in the Chinook Salmon Savings Areas through April 15 if and when a bycatch limit of 48,000 chinook salmon was attained in the Bering Sea and Aleutian Islands trawl fisheries. More than 48,000 chinook salmon were taken as bycatch annually from 1996 through 1998, but closures were not triggered because bycatch limits were not exceeded before April 15.

In 1999, the Council adopted Amendment 58 to reduce the amount of chinook salmon allowed to be taken as bycatch in BSAI trawl fisheries. Specifically, the amendment did the following (1) incrementally reduced the chinook salmon bycatch limit from 48,000 to 29,000 chinook salmon over a 4-year period, (2) implemented year-round accounting of chinook salmon bycatch in the pollock fishery, beginning on January 1 of each year, (3) revised the boundaries of the Chinook Salmon Savings Areas, and (4) set more restrictive closure dates. In the event the limit is triggered before April 15, the Chinook Salmon Savings Area closes immediately. The closure would be removed on April 16, but would be reinitiated September 1 and continue through the end of the year. If the limit were reached after April 15, but before September 1, then the areas would close on September 1. If the limit were reached after September 1, the areas would close immediately through the end of the year. The bycatch limit for 2002 BSAI pollock fisheries will be set at 33,000 chinook salmon.

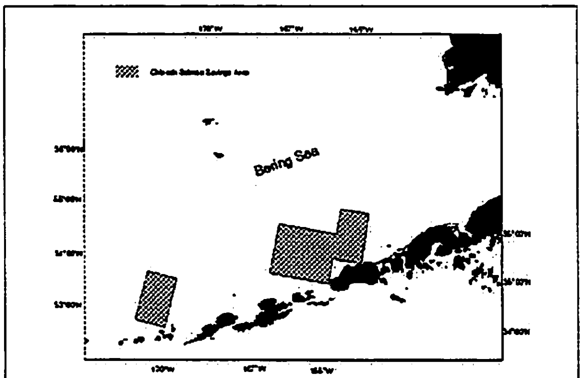

Figure 2. Location of the chinook salmon savings areas in the BSAI, as modified by Amendment 58.

What changes are expected for 2002?

The effects of different alternatives on bycatch of salmon and other prohibited species was examined in section 4.6 of the Steller Sea Lion Protection Measures Supplemental Environmental Impact Statement (NMFS 2001b). Relative to a 1997-1999 average baseline catch of 33,500 chinook salmon and 55,500 other salmon for BSAI trawl fisheries, adoption of alternative 4 was projected to result in similar bycatch amounts of about 30,000 chinook salmon (10% decrease) and 59,300 other salmon (7% increase). In the GOA, the SEIS examined changes relative to baseline bycatches of about 20,800 chinook salmon and 7,600 other salmon. Adoption of alternative 4 was projected to result in similar bycatch amounts of about 22,000 chinook salmon (6% increase) and 6,900 other salmon (9% decrease) in GOA trawl fisheries. The SEIS concluded that changes of this magnitude would not be practically detectable in the range of bycatch levels experienced in recent years, and therefore the management measures adopted to protect Steller seal lions would have insignificant impacts on salmon bycatch.

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4.5 Effects on Prohibited Species Bycatch

Prohibited species taken incidentally, or as bycatch, in groundfish fisheries include: Pacific salmon (chinook, coho, sockeye, chum, and pink salmon), steelhead trout, Pacific halibut, Pacific herring, and Alaska king, Tanner, and snow crabs. Background information on these species is provided in section 3.5. Discussion of the effects of the alternatives on the bycatch of prohibited species in the Bering Sea and Aleutian Islands Area (BSAI) and the Gulf of Alaska Area (GOA) are provided separately in sections 4.5.1 and 4.5.2, respectively.

Prohibited species bycatch is a function of the rate at which a prohibited species is encountered per metric ton of groundfish caught. Bycatch rates can be area and time specific, so that for instance, a higher bycatch rate for chinook salmon can be expected in the vicinity of Unimak Island and the 200 m depth contour during the first four months of the year. The bycatch rate for chinook salmon is much lower in other areas of the Bering Sea during that period.

Implementation of the measures proposed under the various alternatives will have impacts on bycatch by moving fishing effort away from closed areas. If the new resulting fishing locations are away from areas of high bycatch rates, the subsequent bycatch levels should be reduced. Conversely, if fisheries are moved to locations with high bycatch rates, the bycatch levels should increase.

Data from the 1997 - 1999 groundfish fisheries were used in estimating changes in bycatch due to the various alternatives. Groundfish data from 1997 - 1999 were obtained from a database created by combining groundfish observer data, ADF&G fish tickets and federal weekly processor reports. The database was constructed to account for all groundfish catch in the BSAI and GOA while ensuring that the possibility of overlapping data sources, or duplicate data was minimized. The groundfish observer program is the only source for prohibited species bycatch numbers, and completely processed datasets that could be combined with the groundfish data were only available for 1998 and 1999.

The amount of groundfish and prohibited species bycatch was calculated inside and outside of the closure options under each alternative. The species catch by ADF&G statistical area was calculated for the pollock, Atka mackerel and Pacific cod fisheries. A geographical information system (GIS) was used to overlay ADF&G statistical areas with 3, 10 and 20 nm buffers around all rookeries and haulouts. Coding allowed distinction of rookeries, haulouts and newer RPA listed haulouts. Each larger RPA site described in the 2001 biological opinion was also coded (NMFS 2000a). After merging the ADF&G statistical areas with rookery and haulout buffers, the resulting smaller area proportions (e.g. 12.0234% of a statistical area was within 3 nm of a rookery) were calculated so that the proportions for each ADF&G statistical area summed to one. The amount of catch within each closed area that did not conform perfectly with existing ADF&G statistical areas was apportioned based the percentage of a statistical area that lay within the closure zone. For instance in a statistical area for which 40% lay within a defined closed area (e.g. a 20 nm critical habitat buffer from a rookery), 40% of the catch from that statistical area would be considered to be from the closed area. Bycatch amounts were calculated similarly using observer data. The expected changes in bycatch levels were estimated by comparing bycatch rates in closed areas with the bycatch rates of the remaining open areas.

This chapter provides bycatch estimates for the Atka mackerel, Pacific cod and pollock fisheries. The use of historical bycatch rates based on location and fishery provides indications of how bycatch might change due to changes in fishing patterns under the various alternatives. However, the alternatives may cause changes in fisheries that could obscure the expected effects based solely on rates in the three fisheries under analysis. To illustrate the complex interactions of fisheries, the following hypothetic example provides a plausible scenario. If the trawl fishery for Pacific cod was closed earlier than might be expected due to a given alternative (reaching a bycatch cap, attainment of TAC, inability to harvest substantial portion of the TAC), the expected bycatch amounts of some species for that fishery might be reduced. However, the remaining allowance of halibut that the Pacific cod fishery did not take might be released to another fishery. This other fishery, for instance yellowfin sole, might then fish longer than in another scenario and incur high crab bycatch. Whereas the bycatch rates for an alternative might indicate a slight increase in crab bycatch in the Pacific cod fishery, there might be a substantial increase in crab bycatch under the alternative due overall fishery interactions. The effects of multiple fishery interactions on bycatch are not addressed in the current analysis.

4.5.1 Bering Sea and Aleutian Islands Area

Sections 4.5.1.1 - 4.5.1.5 below describing the effects of each alternative on BSAI bycatch will refer to Table 4.5-1 which presents the percentage change in bycatch levels expected under each of the alternatives. Prohibited species bycatch by alternative relative to the baseline (1997-1999 average) catch is first calculated for each species. Percentage values in the table are computed as the ratio of the change in *per-unit* catch of the bycatch species by alternative relative to the baseline catch. For example, let $U_{b,s,t}$ be the catch in target fishery t of species s for the Alternative data a. The values are computed for each species in Alternative 1 (where b represents the baseline data) as:

$$(U_{a,s,t} - U_{b,s,t}) / U_{b,s,t} .$$

To illustrate further a real example is done as follows:

$$U_{b,s=halibut,t=pollock} = 553/941{,}282 = 0.000587$$

$$U_{1,s=halibut,t=pollock} = 543/918{,}765 = 0.000591$$

$$(0.000591-0.000587) / 0.000587 = 0.00681 \sim 1\%$$

for the change in bycatch under Alternative 1 compared with the average estimated from 1997-1999. Crabs and salmon units are in numbers, all other species in metric tons.

It should be noted that the data are based on historic fishing patterns and management strategies. Non-pelagic trawl gear in the pollock fishery was banned in 2000, and was in effect in 1999 through the TAC setting process which allocated zero pollock to non-pelagic gear (65 FR 31105, May 16, 2000). The bycatch levels of crab and halibut that were present in the fishery in 1997 and 1998 are not expected to continue. For example, the bycatch of red king crab in 1998 of 13,950 crab was reduced to 91 crab in 1999 and 0 crab in 2000. The percentage changes in bycatch levels in Tables 4.5-1 and 4.5-5 may be similar to actual changes due to implementation of an alternative, however, the actual numbers should be significantly reduced from those indicated in the baseline data for the pollock fishery.

Also, expected increased catch of prohibited species for which prohibited species caps apply would result in earlier attainment of the PSC cap and then earlier closure of the fishery rather than an actual bycatch amount over the cap. This applies especially to halibut bycatch. For instance in the GOA, certain fisheries TACs are routinely not attained due to the constraints of the halibut bycatch caps. The fishery is in essence managed by the halibut allowance and caps rather than the directed fishery catch.

Table 4.5-1 **The estimated change in bycatch levels in the BSAI when compared to the average estimated from 1997 and 1999**

Pollock Fishery Catch of 941,282 Tons **Stock**	**Alt.1**	**Alt.2**	**Alt.3**	**Alt.4**	**Alt.5**	**Baseline Catch**
Halibut	-2%	2%	6%	-23%	-3%	501
Herring	1%	-1%	-12%	16%	-9%	804
C. bairdi Crab	-4%	41%	26%	-6%	0%	105,227
Other Tanners	-3%	32%	26%	-8%	2%	202,469
Red king Crab	-11%	20%	33%	-20%	-6%	15,787
Other king Crab	1%	101%	32%	31%	7%	3,512
Chinook Salmon	0%	-59%	-33%	-9%	-6%	31,007
Other Salmon	2%	-35%	-26%	7%	1%	54,804

Pacific Cod Fishery Catch of 169,690 Tons **Stock**	**Alt.1**	**Alt.2**	**Alt.3**	**Alt.4**	**Alt.5**	**Baseline Catch**
Halibut	1%	-20%	-6%	-11%	1%	1,579
Herring	3%	54%	31%	16%	2%	1
C. bairdi Crab	-7%	-21%	9%	-30%	-5%	73,554
Other Tanners	2%	36%	18%	4%	2%	560,926
Red king Crab	2%	26%	30%	5%	1%	8,261
Other king Crab	4%	65%	8%	18%	3%	28,052
Chinook Salmon	-5%	-49%	5%	-25%	-5%	2,222
Other Salmon	4%	-75%	-28%	-8%	4%	122

Atka Mackerel Fishery Catch of 56,473 Tons **Stock**	**Alt.1**	**Alt.2**	**Alt.3**	**Alt.4**	**Alt.5**	**Baseline Catch**
Halibut	-12%	-30%	9%	-37%	-12%	117
Herring	19%	-100%	-100%	-42%	19%	0
Other Tanners	-4%	-100%	-100%	-65%	-4%	31
Other King Crab	18%	34%	-3%	23%	18%	2,260
Chinook Salmon	-78%	-91%	64%	-94%	-78%	266
Other Salmon	8%	-9%	-21%	-2%	8%	532

Note: Baseline units for crabs and salmon are in numbers; all other species are in metric tons. Other Tanners are mainly *C. opilio* crab, and other Salmon are primarily chum salmon.
Source: NMFS Catch by Vessel database (same as used to prepare Appendix E).

4.5.1.1 Effects of Alternative 1 on Prohibited Species Bycatch in the BSAI

Alternative 1 is the most similar to the fishing conditions present in 1997 - 1999, and the estimated impacts on bycatch by the alternatives are small for this alternative in terms of percentage change in expected bycatch levels (Table 4.5-1). Alternative 1, No Action, in essence mirrors many of the regulatory elements that were in place during the time the data were collected, so small percentage changes might be expected. In the pollock fishery, the largest percentage change from the baseline data was the bycatch of red king crab which was projected to decline by 11%. The bycatch of red king crab in the pollock fishery will be significantly reduced in future years due to the 2000 ban on non-pelagic trawl gear in this fishery discussed above.

Similarly, the predictions of bycatch changes in the Pacific cod fisheries indicate slight decreases in numbers of intercepted *C. bairdi* crab and chinook salmon, and slight increases in other species bycatch.

There were no critical habitat limitations on Atka mackerel fishing in the Aleutian Islands in 1997 or 1998. In 1999, a limit was made on the amount of Atka mackerel harvested in critical habitat to 65% of the seasonal allowance in the Western Aleutian Islands, and to 80% in the Central Aleutians (64 FR 3446, January 22, 1999). Further reductions on critical habitat limits were made to extend over a four year period in this final rule as well. Alternative 1 reduces the amount of Atka mackerel that can be taken in critical habitat to 40% of the directed fishing allowance. The decrease in critical habitat allowance under Alternative 1 is apparent in the predicted changes in bycatch levels in the Atka mackerel fishery. Fishing effort is moved outside of critical habitat compared to the historic catch 1997 - 1999. It appears that chinook salmon, other Tanner crab (*C. opilio*), and halibut bycatch rates are lower outside of critical habitat, and the shift in effort outside of critical habitat led to reductions in the expected bycatch of these three species. Although the percentage decrease in chinook salmon bycatch appears to be high (78%), the actual numbers of chinook salmon taken in the Aleutian Islands is relative low to begin with (baseline of 266 fish). Under Alternative 1 there would be expected to be a 19% rise in herring bycatch and a 18% rise in other king crab bycatch., however, the herring baseline catch for the Aleutian Islands is less than one ton.

4.5.1.2 Effects of Alternative 2 on Prohibited Species Bycatch in the BSAI

Alternative 2 prohibits trawling in the largest amount of area across the five alternatives. The pollock and Atka mackerel fisheries are prosecuted exclusively with trawl gear, and there is a component of the Pacific cod fishery that relies on trawl gear as well. This alternative predicts the greatest change in bycatch percentages in the trawl fisheries.

The critical habitat closed under Alternative 2 includes areas of high salmon bycatch and contains the Chinook Salmon Savings Area and the Chum Salmon Savings Area (section 3.5) which were defined based on the spatial locations of salmon bycatch. Chinook salmon bycatch would be expected to decline from the baseline by 59% in the pollock fishery and by 49% in the Pacific cod fishery under this alternative and a reduction in chum salmon bycatch of 35% in the pollock fishery and 75% in the Pacific cod fishery would be expected.

Halibut bycatch would be expected to be similar to the baseline in the pollock fishery, and decline in the Pacific cod fisheries. In general there would be an increase in crab bycatch, especially in red king crab and *C. opilio* because the bycatch of these species are spatially removed from the critical habitat areas closed under Alternative 2 and increased fishing due to displaced effort would lead to increases in bycatch. Red king crab bycatch would be predicted to increase by 20% in the pollock fishery and by 26% in the Pacific cod fisheries, although as noted above, the pollock fishery would not be expected to have appreciable crab bycatch in the future. Similarly other Tanner (*C. opilio*) bycatch would be expected to increase by 32% in the pollock fishery and 36% in the Pacific cod fisheries. Based on historic fishing patterns, other king crab bycatch in the Pacific cod fisheries would be expected to increase by 65% under Alternative 2 (and by 101% in the pollock fisheries, although that would not be the case in future pollock fisheries).

Pacific herring bycatch would be expected to decrease slightly under Alternative 2 in the pollock fisheries. A predicted increase of 54% in the Pacific cod fishery would not result in substantial amounts of herring bycatch since the baseline amount is one ton of herring.

All bycatch amounts in the Aleutian Islands Atka mackerel fishery would be predicted to decline under Alternative 2 with the exception of other king crab bycatch which would be expected to increase by 34%. In terms of actual numbers, the other king crab bycatch amount would be the most substantial change in any of the Atka mackerel bycatch species as well.

4.5.1.3 Effects of Alternative 3 on Prohibited Species Bycatch in the BSAI

Alternative 3 would close portions of critical habitat to all fishing, and would close a smaller area to trawling than Alternative 2. Similar to Alternative 2 above, Alternative 3 would lead to predicted decreases in the bycatch of Pacific herring, chinook salmon and other salmon (12%, 33%, and 26%, respectively) in the pollock fishery. This is because the areas of high salmon and herring bycatch are largely contained in closed areas under both alternatives, however, the area containing the chinook and chum salmon savings areas would be open under this alternative. Critical habitat catch restrictions within open critical habitat would move effort out of these high bycatch zones, resulting in some bycatch reductions. Alternative 3 would be expected to increase the bycatch of crab in the pollock fishery by 25% - 35% depending on the species, although such increases would not be expected in future fisheries as discussed above.

Alternative 3 would likely increase the bycatch of red king crab by 30% and other Tanners (*C. opilio*) by 18% in the Pacific cod fisheries. Pacific herring would be expected to increase by 31% under the alternative, however, the baseline herring amount is small (one metric ton). The bycatch of other species would be expected to increase by no more than 10% or decrease in the Pacific cod fishery. Alternative 3 is the only alternative under which the amount of bycaught chinook salmon might be expected to increase (by 5%).

The two species that would have predicted increases in bycatch levels in the Aleutian Islands Atka mackerel fishery under Alternative 3 were Pacific halibut (9% increase), and chinook salmon (64% increase). It should be noted that the baseline number for chinook salmon in the Atka mackerel fishery is 266 fish, so that a 64% increase would not result in a substantial number of chinook salmon.

4.5.1.4 Effects of Alternative 4 on Prohibited Species Bycatch in the BSAI

The complicated pattern of closure areas under Alternative 4 makes it difficult to explain the impacts that specific fisheries closures have on bycatch. Generally, less of the area where salmon and herring are bycaught remains closed, so that there is a predicted increase in other salmon bycatch of 7% and in herring bycatch of 16% in the pollock fishery. Chinook salmon bycatch on the other hand had an expected decrease of 9%, probably due to the 10 nm buffer zone in the vicinity of Unimak Island. The bycatch of all other species in the pollock fishery were predicted to decrease under this alternative (with the exception of other king crab bycatch, but again, existing and future management measures should keep the bycatch of crab in the pollock fisheries to a minimum).

In the fisheries for Pacific cod, Pacific halibut, Tanner crab (*C. bairdi*), chinook salmon and other salmon bycatch would all be expected to be reduced under this alternative (by 11%, 30%, 25%, and 8%, respectively). The bycatch of all other species would likely increase slightly, with higher level of 18% increase in other king crab bycatch. The 16% increase in herring is minimal due to the 1 mt of baseline bycatch.

The Atka mackerel fishery would have expected reductions of all species under Alternative 4 with the exception of an increase in the bycatch of other king crab by 23%.

4.5.1.5 Effects of Alternative 5 on Prohibited Species Bycatch in the BSAI

Alternative 5 increases the restrictions on trawl gear compared to Alternative 1, by including 10 or 20 nm buffers around 70 haulouts to be closed to pollock trawling. The percentage changes are relatively small in the pollock fishery, and the bycatch of Pacific herring and chinook salmon would be expected to decrease by 9% and 6%, respectively, with a small predicted increase in other salmon bycatch of 1%.

Similarly, the predicted changes in bycatch are small in the Pacific cod fishery with the highest percent changes being a 5% decrease in the bycatch of both Tanner crab (*C. bairdi*) and chinook salmon.

The expected effects on the Atka mackerel fishery are identical to those presented under 4.5.1.1 above.

4.5.1.6 Summary of Effects on Prohibited Species Bycatch in the BSAI

An explanation of the criteria used to describe the significance of impacts is summarized in Table 4.5-2. The significance of the predicted effects of the alternatives on prohibited species bycatch are presented in Table 4.5-3 for the Bering Sea pollock and Pacific cod fisheries, and 4.5.1.6-3 for Aleutian Islands Atka mackerel fisheries.

Chinook and other salmon are bycaught almost exclusively by trawl fisheries. The bycatch in the Aleutian Islands is considered insignificant, regardless of the alternative because of low bycatch numbers. Most of the alternatives resulted in expected decreases in salmon bycatch. The highest increase in chinook salmon bycatch was 5% under any alternative, and the highest predicted increase in other salmon was 7% under any alternative. Increases of this magnitude would not be practically detectable in the range of bycatch levels experienced in recent years, and are therefore, insignificant.

The bycatch of halibut in the BSAI is managed under caps allocated to specific fisheries, often on a seasonable basis. Since the bycatch of halibut is managed, it is not expected that bycatch levels would exceed historic or proscribed levels. The impacts of increased bycatch would therefore impact the fishery experiencing the higher bycatch and not the halibut resource itself.

Red king crab are intercepted primarily in Zone 1 of the Bering Sea, and bycatch levels are managed by a PSC cap for trawl fisheries in that area. The total estimated abundance of Bristol Bay red king crab in 2000 was 33.3 million crab (NMFS 2000d). Assuming that bycatch would need to exceed at least 1% of the population to be considered significant, 333,000 crab would need to be bycaught. Based on historical bycatch rates, this amount should not be approached. In addition, the existing Zone 1 PSC cap for red king crab is 89,725 crab for all fisheries combined, and the Pacific cod trawl allocation is 11,664 crab (Table 3.5-1). These caps would prevent the bycatch of red king crab from approaching significant levels, but would impact fisheries though directed fishery closures due to PSC cap attainment.

Similarly, Tanner (*C. bairdi*) and other Tanner (*C. opilio*) bycatch levels are managed by zonal caps in the Bering Sea. The total estimated abundance for Tanner (*C. bairdi*) crab in the Eastern Bering Sea was 36.7 million crab (NMFS 2000d). The Zone 1 cap for Tanner crab was set at 675,250 crab in 2001, and the Zone 2 cap at 1,914,750 crab (Table 3.5-4). The Pacific cod fishery allocation was 136,400 crab in Zone 1 and 225,941 crab in Zone 2 for a total PSC allotment of 362,341 crab, or approximately 1% of the overall 2000 estimated population. The baseline catch of Tanner crab in the Pacific cod fishery was approximately 175,000 crab, and the highest percentage of expected increase under any alternative was 41% which would still be well below the PSC cap, and thus insignificant. The opilio cap was set at 4,023,750 crab for all fisheries, and at 24,736 crab for the Pacific cod trawl fishery (Table 3.5-5). The baseline catch of 560,926 is above this level, however, not all of the catch contributing to the baseline is from the trawl fishery. The highest increase in bycatch would lead to an earlier attainment of the cap triggering the closure of the C. Opilio Bycatch Limitation Zone, but should not lead to an increased bycatch of crab beyond the cap.

The overall bycatch limit for Pacific herring was set at 1% of the estimated Bering Sea biomass, or 1,525 mt in 2001 (Table 3.5-1), with 1,184 mt allocated to the pelagic pollock trawl fishery, the primary interception fishery for herring. Exceeding the PSC cap for Pacific herring results in the closure of seasonal Herring Savings Areas, designed to reduce further herring bycatch. The baseline bycatch of herring as a two-year average was 804 mt in the pelagic pollock fishery (Table 4.5-1). The highest predicted percent increase in herring bycatch of 16% would not result in the herring cap being reached and the closure being triggered.

Other king crab do not have bycatch restrictions other than protection of Blue king crab in the vicinity of the Pribilof Islands in the Pribilof Habitat Conservation Area that was designed to offer protection to their rearing halibut from trawl effects. Although there is a projected increase of 101% under Alternative 2 in the pollock fishery, the numbers are low, and pollock has been redefined to ban the use of non-pelagic trawl gear, so the impact is insignificant under this alternative. Elsewhere, other king crab bycatch has been low enough to be insignificant.

Bycatch levels in the Aleutian Islands subarea are low in the Atka mackerel fishery and the predicted changes in bycatch levels would be considered insignificant, although some are shown as conditionally significant in Table 4.5-4.

Table 4.5-2 Criteria used to describe significance of impacts on prohibited species bycatch

Issue	Effect	Significant	Conditionally Significant* (beneficial)	Conditionally Significant* (adverse)	Insignificant	Unknown
Salmon Bycatch	Direct	Substantial difference in bycatch (+->100%) removal	Marginally less (>-50%-99%) bycatch removed by trawl fisheries	Marginally more (>+50%-99%) bycatch removed by trawl fisheries	No substantial difference in bycatch (+-0-50%) removed by trawl fisheries	Insufficient Information Available
Halibut Bycatch	Direct	Substantial difference in bycatch (+->100%) removal	Marginally less (>-50%-99%) bycatch removed by all fisheries	Marginally more (>+50%-99%) bycatch removed by all fisheries	No substantial difference in bycatch (+-0-50%) removed by all fisheries	Insufficient Information Available
Herring Bycatch	Direct	Substantial difference in bycatch (+->100%) removal	Marginally less (>-50%-99%) bycatch removed by trawl fisheries	Marginally more (>+50%-99%) bycatch removed by trawl fisheries	No substantial difference in bycatch (+-0-50%) removed by trawl fisheries	insufficient Information Available
Crab Bycatch	Direct	Substantial difference in bycatch (+->100%) removal	Marginally less (>-50%-99%) bycatch removed by all fisheries	Marginally more (>+50%-99%) bycatch removed by all fisheries	No substantial difference in bycatch (+-0-50%) removed by all fisheries	Insufficient Information Available
Spatial Temporal Concentration of Bycatch	Direct	Substantially more or less concentration of fisheries bycatch	Marginally less concentration of all fisheries bycatch	Marginally more concentration of all fisheries bycatch	Same concentration of fisheries bycatch	Insufficient Information Available
Prey Competition	Indirect	Substantial biomass removal (+/-) of by all fisheries	Marginally less biomass removal of prey by all fisheries	Marginally more biomass removal of prey by all fisheries	No substantial difference in prey biomass removal by all fisheries	Insufficient Information Available

Note: Almost the entire bycatch of herring and salmon are taken in trawl fisheries, whereas the bycatch of crab and halibut are taken by multiple gear types.

*The "Conditionally Significant" category reflects both defined criteria and a level of uncertainty in estimating effects.

Table 4.5-3 Summary of effects of Alternatives 1 through 5 on prohibited species bycatch (pollock and Pacific cod) in the Bering Sea.

Species/Species Group	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Halibut	I	I	I	I	I
Herring	I	CS-	I	I	I
Chinook Salmon	I	CS+	I	I	I
Other Salmon	I	CS+	I	I	I
Red King Crab	I	I	I	I	I
Tanner Crab	I	I	I	I	I
Other Tanner Crab	I	I	I	I	I
Other King Crab	I	CS-	I	I	I
Spatial Temporal Concentration of Bycatch - BSAIAll Species	I	I	I	I	I
Prey Competition	I	I	I	I	I

S = Significant, CS = Conditionally Significant, I = Insignificant, U = Unknown, + = positive, - = negative

Table 4.5-4 Summary of effects of Alternatives 1 through 5 on prohibited species bycatch (Atka mackerel) in the Aleutian Islands.

Species/Species Group	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Halibut	I	I	I	I	I
Herring	I	CS+	CS+	I	I
Chinook Salmon	CS+	CS+	CS-	CS+	CS+
Other Salmon	I	I	I	I	I
Red King Crab	I	I	I	I	I
Tanner Crab	I	I	I	I	I
Other Tanner Crab	I	CS+	CS+	CS+	I
Other King Crab	I	I	I	I	I
Spatial Temporal Concentration of Bycatch - BSAI All Species	I	I	I	I	I
Prey Competition	I	I	I	I	I

S = Significant, CS = Conditionally Significant, I = Insignificant, U = Unknown, + = positive, - = negative

4.5.2 Gulf of Alaska

Sections 4.5.2.1 - 4.5.2.5 below describing the effects of each alternative on Gulf of Alaska (GOA) Area bycatch will refer to Table 4.5.2-1 which presents the percentage change in bycatch levels expected under each of the alternatives. A description of the data and analysis used in the creation of Table 4.5.2-1 are provided in section 4.5.1 above. The baseline bycatch amounts for herring, other Tanner crab, and red king crab are very small. Since there are no bycatch limits on these species in the GOA, the bycatch is generally low, and was low during the years included in the analysis, the expected effects due to the alternatives for these species will not be discussed. The only species with a prohibited species bycatch limit in the GOA is halibut.

Table 4.5-5 The estimated change in bycatch levels in the GOA when compared to the average estimated from 1997 and 1999.

Pollock Fishery Catch of 104,095 Tons **Stock**	**Alt.1**	**Alt.2**	**Alt.3**	**Alt.4**	**Alt.5**	**Baseline Catch**
Herring	1%	-31%	-8%	-2%	6%	15
Halibut	0%	51%	3%	8%	13%	37
C. bairdi Crab	4%	-49%	9%	15%	-19%	1,967
Other Tanners	35%	-100%	19%	60%	40%	4
Red King Crab	1%	-100%	19%	20%	31%	11
Chinook Salmon	2%	-49%	11%	6%	14%	20,013
Other Salmon	3%	-45%	12%	-11%	-1%	7,036

Pacific Cod Fishery Catch of 72,841 Tons **Stock**	**Alt.1**	**Alt.2**	**Alt.3**	**Alt.4**	**Alt.5**	**Baseline Catch**
Herring	3%	-92%	45%	17%	2%	0
Halibut	0%	6%	14%	1%	0%	878
C. bairdi Crab	1%	10%	7%	12%	2%	52,517
Other Tanners	-2%	25%	-65%	-49%	1%	1,642
Red king Crab	3%	51%	46%	18%	2%	14
Other King Crab	30%	90%	43%	49%	30%	40
Chinook Salmon	7%	-33%	38%	2%	7%	778
Other Salmon	3%	30%	46%	13%	3%	597

Note: Baseline units for crabs and salmon are in numbers; all other species are in metric tons. Note that other Tanners are mainly *C. opilio* crab, and other salmon are primarily chum salmon.
Source: NMFS catch by vessel database (same as used to prepare Appendix E).

4.5.2.1 Effects of Alternative 1 on Prohibited Species Bycatch in the GOA

As was the case in the BSAO (4.5.1.1), Alternative 1 is the most similar to the fishing conditions in place during the period 1997 - 1999, so that small percentage changes in bycatch levels would be expected. There was no expected change in halibut bycatch under Alternative 1 in either the pollock or Pacific cod fisheries.

Chinook salmon and other salmon had small predicted increases in bycatch (2% and 3%, respectively, in the pollock fishery, and 7% and 3%, respectively, in the Pacific cod fisheries) under this alternative.

Tanner (*C. bairdi*) crab bycatch was expected to increase marginally (1%) under Alternative 1 in the Pacific cod fisheries.

4.5.2.2 Effects of Alternative 21 on Prohibited Species Bycatch in the GOA

Alternative 2 prohibits trawling in the largest amount of area across the five alternatives in the GOA in the pollock fishery. The pollock fishery is prosecuted exclusively with trawl gear, and this alternative predicts the greatest change in bycatch percentages in the pollock trawl fishery.

Halibut bycatch was predicted to increase by 51% in the pollock fishery under Alternative 2. However, the baseline catch amount in this fishery is low (37 mt), and recent changes in the pollock fishery (non-pelagic trawl ban, see 4.5.1 above) would maintain low bycatch levels in this fishery. There was a predicted increase in halibut bycatch of 6% in the Pacific cod fisheries.

Alternative 2 is expected decrease the bycatch of all other species in the pollock fishery. The alternative is expected to reduce chinook salmon bycatch in both the pollock and Pacific cod fisheries (49% and 33%, respectively). Other salmon bycatch was expected to decrease in the pollock fishery by 45% and increase in the Pacific cod fishery by 30%, although the baseline bycatch numbers for this fishery are low.

The bycatch of Tanner (*C. bairdi*) crab would be expected to increase by 10% in the Pacific cod fisheries under this alternative.

4.5.2.3 Effects of Alternative 3 on Prohibited Species Bycatch in the GOA

Alternative 3 closes entire areas to all fisheries, and thus has the highest predicted changes in the Pacific cod fishery bycatch levels (the largest area closure for the pollock fishery was under Alternative 2).

Predictions under Alternative 3 led to expected increases in all bycatch species with the exception of a decrease in Pacific herring bycatch (8%) in the pollock fishery and a decrease in Tanner (*C. bairdi*) crab (65%) in the Pacific cod fisheries.

Based on the historic data, increases of 9%, 11% and 12% were predicted for Tanner crab, chinook salmon, and other salmon, respectively in the pollock fishery. The predicted percentage increases in halibut, chinook salmon, and other salmon bycatch were the highest of any alternative in Alternative 3 for the Pacific cod fisheries. Halibut was expected to increase by 14%, and chinook salmon and other salmon were expected to increase by 38% and 46%, respectively in the Pacific cod fishery under Alternative 3. The increased halibut bycatch would be expected to lead to an earlier closure for one or more of the Pacific cod fisheries, depending on PSC cap levels.

4.5.2.4 Effects of Alternative 4 on Prohibited Species Bycatch in the GOA

Under the complex scenarios of Alternative 4, halibut and chinook salmon bycatch would be expected to increase by 8% and 6%, respectively in the pollock fishery, and other salmon bycatch would be expected to decrease by 11%.

Tanner crab bycatch in the pollock fishery would be expected to increase by 15% were the ban on non-pelagic gear not in effect in the future.

Halibut and chinook salmon bycatch would be relatively unchanged from the baseline under Alternative 4 in the Pacific cod fisheries (1% increase in halibut and 2% increase in chinook salmon bycatch).

Tanner (*C. bairdi*) crab bycatch would be expected to increase by 12% under Alternative 4 in the Pacific cod fisheries, and other salmon bycatch might increase by 13%.

4.5.2.5 Effects of Alternative 5 on Prohibited Species Bycatch in the GOA

Alternative 5 increases the area closed to pollock trawling compared to the baseline years of 1997-1999 by closing areas outside of specified haulouts. This would be expected to increase chinook salmon bycatch by 14% and decrease other salmon bycatch slightly by 1%. The predicted increase in halibut bycatch of 13% would be precluded by the recent ban on non-pelagic trawling.

Alternative 5 is similar in the Pacific cod to the measures in existence when the data was collected. The changes in bycatch levels in the Pacific cod fisheries area marginal.

4.5.2.6 Summary of Effects on Prohibited Species Bycatch in the GOA

An explanation of the criteria used to describe the significance of impacts is summarized in Table 4.5.2.6-1. The significance of the predicted effects of the alternatives on prohibited species bycatch are presented in Table 4.5.2.6-2 for the Gulf of Alaska. .

The bycatch rates for prohibited species in the GOA are low, and the only prohibited species bycatch that is actively managed through caps is that for Pacific halibut. The 2,000 mt trawl halibut mortality cap would trigger fishery closures that would prevent the cap from being exceeded. None of the bycatch levels would be expected to be significant for any prohibited species.

Table 4.5-6 Criteria used to describe significance of impacts on prohibited species bycatch

Issue	Effect	Significant	Conditionally Significant* (beneficial)	Conditionally Significant* (adverse)	Insignificant	Unknown
Salmon Bycatch	Direct	Substantial difference in bycatch (+->100%) removal	Marginally less (>-50%-99%) bycatch removed by trawl fisheries	Marginally more (>+50%-99%) bycatch removed by trawl fisheries	No substantial difference in bycatch (+-0-50%) removed by trawl fisheries	Insufficient Information Available
Halibut Bycatch	Direct	Substantial difference in bycatch (+->100%) removal	Marginally less (>-50%-99%) bycatch removed by all fisheries	Marginally more (>+50%-99%) bycatch removed by all fisheries	No substantial difference in bycatch (+-0-50%) removed by all fisheries	Insufficient Information Available
Herring Bycatch	Direct	Substantial difference in bycatch (+->100%) removal	Marginally less (>-50%-99%) bycatch removed by trawl fisheries	Marginally more (>+50%-99%) bycatch removed by trawl fisheries	No substantial difference in bycatch (+-0-50%) removed by trawl fisheries	insufficient Information Available
Crab Bycatch	Direct	Substantial difference in bycatch (+->100%) removal	Marginally less (>-50%-99%) bycatch removed by all fisheries	Marginally more (>+50%-99%) bycatch removed by all fisheries	No substantial difference in bycatch (+-0-50%) removed by all fisheries	Insufficient Information Available
Spatial Temporal Concentration of Bycatch	Direct	Substantially more or less concentration of fisheries bycatch	Marginally less concentration of all fisheries bycatch	Marginally more concentration of all fisheries bycatch	Same concentration of fisheries bycatch	Insufficient Information Available
Prey Competition	Indirect	Substantial biomass removal (+/-) of by all fisheries	Marginally less biomass removal of prey by all fisheries	Marginally more biomass removal of prey by all fisheries	No substantial difference in prey biomass removal by all fisheries	Insufficient Information Available

Note: Almost the entire bycatch of herring and salmon are taken in trawl fisheries, whereas the bycatch of crab and halibut are taken by multiple gear types.
*The "Conditionally Significant" category reflects both defined criteria and a level of uncertainty in estimating effects.

Table 4.5-7 Significance of impacts of the alternatives on prohibited species bycatch in the GOA.

Species/Species Group	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Halibut	I	I	I	I	I
Herring	I	I	I	I	I
Chinook salmon	I	I	I	I	I
Other salmon	I	I	I	I	I
Red king crab	I	I	I	I	I
Tanner crab	I	I	I	I	I
Other tanner crab	I	I	I	I	I
Other king crab	I	I	I	I	I
Spatial Temporal Concentration of Bycatch - BSAIAll Species	I	I	I	I	I
Prey Competition	I	I	I	I	I

S = Significant, CS = Conditionally Significant, I = Insignificant, U = Unknown, + = positive, - = negative

The West Coast Groundfish Harvest Policy Workshop

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Along the west coast of the continental United States, which includes the States of California, Oregon, and Washington, the Pacific Fishery Management Council has the authority to promulgate fishery management regulations for salmon, groundfish, coastal pelagic, and highly migratory stocks of fish within the Exclusive Economic Zone. That authority originated with the passage of the Magnuson-Stevens Fishery Conservation and Management Act of 1976, although all regulatory actions by the Council are ultimately subject to approval by the National Marine Fisheries Service. Since a functional management system was first implemented in the early 1980s, it has been the Council's practice to manage groundfish stocks using a quota management system that requires the scientific determination of an acceptable biological catch (ABC) and, based on that, an optimum yield (OY).

Furthermore, up until 1998 it was the policy of the Council to set the ABCs of groundfish stocks by simply applying the fishing mortality rate that produces maximum sustainable yield (F_{MSY}) to an estimate of exploitable biomass. Policies of this kind are termed constant rate policies because, once the estimate of F_{MSY} is determined, the annual ABC is strictly proportional to estimates of exploitable biomass. However, owing to short data series and other technical issues, it generally was not possible to obtain reliable estimates of F_{MSY} for any groundfish stock. Consequently, during the 1980s and into the early 1990s, several common surrogate or proxy estimates of F_{MSY} were used (e.g., $F_{0.1}$ or F=M).

Clark (1991) originally proposed the $F_{35\%}$ harvest rate as a general and rational surrogate fishing rate. $F_{35\%}$ is the fishing mortality rate that reduces the spawning potential *per recruit* to 35% of the unfished level. If fecundity is directly proportional to individual female weight, it is also the rate of fishing that reduces the spawning biomass *per recruit* to 35% of what would exist in the absence of fishing. Clark showed that this rate is easily calculated from basic biological information and that it would produce a yield close to MSY for a range of life history parameters and productivity relationships, covering an array of well-studied groundfish stocks with long histories of exploitation, most of which were Atlantic stocks. He also showed that $F_{35\%}$ was very close to both $F_{0.1}$ and F=M when the schedules of recruitment and maturity coincided, and that $F_{35\%}$ was sensibly higher or lower when these schedules differed. In a second paper he extended the original analysis to cases with random and serially correlated recruitment variation (Clark 1993) and, based on those refinements, concluded that $F_{40\%}$ was a better proxy for F_{MSY} than $F_{35\%}$. Mace (1994) also recommended the use of $F_{40\%}$ on the basis of deterministic calculations. Based on productivity determinations worldwide, the current scientific consensus now indicates that $F_{40\%}$ is a reasonable harvest rate to use for stocks with unknown productivity parameters, at least in the initial stages of fishery development.

According to prevailing theories of stock population dynamics, harvesting at a constant rate equal to F_{MSY} will result in stock biomass approaching an equilibrium point that is equal to B_{MSY}. Importantly, if the fishing rate is held constant, the population's trajectory during the transition to the B_{MSY} equilibrium will generally be asymptotic, with the expected annual decrement (or increment) in stock biomass becoming progressively reduced over time. While a stock fished persistently at $F_{40\%}$ would not necessarily approach the stock size producing MSY, if the proxy harvest rate is reasonable it should be attracted to a biomass equilibrium somewhere in the range of 25-50% of the unexploited population level (B_0). That is why Clark (1991) suggested $B_{40\%}$[1] as a robust alternative biomass-based proxy for guiding management in the absence of credible stock-specific information.

Declines of Pacific Coast Stocks Fished at $F_{35\text{-}40\%}$

During the mid-1990s it became increasingly apparent that many groundfish stocks were not approaching an equilibrium above $B_{20\%}$. Ralston (1998) showed that a number of Pacific coast rockfish stocks (*Sebastes* sp.) had declined to alarmingly low levels, contributing to concerns about the validity of the Pacific Council's use of $F_{35\%}$ as a proxy for F_{MSY}. His findings, as well as analyses conducted during the preparation of Amendment 11 to the Groundfish Fishery Management Plan (PFMC 1998), led to a series of informal meetings that focused on the relative productivity of west coast groundfish stocks.

Ultimately, due to continued concern over declining trends in groundfish stocks, and their apparent inability to sustain historical harvest rates, the Council's Scientific and Statistical Committee (SSC) sponsored a formal workshop to evaluate the issue and to make recommendations to the Council concerning the suitability of the Council's default groundfish harvest rates, which in 1998 had been changed from $F_{35\%}$ to $F_{40\%}$ for *Sebastes* spp., but remained at $F_{35\%}$ for all other stocks. The West Coast Groundfish Harvest Rate Policy Workshop was held from March 20-23, 2000 at the Alaska Fishery Science Center in Seattle, Washington. The format of the meeting consisted of a series of 12 presentations by interested scientists that were made to a panel of three SSC and three outside

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[1] $B_{40\%}$ is equal to $0.4 \times B_0$, i.e., 40% of the absolute unexploited population size. Note that $F_{40\%}$ is the fishing mortality rate that reduces spawning potential *per recruit* to 40% of the unfished condition. If recruitment is unaffected by fishing, a population will approach $B_{40\%}$ when fished at $F_{40\%}$; however, if recruitment declines due to the effects of fishing (a plausible scenario), the population will approach a biomass equilibrium that is something less than $B_{40\%}$.

reviewers. The panel evaluated and considered all of the oral and written material presented at the workshop, as well as other information available in the published scientific literature, and issued a report, which supported the consensus finding that groundfish harvest rates should be reduced[2].

The scientific papers included here include all but two of the working documents that were prepared for the workshop. The broad range in topics addressed (e.g., meta-analysis, surplus production modeling, statistical bias, discard, etc.) allowed a wide-ranging discussion of the issues, which were nonetheless focused primarily on the appropriateness of existing harvest rates. Ultimately, the Council adopted a revised set of harvest rates for west coast groundfish that reflected the apparent low productivity of these stocks, at least over the last two decades.

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[2] Ralston, S., J. R. Bence, W. G. Clark, R. J. Conser, T. Jagielo, and T. J. Quinn II. 2000. West Coast Groundfish Harvest Rate Policy Workshop – Panel Report, 10 p. [available upon request]

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SCIENTIFIC AND STATISTICAL COMMITTEE STATEMENT ON DEFAULT MAXIMUM SUSTAINABLE YIELD FISHING RATE WITHIN THE HARVEST RATE POLICY

Due to concern over declines in West Coast groundfish populations, and the inability of those stocks to sustain historical harvest rates, the Scientific and Statistical Committee (SSC) sponsored a workshop to evaluate the issue and to make recommendations to the Pacific Fishery Management Council (PFMC) concerning the suitability of the Council's default harvest rates. The West Coast Groundfish Harvest Rate Policy Workshop was held from March 20-23, 2000 at the Alaska Fishery Science Center in Seattle, Washington (Terms of Reference are presented in Appendix A). The format of the meeting consisted of a series of 12 presentations by interested scientists, which were made to a panel of three SSC and three outside reviewers. The panel evaluated and considered all of the oral and written material presented at the workshop, as well as other information available in the published scientific literature, and issued a Panel Report (Appendix B). The Panel Report was available at the PFMC meeting in April, 2000 and the whole SSC provided preliminary comment on the findings of the workshop at that time. In particular, the SSC's initial review supported the panel's consensus findings that groundfish harvest rates should be reduced.

Having had the opportunity to examine the Panel Report in detail, the SSC agrees with the panel's recommended "risk-neutral" proxies for F_{msy}. Namely,

Sebastes and *Sebastolobus*	$F_{50\%}$
Pacific whiting	$F_{40\%}$
Flatfishes	$F_{40\%}$
Other groundfish	$F_{45\%}$
"Remaining Rockfish"	0.75 M

Due to the apparent low productivity of west coast groundfish stocks, the SSC recommends that harvest rates be reduced to these levels to support risk-neutral management, and to even lower harvest rates to support risk-averse or precautionary management. According to the best available scientific information at this time, these fishing mortality rates should be viewed as harvest rates that will produce the maximum sustainable yields (MSY) for the stock complexes in question. They represent proxies for F_{msy} because they are based on information summarized from a wide variety of stock-specific analyses and they are applied generically within each group. One problem with this approach is that, within each complex, one would expect some stocks to be overfished and some stocks to be underutilized. As more information becomes available, and credible analysis supports it, the SSC recommends that species-specific analyses of productivity be conducted whenever possible.

Because these values are properly considered risk-neutral (i.e., they are just as likely to overestimate as underestimate the actual F_{msy} rate), the issue of precautionary adjustments has been raised. Precautionary adjustments to harvest control rules are appropriate when the repercussions of over-harvesting a resource are less acceptable than under-harvesting it. Within the context of setting west coast groundfish catch levels, it is important to identify where and when precautionary adjustments are incorporated, to insure a proper understanding of the process by all concerned.
Under current Council procedures, catch levels are set based on guidelines provided in Amendment 11 to the groundfish Fishery Management Plan (FMP). Specifically, language in that amendment states:

> "In general, ABC will be calculated by applying $F_{35\%}$ (or $F_{40\%}$ or other established MSY proxy) to the best estimate of current biomass."

Note that the effect of the recommended revisions to the default harvest rate proxies (see above) will be realized here and here only, i.e., in the calculation of the Allowable Biological Catch (ABC). However, the FMP also states:

> "Reduction in catches or fishing rates for either precautionary or rebuilding purposes is an important component of converting values of ABC to values of OY."

"For category 1 species, in addition to the overfished/rebuilding threshold, a precautionary threshold is established. The default value will be 40% of mean $B_{unfished}$. This level of biomass is expected to be near B_{msy}, and if abundance is between the overfished/rebuilding threshold and the precautionary threshold, a precautionary reduction in harvest will implemented [*sic*] to avoid further declines in abundance."

The harvest control rule used to specify the amount of precautionary reduction is the "40-10" policy, which states that OY declines linearly from OY=ABC at $B_{40\%}$ to OY=0 at $B_{10\%}$ (see glossary in Appendix C for definitions). For stock sizes that are greater than $B_{40\%}$, no precautionary adjustment is required (i.e., OY=ABC). In addition, Amendment 11 stipulates:

"Uncertainty adjustments: In cases where there is a high degree of uncertainty about the biomass estimate and other parameters, OY may be further reduced accordingly."

From these citations it is clear that, at this time, the primary form of precautionary adjustment to be made in the setting of OYs for west coast groundfish is through use of the "40-10" harvest control rule. No further precautionary reduction in harvest rate *per se* is required, beyond the reduction required to meet the harvest policy itself. However, the FMP allows for additional reductions in OY in situations where there is a high degree of uncertainty, particularly about stock size. Improvements in the analytical software available to stock assessment scientists now permit a much better characterization of the statistical uncertainty in the estimated size of exploited stocks and it is increasingly possible to generate more realistic confidence intervals (i.e., biomass ± ***xx***% with 95% certainty). In situations where "***xx***" is large, uncertainty is high and the likelihood of severely overestimating stock size is not inconsequential. Therefore, it may often be prudent to further reduce OY when stock size has been estimated imprecisely, although this apparently is not required by Amendment 11.

It would be possible to modify the Council's current harvest control rule, i.e. the "40-10" rule, so as to automatically undertake "uncertainty adjustments" that would be based on the statistical imprecision in the estimation of stock size, i.e., the greater the level uncertainty (***xx*** above), the greater the reduction in OY. Undoubtedly the development of such a rule to more fully embrace the precautionary principle would require significant analytical work. But fundamentally, a decision to lower risk when uncertainty is great reduces to a policy decision, akin to the choices made by a portfolio manager investing in the stock market. Namely, how does one value the risks of stock collapse against the rewards of higher yields. On this spectrum of risk and return, the Council properly exercises its judgement and authority. We note that this type of adjustment for "uncertainty" is not presently codified into a control rule, like the "40-10" policy, although that is something the Council may wish implement at some point in the future, with assistance from the SSC and/or GMT. If the Council wishes to pursue the issue of further precautionary adjustments to the "40-10" harvest control rule (to incorporate uncertainty in stock size estimates), the SSC recommends a two-step procedure:

(1) The North Pacific Fishery Management Council (NPFMC) has been incorporating a precautionary adjustment to their harvest control rule that incorporates uncertainty in stock size estimates. In the near future, invite the NPFMC SSC Chair to discuss this policy with the PFMC SSC and full Council.

(2) Convene a scientific workshop (similar in scope to the recent SSC-convened Harvest Rate Policy Workshop) to address the analytic procedures and methods, and to prepare a report to the SSC addressing the full range of scientific and implementation issues involved.

Although the "40-10" harvest control rule automatically results in some precautionary (or risk-averse) adjustment for Category 1 species (i.e., those stocks that have been fully assessed and have time series of biomass and recruitment), there are other stocks with less information available for management purposes. For example, how does one implement precautionary adjustments for the "remaining rockfish" category? If the new F_{MSY} proxies (see above) are approved by the Council, the ABCs for those stocks will now be calculated using a risk-neutral harvest rate equal to 0.75 M.

We draw the Council's attention to text within the current 1999 SAFE document, which states:

> "For 1999 the Council endorsed the GMT's proposal to reduce the remaining rockfish component by 25% (i.e., to 75% of the current level) and the other rockfish component by 50%. These reductions of 25% and 50% were based on suggested target catch levels for data-poor situations from Restrepo *et al.* (1998. Technical Guidance on the Use of Precautionary Approaches to Implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act. Draft NOAA Tech. Memo.). This technical guidance suggests a 25% reduction for stocks above the B_{msy} level and a 50% reduction for stocks between the minimum stock size threshold (i.e., the overfished/rebuilding threshold) and the B_{msy} level. The GMT recommends continuation of this reduction."

The Council may, therefore, wish to consider maintaining a *status quo* percentage reduction in setting the OYs of the "remaining" and "other" rockfish. The old, risk-neutral, harvest rate for the remaining rockfish was 1.00 M, which was reduced to 0.75 M as a precautionary measure, amounting to a 25% reduction off of the ABC. An equivalent 25% precautionary reduction from ABC to OY under the new proposed rate would be ABC = 0.75 M·B and OY = 0.56 M·B.

As one of two alternatives to this *status quo* percentage reduction option, Walters and Parma[1] have stated:

> "Patterson's (1992) finding that pelagic stocks have generally been able to sustain exploitation rates of approximately only 0.5 to 1 times the natural mortality rate, as predicted from some modeling studies (reviewed in Patterson 1992), appears to work for demersal species as well. A worrisome point about the Patterson (1992) finding is that the popular $F_{0.1}$ harvest rate, which usually implies $F \approx M$ and is generally considered to be quite conservative (Deriso 1987), may in fact be too high for the majority of natural populations. Because underestimation of the optimal exploitation rate for long-lived species is not particularly costly ... , we consider the prudent approach to assume $\mu_o \leq 0.5$ M [μ_o is the optimal harvest rate] and to place the burden of proof on whoever advocates a higher rate to demonstrate that it is sustainable (by substantial direct analysis of historical stock-recruit data)."

Based on the arguments of these leading authorities, the Council may want to consider a more conservative precautionary adjustment of the risk-neutral ABC = 0.75 M·B policy for the remaining rockfish to a policy of OY = 0.5 M·B.

A third approach to implementing precautionary management for the remaining rockfish might be to utilize the "risk-averse" results presented in Dorn's harvest policy workshop paper (see Workshop Agenda, pg. 13 of Panel Report [Appendix B]): Advice on west coast rockfish harvest rates from Bayesian meta-analysis of stock-recruit dynamics). He showed that for west coast *Sebastes* stocks, exclusive of Pacific ocean perch, optimal risk-neutral SPR harvest rates were in the range of $F_{45\%}$-$F_{54\%} \approx F_{50\%}$ (see above). In contrast, the equivalent risk-averse SPR harvest rates[2] were in the range $F_{47\%}$-$F_{57\%} \approx F_{52\%}$, which amounts to a 7% reduction in harvest rate. This option would embrace a relatively small amount of precaution in the setting of the optimum yields of the remaining rockfish at OY = 0.70 M·B.

In the following summary table, the SSC-recommended risk-neutral proxies for F_{MSY} and precautionary adjustments to the harvest rates are provided, and compared to the status quo. Note, however, that these precautionary adjustments (both "SSC-Recommended" and "Status Quo") do not fully incorporate the uncertainty in stock size estimation, as described above.

Risk-Neutral Proxies for F_{MSY} and Precautionary Harvest Rates

	—SSC Recommended—		—Status Quo—	
	Risk-Neutral	Precautionary F based on:	Risk-Neutral	Precautionary F based on:
Sebastes and *Sebastolobus*	$F_{50\%}$	40-10	$F_{40\%}$?	40-10
Pacific whiting	$F_{40\%}$	40-10	$F_{40\%HYBRID}$	40-10
Flatfishes	$F_{40\%}$	40-10	$F_{35\%}$	40-10
Other groundfish	$F_{45\%}$	40-10	$F_{35\%}$	40-10
"Remaining Rockfish"	0.75 M	0.5-0.7M	M	0.75M

[1] Walters, C., and A. M Parma. 1996. Fixed exploitation rate strategies for coping with effects of climate change. Can. J. Fish. Aquat. Sci. 53:148-158.

[2] Wherein $\lambda=0.5$ in the fishery loss function of Thompson, G. G. 1992. A Bayesian approach to management advice when stock-recruitment parameters are uncertain. Fish. Bull., U. S. 90:561-573.

APPENDIX A

The terms of reference of the workshop, as specified in the minutes of the November 1999 SSC meeting, were as follows:

> Recent scientific studies have suggested that the proxies currently used for West Coast groundfish may overestimate the true F_{msy} for these species. The SSC will convene a Harvest Rate Policy Review Workshop to address this issue. The review will be chaired by Dr. Steve Ralston of the SSC. It will be held at the National Marine Fisheries Service (NMFS) Alaska Fisheries Science Center (Seattle, Washington) during March 20-24, 2000.
>
> The formal review panel will consist of five scientists (in addition to the Chairman): (1) two additional SSC members; (2) two external experts; and (3) one expert from within the west coast groundfish scientific community. In addition, the Groundfish Management Team (GMT) and Groundfish Advisory Subpanel (GAP) will each designate one representative to contribute to the review, but the GMT and GAP representatives will not serve as formal panel members. The principal investigators involved in recent scientific studies on this issue will be invited to present their work to the review panel. The process will also be open for other scientists to present relevant work to the review panel (at the discretion of the Chairman).
>
> The terms of reference for the review panel are:
>
> - Review the current body of existing scientific work and any additional (relevant) work presented during the review panel meeting. All scientific contributions must be well documented with draft papers provided to the review panel in advance of the meeting.
> - Evaluate the appropriateness of the current Council F_{msy} proxies (i.e., $F_{40\%}$) for *Sebastes* species and $F_{35\%}$ for other groundfish.
> - Suggest procedures for incorporating uncertainty, risk, and the precautionary approach in establishing harvest rate policies.
> - Provide a comprehensive report to the SSC and the Council that clearly documents the findings and recommendations of the review panel.

APPENDIX B

Panel Report

West Coast Groundfish Harvest Rate Policy Workshop
AFSC, Seattle, Washington: March 20-23, 2000
Sponsored by the Scientific & Statistical Committee of the Pacific Fishery Management Council

Panel Report

Stephen Ralston (chairman), James R. Bence, William G. Clark,
Ramon J. Conser, Thomas Jagielo, and Terrance J. Quinn II.

Scientific and Management Background

Through 1998 the policy of the Pacific Fishery Management Council (PFMC) was to set the Allowable Biological Catch (ABC) of a stock by applying the fishing mortality rate that produces Maximum Sustainable Yield (F_{MSY}) to an estimate of exploitable stock biomass. Policies of this kind are termed constant rate policies because, once the estimate of F_{MSY} is determined, the annual ABC is strictly proportional to estimates of exploitable biomass. However, owing to short data series and other technical issues, it generally has not been possible to directly estimate F_{MSY} reliably for any stock. Consequently, during the 1980s and into the early 1990s, one of several common surrogate or proxy estimates of F_{MSY} was used (e.g., $F_{0.1}$ or F=M).

Clark (1991) proposed the $F_{35\%}$ harvest rate as a more general and rational surrogate rate. $F_{35\%}$ is the fishing mortality rate that reduces the spawning potential *per recruit* to 35% of the unfished level. By reasonably assuming that fecundity is proportional to average weight, it is the rate of fishing that reduces the spawning biomass *per recruit* to 35% of what would exist if there were no fishing. Clark showed that this rate would produce a yield close to MSY for a range of life history parameters and productivity relationships that were intended to cover the great majority of well-studied groundfish stocks with long histories of exploitation (most of which were Atlantic stocks). He also showed that $F_{35\%}$ was very close to both $F_{0.1}$ and F=M when the schedules of recruitment and maturity coincided, and were sensibly higher or lower when they differed. However, a later paper extended the original analysis to cases with random and serially correlated recruitment variation (Clark 1993), and concluded that $F_{40\%}$ would be a better choice overall than $F_{35\%}$. Mace (1994) also recommended $F_{40\%}$ on the basis of deterministic calculations. The current scientific consensus now indicates that $F_{40\%}$ is an appropriate default harvest rate for stocks with unknown productivity parameters.

The PFMC adopted $F_{35\%}$ as its standard surrogate in 1992, and switched to $F_{40\%}$ for *Sebastes* only in 1997, based principally on the conclusions of Clark (1993) and Mace (1994). In 1998 it then adopted the so-called "40-10" rule under Amendment 11 to the groundfish FMP. The 40-10 rule represented a departure from prior constant rate harvest policies, wherein the target fishing mortality rate is reduced for stocks whose biomass is below 40% of the estimated unfished biomass (B_0).

Common Confusion Over Relative Biomass and Relative Biomass per Recruit

In addition to recommending the $F_{35\%}$ strategy, Clark (1991) suggested a more robust biomass-based strategy that consists of simply maintaining spawning biomass at around 40% of the estimated unfished level. Perhaps partly because of the shared "40%" level, it is often supposed that the $F_{40\%}$ harvest rate will reduce spawning biomass to 40% of unfished biomass, but that is only true for stocks with highly resilient spawner-recruit relationships. For less resilient stocks, $F_{40\%}$ will reduce biomass to a lower level, possibly much lower, while still providing a yield near MSY. That is possible because yield is not very sensitive to equilibrium biomass over a wide range of biomass levels, so a yield near MSY can be obtained even when biomass is well below B_{MSY}. It is this feature of yield curves that makes it possible for a rate like $F_{40\%}$ to perform well in terms of yield over a wide range of spawner-recruit productivity curves. For some curves $F_{40\%}$ is well above F_{MSY} and for some of the curves it is well below, but in none of the cases considered is it so far above or below F_{MSY} that yield is much lower than MSY.

For the most likely sort of groundfish spawner-recruit relationships (i.e., asymptotic curves such as the Beverton-Holt model), and if other forms of stock compensation are negligible, B_{MSY} is likely to lie in the range of 25-40% of unfished biomass. Therefore, even if F_{MSY} was known and was implemented for a stock, the resulting biomass level would generally be less than 40% of B_0 on average. For some stocks, recruitment variations alone might then result in biomass levels falling below 25% of the unfished level, which is the overfished threshold as implemented in Amendment 11 to the groundfish FMP. Thus, fishing at $F_{40\%}$, which can be well above (or below) F_{MSY}, can be expected to result in biomass levels that are occasionally or on average very low for some stocks. Thus, given the new requirement of biomass-based overfished thresholds (Department of Commerce 1998), the relationship between harvest rates and biomass levels becomes more critical.

Declines of Pacific Coast Stocks Fished at $F_{35\text{-}40\%}$

Ralston (1998) showed that a number of Pacific coast rockfish stocks declined to low levels during the last two decades, contributing to concerns about the wisdom of the $F_{35\%}$ policy. His findings, as well as analyses conducted by the GMT during the preparation of Amendment 11, led to a series of workshops, including this latest review. This panel received a number of papers dealing with the productivity of the stocks in question and considered arguments for and against retaining the $F_{35\%}/F_{40\%}$ rate (in conjunction with the 40-10 rule) for all stocks.

We believe there are at least three possible factors that are responsible for the observed declines in groundfish stocks:

1. Normal operation of the $F_{35\%}/F_{40\%}$ strategy.

As explained above, either an $F_{35\%}$ or $F_{40\%}$ harvest rate will often lead to biomass levels that are well below what many people commonly expect, even when the rate is no larger than F_{MSY}. When it is larger, as will happen for some stocks, resulting biomasses can be very low. The important point is that both F_{MSY} and the proxy rate are calculated to achieve a certain level of yield, not biomass. In addition, harvesting at $F_{35\%}/F_{40\%}$ should be viewed as a risk-neutral policy in that, being a compromise intermediate rate, some stocks will be over-exploited and some stocks will be under-exploited, with no penalty imposed for over-exploitation.

2. Higher than intended harvest rates.

Recent assessments show that in many cases, actual fishing mortality rates were well above $F_{35\%}$. This can happen in any fishery when quotas are set on the basis of current biomass estimates, which are subsequently revised downward in a later assessment.

3. Apparently low productivity of Pacific coast stocks.

The spawner-recruit estimates that have accumulated over the last twenty years on Pacific coast groundfish stocks indicate very low resiliency in the spawner-recruit relationships — at or below the lowest values estimated for well-studied stocks elsewhere in the world (Myers *et al.* 1999). It is not surprising then, that the estimated productivity of these stocks is in many instances lower than the range of values considered plausible by Clark (1991) in his derivation of the $F_{35\%}$ strategy.

Because these low productivity estimates are so common among Pacific coast groundfish stocks, and so uncommon elsewhere, there is some suspicion that they result from some unrecognized flaw common to all of the Pacific coast groundfish assessments. However, with the exception of discards (see below), the panel has no reason to doubt the accuracy of west coast groundfish stock assessments. The same methods and models have produced estimates of higher productivity elsewhere (e.g., in Alaska). For the time being, therefore, we believe that all of the assessment results should be taken at face value, and that the Council's harvest strategy should be reconsidered in light of the apparently low productivity of many of the stocks.

The reason for anomalously low productivity in this region is not certain, but it may well be linked to the climatic regime shift that occurred in the eastern Pacific ocean around 1977-78. Since then, ocean conditions have been generally more favorable for many Alaskan stocks and have been less favorable for many Pacific coast stocks. Sometime in the future conditions on the west coast are likely to change again. Still, there is no assurance that this will occur in the near future and so, in the interim, the PFMC should manage groundfish stocks according to their current productive capacity.

The panel reviewed results presented by Williams (see Appendix A), which suggest that discards of small fish could contribute to the perception of low groundfish productivity. To the extent that this occurs, its effect is to reduce apparent recruitments and therefore to make ground-fish stocks appear to be less resilient. This scenario depends on: (1) an increasing exploitation rate over time and (2) substantial unaccounted for discarding of the smallest fish captured. While groundfish exploitation rates have certainly risen, and substantial unaccounted for discards of small fish is likely in some fisheries, discards are generally not documented for these stock and cannot be quantified at present. Clearly more research on this issue is desirable and, in general,

the panel stresses that a full accounting of total catch is necessary for the PFMC to adequately manage any of the resources under its authority.

Panel Recommendations for Default Groundfish Harvest Rates

The panel reviewed the information presented by each presenter (see Appendix A), as well as other recently published material (e.g., Myers *et al.* 1999). Of particular importance were the works of Brodziak, Dorn, MacCall, and Parrish because each of these studies broadly re-analyzed the information presented in historical PFMC stock assessments in an attempt to estimate F_{MSY} for each stock and their F_{spr} equivalents (i.e., the spawning potential per recuit fishing mortality rate). Significantly, each of these studies indicated that in many instances groundfish productivity, as estimated from the results of stock assessments, is insufficient to support harvests at the $F_{35\%}$ or even $F_{40\%}$ rates.

With respect to the rockfishes (*Sebastes* spp.) the panel found the work of Dorn to be very compelling. His results showed that, when the genus is examined as a whole through the use of meta-analysis, west coast rockfish stocks (exclusive of Pacific ocean perch) have F_{MSY} rates that range between $F_{45\%} - F_{67\%}$ for risk-neutral models, assuming either the Beverton-Holt or Ricker models with lognormal or gamma errors (four cases). However, gamma error models fit the data more poorly than models with a lognormal error structure and, as a consequence, the panel supported the use of Dorn's lognormal analysis only. For that subset of cases, the estimated F_{MSY} rates ranged $F_{45\%} - F_{54\%}$ over the two recruitment models. The panel then adopted $F_{50\%}$ as a midpoint, risk-neutral, proxy for rockfish F_{MSY}. In addition, the panel recommends including the thorneyheads (genus *Sebastolobus*) with the rockfish in the setting of default harvest rate proxies

The panel discussed results for Pacific whiting and concluded that the information base for that species was the best available for any west coast groundfish. Harvests are currently determined using the 40-10 policy in association with a fishing mortality rate equal to $F_{40\%}$. This rate is based on a separate and distinct meta-analysis of worldwide *Merluccius* productivity that was conducted as part of the last stock assessment (Dorn *et al.* 1999) and seems appropriate as a risk-neutral harvest policy. Consequently, the panel does not recommend any changes in harvest rate for Pacific whiting.

For flatfishes (including Dover sole), the panel concluded that resiliency is typically higher than in other taxa (e.g., Brodziak *et al.* 1997, Mace and Sissenwine 1993, Myers *et al.* 1999). As a consequence, the panel recommends using a default rate of $F_{40\%}$ for all flatfish species in the groundfish FMP. This rate is consistent with the general findings of Clark (1993) and Mace (1994).

For all other species in the groundfish FMP (including sablefish and lingcod) the panel recommends an intermediate harvest rate of $F_{45\%}$. This intermediate rate was selected as a sensible risk-neutral alternative that would afford increased protection to all the remaining groundfish stocks. However, the level of certainty in setting this default rate is very low. Consequently, the panel makes two recommendations with respect to the estimation of groundfish productivity, i.e.,

(1) Assessment authors are encouraged to evaluate the resiliency of the specific stocks they model. When such analysis produces scientifically credible estimates of productivity, the analyst is encouraged to present those findings as part of their stock assessment. However, any productivity analysis should always include a measure of the uncertainty in the point estimates of management reference points (e.g., F_{MSY}, B_{MSY}, and B_0).

(2) A proper consideration of risk is essential in the setting of optimum yields for west coast groundfish stocks. Utilization of a risk-neutral harvest rate proxy (e.g., $F_{50\%}$ for *Sebastes* and *Sebastolobus*) implies that some stocks within the group are quite likely to be over-exploited. Similarly, calculation of an ABC using an unbiased stock-specific point estimate of F_{MSY} will result in overfishing if the estimate is, by chance, too high. It is the PFMC's responsibility to account for these risks of overfishing through the use of a precautionary approach in the establishment of optimum yields. In addition, the NMFS Guidelines specify that status determination criteria must specify a maximum fishing mortality rate threshold that is less than or equal to F_{MSY} (Department of Commerce 1998). While this issue is not specifically addressed in this report, the choice of the threshold should depend on the level of uncertainty associated with the estimate of F_{MSY} or its proxy.

In summary, panel recommendations with respect to risk-neutral default harvest rate F_{MSY} proxies for west coast groundfish are:

Pacific whiting	$F_{40\%}$
Sebastes & Sebastolobus	$F_{50\%}$
Flatfish	$F_{40\%}$
Other groundfish	$F_{45\%}$

Due to a lack of detailed life history and stock status information, it will not be possible to implement these recommendations for many stocks. In particular, the "remaining rockfish" management unit (PFMC 1999) includes a number of species for which the ABC has been set using the F=M harvest rate proxy (Rogers *et al.* 1996). Currently, the optimum yield (OY) of those species is reduced by 25% as a "precautionary adjustment" (PFMC 1999), amounting to an F=0.75M policy. The panel discussed the remaining rockfish category in light of results presented in MacCall's production model analysis (Appendix A), which indicated that 0.40M may be a better proxy for an optimal exploitation rate. However, due to the review panel's unwillingness to fully endorse production modeling as a viable means of estimating groundfish productivity (see below), the panel recommended that the PFMC establish F=0.75M as the default, risk-neutral policy for the remaining rockfish management category. This determination was consistent with results presented for Pacific ocean perch, for which $F_{MSY}\approx 0.80M$. Even so, concern was expressed within the panel that a more conservative harvest rate might be warranted, such as that used by the North Pacific Fishery Management Council, which in similar swept-area applications assumes that q=1.0. In either case, given the high degree of uncertainty underlying the technical basis of this recommendation, and the real possibility that MacCall's findings are accurate, precautionary adjustments in setting the OY of the remaining rockfish are recommended.

The panel discussed the hardship to the fishing industry that the immediate application of these new, more restrictive, rates will cause. The National Standard Guidelines for implementa-tion of the Magnuson-Stevens Act specify (Department of Commerce 1998): "Overfishing occurs whenever a stock of stock complex is subjected to a rate or level of fishing mortality that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis." The PFMC may, therefore, wish to consider the propriety and legality of a short-term phase-in of these new rates to ameliorate the immediate impact to the groundfish industry.

Surplus Production Models

During the workshop, methods considering an examination of the relationship between surplus production and stock biomass were discussed as potential alternatives to methods based on stock-recruit models for determining appropriate exploitation rates. The panel generally agreed that an examination of estimates of surplus production and their relationship with estimates of biomass or other variables is useful. However, the panel does not endorse the general replacement of a stock-recruitment based approach at this time, nor the requirement of using a biomass-based surplus production model as one approach for estimating MSY, F_{MSY} and B_{MSY} for all assessed stocks. The panel concluded that this is an area that could benefit from additional research.

There were three presentations dealing with biomass-based production model approaches on the agenda (Jacobson *et al*, MacCall, and Parrish; see Appendix A). The fundamental premise of these approaches was to use the output from a detailed age-structured model as an accurate representation of exploitable stock biomass (i.e., assume $q = 1.0$) and to estimate the relationship between catches and changes in biomass to determine production. Most of the panel concluded that this kind of approach has potential application when applied to estimates generated from age-structured or delay-difference assessments. This is possible because absolute stock biomass estimates are generally available from the assessment models and, by definition, estimated surplus production can be calculated from the time series of catch and estimated biomass. The disadvantage of this approach, however, is that the various biological processes underlying stock compensation are not directly addressed, whereas in age-structured approaches these processes can be treated explicitly. Whether surplus production is estimated internally within the model (e.g., Jacobson *et al.*) or externally after the fact (MacCall, Parrish), is an issue deserving of more study (see also results from Ianelli).

Although the full panel saw benefits to explicit consideration of biomass production implied by assessments, some panelists expressed significant reservations regarding the use of production models to determine F_{MSY} and related quantities. These reservations were largely based on the view that this approach discards important information contained in the original age-structured model results. For example, age-structure can influence production because young fish generally have higher weight-specific growth rates than older fish. As a result, the same biomass can lead to different levels of production, depending upon the age composition of the population. Likewise, changes in selectivity over time will change the amount of surplus production at a given biomass. Although such variation in surplus production could be dealt with as correlated process error (Jacobson *et al.*) this converts variation explained by the age-structured model into additional error. In any event, age-structured analyses can provide specific information on the nature of compensation (e.g., in individual growth, maturation, or recruitment), which is not possible from an examination of the aggregate surplus production-biomass relationship alone.

Other panelists argued that estimates of F_{MSY} from surplus production models might be more robust than those that depend upon solely on stock-recruitment relationships. The idea here is that (1) error in assessment model estimates of biomass may cancel-out because production estimates involve differencing model biomass estimates, and (2) potentially biased estimates of recruitment (e.g., discards of small fish) play a less critical role in the analysis. Simulations presented by MacCall at the second Groundfish Productivity Workshop in Monterey, CA suggested this was the case. However, given the few number of replicate simulations and the limited suite of scenarios in that paper, the panel did not view this work as definitive.

Estimation of B_0, B_{40} and Related Problems

Although variable rate biomass-based harvest policies were not the primary focus of the workshop, the newly implemented 40-10 harvest policy was, nonetheless, the subject of much discussion. While in practice it is possible to consider F_{MSY} proxies in isolation from biomass targets and thresholds, in principle these two subjects are inextricably linked.

The main concern about the 40-10 harvest policy is that it involves the calculation of two biomass reference points, i.e., the virgin biomass that would exist in the absence of fishing (B_0) and the exploited biomass that is 40% of that pristine level ($B_{40\%}$). Within the PFMC, it appears that parameter B_0 is usually obtained from a stock assessment model and estimates of what biomass may have been in the far past.

A number of problems are likely to occur in the estimation of this parameter. First, its estimated value may be far larger than any historical observed biomass due to vagaries of parameter estimation and the age composition of the population at the start of the data series (e.g., Pacific ocean perch; see Ianelli in Appendix A). In some cases, it may be justifiable to constrain the value of B_0 to be near the historical maximum or some other value, as long as a clear rationale is provided and the sensitivity of the constraint is examined.

A second problem is that models are frequently configured to assume that the age composition is at equilibrium at the start of the modeled period. If this assumption fails, then the estimate of parameter B_0 may be biased. Third, there is no guarantee that under any fishing mortality regime, including zero fishing, that the population will rebuild to this level. The reason for this is that the amount of recruitment needed to produce historical levels of spawning biomass may not occur in the future. Given that many West Coast stocks have been on a "one-way trip" downward, a sensible harvest policy would first reverse the decline, and then rebuild to a level that could be expected based on current and expected future conditions. Once that level of rebuilding is accomplished, it may then be possible to rebuild toward a level consistent with historical patterns.

Therefore, some alternatives for calculating B_0 that look toward the future instead of the past should probably be considered. Two clear alternatives involve determining: (1) whether a spawner-recruit model is used to project the population forward and (2) if not, what exact values of the recruitment time series are to be used in forecasting future biomass. If a spawner-recruit model is used, then it should be possible to determine pristine biomass and B_{MSY} as reference points automatically. These points can then be implemented in the harvest policy, as is done by the North Pacific Fishery Management Council. However, it is often quite difficult to assert that a reliable spawner-recruit relationship is known, so typically such a relationship would not be invoked. Nevertheless, it is often wise to provide for reduced recruitment at low spawning biomass levels, particularly if the stock has been fished down to a point where recruitment is
believed to have been impacted. Some recent modeling efforts with ADMB and Bayesian considerations (e.g., Pacific hake) lend hope to better determining MSY parameters.

If a spawner-recruit relationship is not used, then a projection of future unfished equilibrium biomass can be made by multiplying contemporary recruitment values by the corresponding spawner biomass per recruit (SPR) function. For example, the average recruitment over the time series might be used with an SPR function at a fishing mortality of 0 to arrive at the expected equilibrium unfished biomass in the future, to be used as B_0. From this information $B_{40\%}$ could be obtained. This type of approach is especially appropriate if it is known there has been a change in stock productivity. A caveat to doing this, however, is that it can be very difficult to detect a change in productivity, so the rationale for restricting the time period must be carefully considered.

Whichever approach is used, it should be documented carefully and properly justified. The same methodology should be used for all biomass reference points and it should be clearly stated whether a reference point is based on SPR calculations that are fully independent of spawning biomass, or whether recruitments have been adjusted downward by a spawner-recruit relationship. We think justification for the calculation of biomass reference points should address consistency between the assumptions used in their derivation and those underlying F_{MSY} estimates or proxies.

We note that another type of calculation is required by the NMFS overfishing guidelines, which could lead to further confusion. Namely, a threshold level that provides for a 10-year rebuilding to a target level such as B_{MSY} must be found (Department of Commerce 1998). This level is also a function of the recruitment series used and depends on whether a spawner-recruit relation exists. Consequently, for consistency the same process that is used for determining other reference points should be used here. The PFMC has apparently been allowed to use $B_{25\%}$ for this threshold, but it is unclear how rebuilding plans, which are triggered when biomass drops below this value, will interface with the 40-10 rule, which in itself, is an automatic rebuilding plan. Other Councils are currently experiencing this confusion as well, so hopefully there will be more flexibility and clarity in the NMFS overfishing guidelines in the future.

Some Relevant Published Literature

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Cook, R. Review of $F_{35\%}$ and $F_{40\%}$ as MSY proxies for west coast groundfish. Final report of consultancy to NMFS office of Science and Technology.

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Parrish, R. H. A synthesis of the surplus production and exploitation rates of 10 west coast groundfish species. (distributed at the March 2000 workshop in Seattle, WA).

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Williams, E. H. The effects of unaccounted discards and mis-specified natural mortality on estimates of spawner-per-recruit based harvest policies. (distributed at the March 2000 workshop in Seattle, WA).

WEST COAST GROUNDFISH PRODUCTIVITY WORKSHOP
Scientific & Statistical Committee, Pacific Fisheries Management Council
Room 2079, Building 4, Alaska Fisheries Science Center
7600 Sand Point Way NE, Seattle, Washington

AGENDA

Monday, March 20

1:00 pm Workshop Int··duction

James Hastie: *An historical overview of Pacific Fishery Management Council groundfish harvest policy.*

William Clark: *$F_{35\%}$ revisited after ten years.*

Alec MacCall: *Designing fishery management and stock rebuilding policies for conditions of l· ·· frequency climate variability.* (preview of a paper to be presented at the PICES meeting in S· · Diego later this week)

Tuesday, March 21

8:00 am R. A. Myers: *The meta-analysis of the maximum reproductive rate for fish populations to estimat· harvest policy; a review.*

Martin Dorn: *Advice on west coast rockfish harvest rates from Bayesian meta-analysis of stock-recruit dynamics.*

Ray Hilborn: *Exploitation rate reference points for west coast rockfish: are they robust and are there better alternatives?*

12:30 pm Lunch

1:30 pm Larry Jacobson: *Try and estimate F_{msy} in every stock assessment model!*

David Sampson: *FINDFMSY: a fishery simulator for exploring constant harvest rate policies.*

Wednesday, March 22

8:00 am Richard Parrish: *A synthesis of the surplus production and exploitation rates of 10 west coast groundfish species.*

Alec MacCall: *Summary of known-biomass production model fits to west coast groundfish stocks.*

Jon Brodziak: *In search of optimal harvest policies for west coast groundfish.*

12:30 pm Lunch

1:30 pm James N. Ianelli: *Simulation analyses testing the robustness of harvest rate determinations from typical west-coast rockfish stock assessment data.*

Erik Williams: *The effects of unaccounted discards and mis-specified natural mortality on estimates of spawner-per-recruit based harvest policies.*

Thursday, March 23

8:00 am Discussion / Public comment

12:00 Lunch

1:00 pm Panel deliberation

Friday, March 24

8:00 am Panel deliberation (if required)

APPENDIX C

Glossary of Terms

ABC	allowable biological catch; the product of the fishing mortality rate that produces MSY (or its proxy) and the current exploitable biomass of a stock.
B	The current exploitable biomass of a stock.
$B_{unfished}$	the size of a stock (in biomass) if there were no fishing.
B_{msy}	the size of a stock (in biomass) if it is fished indefinitely at a constant rate equal to F_{msy}.
$B_{40\%}$	the size of a stock when it is 40% of $B_{unfished}$; this is currently the precautionary threshold if B_{msy} has not been explicitly estimated.
$B_{25\%}$	the size of a stock when it is 25% of $B_{unfished}$; this is currently the overfished threshold if B_{msy} has not been explicitly estimated.
$B_{10\%}$	the size of a stock when it is 10% of $B_{unfished}$.
F_{msy}	the fishing mortality rate that produces MSY.
$F_{40\%}$	the fishing mortality rate that reduces the reproductive output of a female to 40% of what it would be in the absence of fishing.
$F_{45\%}$	the fishing mortality rate that reduces the reproductive output of a female to 45% of what it would be in the absence of fishing.
$F_{50\%}$	the fishing mortality rate that reduces the reproductive output of a female to 50% of what it would be in the absence of fishing.
GMT	Groundfish Management Team; a task-oriented advisory committee to the Council that deals principally with management issues.
M	the natural mortality rate of a stock, i.e., the expectation of death due to all other sources of mortality other than fishing (e.g., predators, parasites, starvation, etc.).
MSY	maximum sustainable yield; in theory, the largest amount of catch that can be obtained on a continuing basis by applying a constant harvest rate.
OY	optimum yield; the amount of fish that is prescribed on the basis of MSY from the fishery as reduced by any relevant economic, social, or ecological factors.
risk-averse	(e.g. as in a risk-averse estimate of F_{msy}) more likely to be an underestimate than an overestimate of the actual F_{msy} (precautionary)
risk-neutral	(e.g. as in a risk-neutral estimate of F_{msy}) equally likely to be an overestimate or an underestimate of the actual F_{msy}
risk-prone	(e.g. as in a risk-prone estimate of F_{msy}) more likely to be an overestimate than an underestimate of the actual F_{msy}
SAFE	Stock Assessment and Fishery Evaluation; the Council's annual report on the status of

groundfish resources.

SPR — spawning potential per recruit; a way of rescaling fishing mortality rate to standardize its effect on the reproductive potential of a individual fish entering the exploitable phase of the population.

SSC — Scientific and Statistical Committee; an advisory body to the Council that deals primarily with scientific and technical issues.

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Agenda Item D-1(e) Differential Gear Analysis

Recommendation to the NPFMC:

- AMCC recommends that the NPFMC proceed with a differential gear analysis by first developing information as a tool for the Essential Fish Habitat Committee.
- The information should inform the committee in its task of developing alternatives to mitigate the effects of fishing practices on EFH. These alternatives will be submitted to the NPFMC for your consideration for the EFH Environmental Impact Statement.
- The committee will be best served by information pertinent to fisheries and community economics, bycatch and effects on habitat.
- AMCC sees the differential gear information as important for other matters the NPFMC has on the horizon, but application in the EFH context is most urgent.

Attached is a draft list of information needs that has been identified as pertinent to assessing differential gear effects on fisheries and community economics, bycatch and effects on habitat. The list is a starting point to identify the range of issues that would be useful to explore.

Differential Gear Analysis for the GOA

Need Statement:

Fishing gears used in the GOA groundfish fishery have different effects on benthic organisms and substrate, different results for bycatch, and different economic implications for harvesters, processors, markets and communities.

Evaluating the effects of the different gears will assist the NPFMC in making informed decisions. The differential gear analysis is expected to help the NPFMC understand how to provide harvest opportunity and at the same time minimize habitat impacts and achieve bycatch reduction in accordance with the Magnuson-Stevens Act, with sensitivity to economic implications.

The following issues are pertinent to future management of the GOA fishery and achieving objectives of the Magnuson-Stevens Act:

- Bycatch and bycatch mortality
- Habitat considerations
- Stock productivity considerations
- Excess harvesting capacity
- Product value and quality
- Economic stability in the fisheries and communities
- Rationalized management
- Broad participation by community-based fishermen

This analysis is to be completed independently of its application. Objective evaluation of differential gear effects on a broad scale should be designed to provide a clear view of the relative effects, and the opportunities for considering differential gear impacts in GOA groundfish management decisions. Information from this analysis has been sought in several actions in recent years but, due to constraints in staff time and the cloud of allocation that its use may generate, it has not been completed.

Specific elements to be reviewed in the analysis:

Gear types:

- Fixed Gears: pot, longline
- Mobile Gears: Dredge, pelagic trawls, non-pelagic trawls, beam trawls, and jig.

Bycatch (including regulatory and economic discards)

- Volume, temporal distribution, species composition, and estimates for unobserved mortality
- Impact of lost gear

(over)

Stocks:

- Potential for localized depletion
- Harvest rates and potential for spatial and temporal compression of fishing effort
- Impact on spawning aggregations
- Impact on stocks at different levels of abundance (including declining species or species low abundance not necessarily associated with fishing pressure)

Habitat:

- Impact on benthic substrates and habitat complexity
- Ability of fished area to support species diversity
- Historical distribution of fishing effort by gear type
- Impact of lost gear
- Potential for changes in the distribution of fishing effort if fishery moves from current open access to a rationalized fishery (will areas currently not fished become desirable fishing grounds?)

Economics:

- Are there differences in ex-vessel price or product quality?
- Are there market-related, product distribution, or other considerations (such as market saturation or consumer preferences) that apply to gears?
- Seasonal value of product (milt, roe, etc.)
- Seasonal product entry into market
- Capacity to harvest the TAC
- What is the implication to processors on quantity per delivery
- Gallons of fuel per unit of harvest and other overhead considerations
- Crew size
- Net margins as a percent of gross and maximum gross if there is a quality price differential
- Cost of conversion from one gear to another
- Mitigation of gear conversion costs

Impacts on communities adjacent to the resource:

- Number of vessels participating
- Number of crew employed
- Number of processing workers employed
- Rent or profits that remain in community

Implications of gear conversion for:

- Rationalized fisheries
- Buy outs
- Options for transitioning from one gear to another