MEMORANDUM

TO: Council, SSC and AP Members

FROM: Clarence G. Pautzke
Executive Director

DATE: September 12, 1997

SUBJECT: Initial Groundfish Specifications for 1998

ESTIMATED TIME
3 HOURS

ACTION REQUIRED

(a) Review Preliminary 1998 BSAI Final Stock Assessment and Fishery Evaluation (SAFE) document.
(b) Approve preliminary BSAI groundfish specifications for 1998:

1. Acceptable Biological Catch (ABC), and Annual Total Allowable Catch (TAC)
2. Division of the pollock TAC into the January 1-April 15 ('A' Season) and September 1-December 31 ('B' Season) allowances;
3. Allocation of the pollock TAC among pelagic and non-pelagic gear;
4. Seasonal apportionment of the fixed gear Pacific cod TAC; and
5. Bycatch allowances, and seasonal apportionments of Pacific halibut, red king crab, Tanner crab, and herring to target fishery (PSC) categories.

(c) Recommend bycatch rate standards for the Vessel Incentive Program.

BACKGROUND

At this meeting, the Council sets initial recommendations for groundfish and bycatch specifications as listed above. The preliminary SAFE report, groundfish ABCs and TACs, and bycatch apportionments need to be approved and made available for public review and comment. These initial specifications will be used for management of the 1998 groundfish fisheries until superseded by publication of the Council's final specifications. On the basis of comments and new information, the Council will adopt final recommendations for the 1998 fishing year at its December meeting.

(a) BSAI SAFE Document

The groundfish Plan Teams met in Seattle during the week of September 2-5, to prepare the preliminary SAFE documents provided at this meeting. This SAFE forms the basis for preliminary groundfish specifications for the 1998 fishing year.

The preliminary BSAI SAFE contains the Plan Team's estimates of biomass and ABCs for all groundfish species covered under the FMP and information concerning PSC bycatch to provide guidance to the Council in establishing PSC apportionments. The attached tables from the SAFE lists the Plan Team's recommended 1998 ABCs and corresponding overfishing levels for each of the species or species complexes. Draft minutes of the BSAI plan team are also attached (Item D-3(a)(1)).

(b) Preliminary ABCs, TACs, and Apportionments

During the week of this Council meeting the SSC and AP recommendations will be provided to the Council. Attached as Item D-3(b)(1) are Tables 6 - 8 from the SAFE summary chapter indicating ABCs and biomass levels. The Plan Team's sum of recommended ABCs for 1998 is 2.49 million mt. Overall, the status of the stocks continues to appear relatively favorable. The Council will establish preliminary catch specifications for 1998 based on this information.

Adopt Seasonal Allowances for the Pollock Seasons

The FMP requires the Council to apportion pollock in the BSAI between the roe (January 1 - April 15) and non-roe (September 1 - December 31) seasons. For the 1991 and 1992 fisheries, the Council recommended a 40/60 percent split between the roe and non-roe seasons, and a 45/55 percent split for the 1993-1997 pollock fishery.

In recommending seasonal allowances of the BSAI pollock TAC, the following factors need to be considered:

1. Estimated monthly catch and effort.
2. Expected changes in harvesting and processing capacity.
3. Current estimates of and expected changes in pollock biomass, and conditions of other fish and marine mammal stocks.
4. Potential impacts of seasonal fishing on pollock stocks, marine mammals, and other fish stocks.
5. The need to obtain fishery related data throughout the year.
6. Effects on operating costs and gross revenue.
7. The need to spread fishing effort over the year.
8. Potential allocative effects among users and indirect effects on coastal communities.
9. Other biological and socioeconomic information.

Allocate Pollock TAC among bottom and pelagic gear

The Council can set a limit on the amount of pollock that can be taken in the bottom trawl pollock fishery to control the bycatch of crab and halibut (Amendment 16a). However, for the past 6 years, the Council did not recommend a specific apportionment between pelagic and bottom gears, noting that additional pollock harvests with non-pelagic trawl gear likely would be constrained by halibut bycatch. In recommending apportionment of pollock between gears, the Council would need to consider PSC limits, projected bycatch, costs, and other factors consistent with goals of the FMP (675.24). An analysis of pollock apportionment among gear types is provided as Appendix D of the preliminary BSAI SAFE. In 1996, 98.6% of the pollock TAC was taken in pelagic mode.

Adopt Seasonal Apportionments of the Pacific Cod TAC Allocated to Fixed Gear

Amendment 24 regulations allow seasonal apportionment of the Pacific cod TAC allocated to vessels using hook-and-line or pot gear. Seasonal apportionments will be divided among trimesters and established through the annual specifications process. In recommending seasonal apportionments, regulations require the Council to base its decision on the following information:

1. Seasonal distribution of Pacific cod relative to PSC distribution;
2. Expected variations in PSC bycatch rates in the Pacific cod fishery throughout the fishing year; and
3. Economic effects of any seasonal apportionment of Pacific cod on the hook-and-line and pot gear fisheries.

Under Amendment 46, two percent of the TAC is reserved for jig gear, 51 percent for fixed gear, and 47 percent for trawl gear. The trawl apportionment will be split between catcher vessels and catcher processors 50/50. Any unused TAC from the jig gear quota will become available to fixed gear on September 15.

For the 1997 fisheries, the Council recommended that 85,000 mt of the fixed gear's allocation be released during the first trimester (January 1 - April 30), 26,500 mt be released for the second trimester (May 1 - August 31), and 5,545 mt for the third trimester.

Adopt bycatch allowances of Pacific halibut, red king crab, Tanner crab (*C. bairdi*), and herring, and seasonal allowances

Halibut PSCs

For the Trawl Fisheries: Amendment 21 established a 3,775 mt limit on halibut mortality for trawl gear. This limit can be apportioned to the following trawl fishery categories:

1. Greenland turbot, arrowtooth flounder and sablefish;
2. rock sole and "other flatfish;"
3. yellowfin sole;
4. rockfish;
5. Pacific cod; and,
6. pollock, Atka mackerel and "other species."

Note that under Amendment 46, the trawl halibut PSC mortality cap for Pacific cod will be no greater than 1,600 mt.

For Fixed Gear Fisheries: A 900 mt non-trawl gear halibut mortality can be apportioned to the following fishery categories:

1. Pacific cod;
2. Other non-trawl (includes hook-and-line sablefish, rockfish and jig gear); and
3. Groundfish pot (recommended exempt for 1997).

Note that under Amendment 46, the hook-and-line halibut PSC mortality cap for Pacific cod will be no greater than 900 mt. Item D-3(b)(2) is a table indicating 1997 PSC allocations and seasonal apportionments for the trawl and non-trawl fisheries. Item D-3(b)(3) is a current summary of PSC bycatch accounting for the 1997 BSAI fisheries.

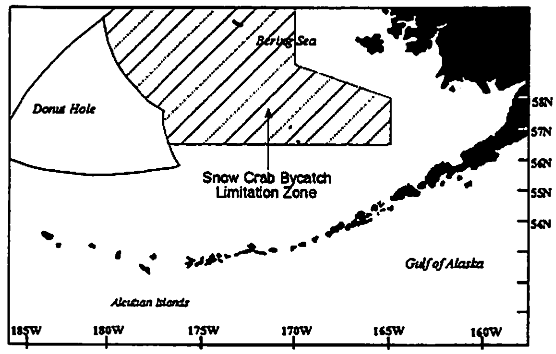
PSC limits for red king crab and C. bairdi Tanner crab.

Species	Zone	Crab Abundance	PSC Limit
Red King Crab	Zone 1	Below threshold or 14.5 million lbs of effective spawning biomass (ESB)	35,000
		Above threshold, but below 55 million lbs of ESB	100,000
		Above 55 million lbs of ESB	200,000
Tanner Crab	Zone 1	0-150 million crabs	0.5% of abundance
		150-270 million crabs	750,000
		270-400 million crabs	850,000
		over 400 million crabs	1,000,000
Tanner Crab	Zone 2	0-175 million crabs	1.2% of abundance
		175-290 million crabs	2,100,000
		290-400 million crabs	2,550,000
		over 400 million crabs	3,000,000

Crab PSCs

Prescribed bottom trawl fisheries in specific areas are closed when prohibited species catch (PSC) limits of C. bairdi Tanner crab, C. opilio crab, and red king crab are taken. Amendment 37 established a stairstep procedure for determining PSC limits for red king crab taken in Zone 1 trawl fisheries. PSC limits are based on abundance of Bristol Bay red king crab as shown in the adjacent table. Given NMFS and ADF&G's 1997 abundance estimate for Bristol Bay red king crab, **a Zone 1 PSC limit will be established at 100,000 red king crabs for 1998.** Amendment 41 established stairstep PSC limits for Tanner crab. Given current total abundance of 180 million Tanner crab, **the 1998 C. bairdi PSC limits will be established at 750,000 Tanner crabs in Zone 1 and 2,100,000 Tanner crabs in Zone 2.**

Under proposed Amendment 40, PSC limits for snow crab (C. opilio) will be based on total abundance of opilio crab as indicated by the NMFS standard trawl survey. The snow crab PSC cap is set at 0.1133% of the Bering Sea snow crab abundance index, with a minimum PSC of 4.5 million snow crab and a maximum of 13 million snow crab. Snow crab taken within the "C. Opilio Bycatch Limitation Zone"accrue towards the PSC limits established for individual trawl fisheries. Upon attainment of a snow crab PSC limit apportioned to a particular trawl target fishery, that fishery are prohibited from fishing within the snow crab zone. The 1997 survey indicated a total population of 4.1 billion crabs. Therefore **the 1998 snow crab PSC limit will be established at 4,654,000 crabs.**



Location of the snow crab bycatch limitation zone.

Herring PSCs

Amendment 16a established an overall herring PSC bycatch cap of 1 percent of the EBS biomass of herring. This cap is to be apportioned to the same six PSC fishery categories listed above, plus a seventh group, mid-water pollock. The Alaska Department of Fish and Game has not completed its forecast for 1998 herring biomass, so interim specifications will be based on the 1997 estimate (1,579,000 mt). The PSC limit is set at 1 percent of the biomass in metric tons. A revised herring assessment should be available for the December Council meeting.

Seasonal Apportionment of PSC

The Council may also seasonally apportion the bycatch allowances. Regulations require that seasonal apportionments of bycatch allowances be based on the following types of information:

1. Seasonal distribution of prohibited species;
2. Seasonal distribution of target groundfish species relative to prohibited species distribution;
3. Expected prohibited species bycatch needs on a seasonal basis relevant to change in prohibited species biomass and expected catches of target groundfish species;
4. Expected variations in bycatch rates throughout the fishing year;
5. Expected changes in directed groundfish fishing seasons;
6. Expected start of fishing efforts; and
7. Economic effects of establishing seasonal prohibited species apportionments on segments of the target groundfish industry.

NOTE: Additional information on PSC limits and apportionments is presented in BSAI SAFE Appendix E.

Staff will present a worksheet with SSC and AP recommendations for ABCs, TACs, PSC and seasonal apportionments when the Council addresses this Action Item.

(c) Bycatch rate standards for the Vessel Incentive Program

The Vessel Incentive Program (VIP) rate for halibut and crab Prohibited Species Catch (PSC) includes all trawl fisheries in both the BSAI and GOA. The grouping for VIP fishing categories is:

	Fishery	PSC Species
BSAI	midwater pollock	halibut*
BSAI	bottom pollock	halibut
BSAI	yellowfin sole	halibut; red king crab**
BSAI	other trawl	halibut; red king crab
GOA	midwater pollock	halibut
GOA	other trawl	halibut

* % of groundfish
**number of crabs per ton of groundfish

Note that regulations specify that the vessel incentive program for the midwater pollock fishery becomes effective after the directed fishery for pollock by trawl vessels using non-pelagic gear is closed.

Item D-3(c)(1) is a letter from the Regional Director containing the VIP rate standards used in 1997 and catch rates observed during past years for these fishery categories. The Council will need to recommend to the Regional Director the bycatch rate standards for these categories for the first two quarters of the 1998 fishery.

Draft Minutes of the Bering Sea and Aleutian Islands Groundfish Plan Team September 2-4, 1997

The Bering Sea/Aleutian Islands (BSAI) Groundfish Plan Team met September 2-4 at the Alaska Fisheries Science Center in Seattle. Members present were Grant Thompson (acting chairman), Dave Witherell, Ivan Vining, Mike Sigler, Andrew Smoker, Farron Wallace, and Gregg Williams. The meeting was open to the public, and several members of the public attended. A packet of materials was distributed to team members prior to the meeting, and several additional documents were distributed at the meeting. The focus of the meeting was to review preliminary stock assessment information and plan amendment proposals, and discuss preparations for the final SAFE and ecosystems chapter in November.

Gary Walters briefed the team on preliminary results of the 1997 Eastern Bering Sea bottom trawl survey. For most stocks, no major changes in abundance were observed. Significant changes were observed for rock sole (up 25%) and Pacific cod (down 30%). The good news was that an average to above-average 1996 year class of cod was observed. Preliminary survey biomass estimates are shown in the adjacent table.

Preliminary 1997 EBS bottom trawl survey results.

	1996	1997
arrowtooth	556,354	478,630
turbot	30,292	29,218
flathead sole	616,373	807,825
yellowfin	2,298,560	2,163,389
rock sole	2,183,071	2,710,916
Alaska plaice	529,327	643,413
Pacific cod	890,793	604,881
pollock	3,204,106	3,031,557

Mike Guttormson provided a summary of the 1997 hydroacoustic survey of the Bogoslof pollock stock. The team remains concerned about the depressed status of the Bogoslof pollock stock. Preliminary hydroacoustic survey results indicate a continual decline to a record low biomass of 342,000 mt. Therefore, the team recommended no directed fishery on this stock in 1998. A similar recommendation may be made in November for the Aleutian Islands pollock stock unless the assessment indicates an upturn in abundance.

The team recommended that Council 1997 ABC and OFL specifications be rolled over as preliminary 1998 numbers, with the exception of Bogolslof pollock and Greenland turbot. Updated survey data will be incorporated into November assessments. The team had a number of recommendations to assessment authors, and a summary of these recommendations is provided below.

Yellowfin sole: The Team noted that a (spawning) $B_{40\%}$ could be calculated from available data and ABC and OFL could be based on a tier 3 strategy.

Greenland turbot: Longline surveys provide an index of adult abundance. Only the index from the Bering Sea from 1984-93 was used in the assessment, yet an index also is available from the Aleutian Islands region and for other years. We suggest that the author use a combined (Bering/Aleutians) index in the assessment and use all available years of data. Since these areas are planned to be surveyed in alternate years in the future (Aleutians 1996, Bering 1997, ...), we suggest that to create the Bering/Aleutians index, the author interpolate each area (Aleutians or Bering) for unsampled years, as is done for sablefish.

A large number of fishery operations successfully caught Greenland turbot on the shelf between the Aleutian and Pribilof Islands (1997 SAFE, Figure 4.2). Is this a directed fishery or a bycatch fishery for Greenland turbot? Are the length frequencies from the shelf and adjacent slope fisheries different?

The Team suggests that information regarding predation of turbot by killer whales should be added to the assessment.

Rock sole: The Team requested that maturity at age and size be explicitly stated in the assessment. The Team noted that a (spawning) $B_{40\%}$ could be calculated from available data and ABC and OFL could be based on a tier 3 strategy.

Flathead sole: The Team requests that the author develop an age- or size-structured model for this species.

Other flatfish: The Team requested that the author report the catch and survey data of the "other flatfish" category by species. If targeted, the minor species in this group could be over-harvested, given that the ABC is based primarily on Alaska plaice. Consideration should be given to breaking out the deepwater components of this complex (Dover sole and Rex sole). The Team noted that a (spawning) $B_{40\%}$ could be calculated from available data and ABC and OFL could be based on a tier 3 strategy.

Pacific Ocean Perch: The Team requests that the authors tabulate biomass by depth and year from trawl surveys in the Bering Sea and Aleutian Islands.

Other rockfish: Species composition of the other rockfish group should be clearly listed, and trawl biomass estimates should be provided for each species separately. Catch of each species should also be provided separately, and broken down by gear type. The Team requested that the authors attempt an age structured model of the AI and GOA thornyhead stock together, using longline survey data.

Sablefish: The Team recommends that the fishery and survey length frequencies be presented in the assessment to provide industry with information on strength of recruiting year classes. The Team requests that the authors examine Japanese longline fishery data prior to 1979 for recruitment strength and biomass estimates.

Walleye pollock: The Team recommends that the two independent assessments, VPA and statistical catch-age, be updated for the final SAFE. The Team recommends that survey data, not fishery data, be used to interpret spatial population changes because regulations and market may affect spatial distribution of the fishery. The Team recommends that consideration be given to the effects of spatial compression on species other than pollock (e.g. sea lions).

Atka mackerel: The Team encourages development of assessments which incorporate depletion estimates of biomass.

Pacific cod: The Team suggests that the assessment use a biologically based estimate of natural mortality for this year's assessment. Data on longevity and GSI are available, and this information suggests that lower estimates of M may be more appropriate. The Team also suggested that the author allow the model to estimate catchability (q).

Non-members in attendance at the BSAI team meeting were: Brent Paine, Lowell Fritz, John Hendereshedt, Tim Mintz, Ken Stump, Shirley White, Paul McGregor, Tamra Farris, and John Gauvin.

Draft

Bering Sea and Aleutian Islands Groundfish Plan Team
Preliminary Recommended 1998 Catch Specifications (mt)

1997 Specifications

Species	Area	1998 Biomass	1998 OFL	1998 ABC	1997 ABC	1997 TAC	1997 Catch*
Pollock	EBS	6,120,000	1,980,000	1,130,000	1,130,000	1,130,000	,528,552
	"A" season					45%	
	"B" season					55%	
	AI	100,000	38,000	28,000	28,000	28,000	24,837
	Bogoslof	280,000	79,000	58,800	32,100	1,000	169
Pacific cod	BS/AI	1,590,000	418,000	306,000	306,000	270,000	199,588
Yellowfin sole	BS/AI	2,530,000	339,000	233,000	233,000	230,000	109,615
Greenland turbot	BS/AI	118,000	25,100	12,350	12,350	9,000	7,368
	BS					67%	
	AI					33%	
Arrowtooth	BS/AI	587,000	167,000	108,000	108,000	20,760	7,455
Rock sole	BS/AI	2,390,000	427,000	296,000	296,000	97,185	64,443
Flathead sole	BS/AI	632,000	145,000	101,000	101,000	43,500	16,666
Other flatfish	BS/AI	616,000	150,000	97,500	97,500	50,750	18,661
Sablefish	EBS	17,900	2,750	1,308	1,308	1,100	545
	AI	18,600	2,860	1,367	1,367	1,200	660
POP complex							
True POP	EBS	72,500	5,400	2,800	2,800	2,800	287
Other POP	EBS	29,700	1,400	1,050	1,050	1,050	171
True POP	AI	324,000	25,300	12,800	12,800	12,800	12,641
	Eastern			3,240	3,240	3,240	2,984
	Central			3,170	3,170	3,170	2,795
	Western			6,390	6,390	6,390	6,862
Sharp/Northern	AI	96,800	5,810	4,360	4,360	4,360	1,996
Short/Rougheye	AI	45,600	1,250	938	938	938	1,045
Other rockfish	EBS	7,100	497	373	373	373	155
	AI	13,600	952	714	714	714	277
Atka mackerel	AI	450,000	81,600	66,700	66,700	66,700	65,681
	Eastern			15,000	15,000	15,000	16235
	Central			19,500	19,500	19,500	19934
	Western			32,200	32,200	32,200	29512
Squid	BS/AI	n/a	2,620	1,970	1,970	1,970	849
Other species	BS/AI	688,000	138,000	25,800	25,800	25,800	17,782
BS/AI TOTAL		16,726,800	4,036,539	2,490,830	2,464,130	2,000,000	1,092,084

EBS – eastern Bering Sea
BS/AI – Bering Sea & Aleutian Islands
BS – Bering Sea
AI – Aleutian Islands

OFL – overfishing level
ABC – acceptable biological catch
TAC – total allowable catch

* – catch as of 8/30/97

Table 6-- Preliminary summary of stock abundance (biomass), overfishing level (OFL), and fishing mortality rates (*F*) for the eastern Bering Sea (EBS), Aleutian Islands (AI), and Bogoslof district for 1998. Biomass and OFL are in metric tons, reported to three significant digits. *F*s are reported to two significant digits.

Species	Area	Biomass[a]	OFL[b]	F_{OFL}[c]	F_{ABC}[d]
Walleye pollock	EBS	6,120,000	1,980,000	0.58	0.30
	AI	100,000	38,000	0.57	0.38
	Bogoslof	280,000	79,000	0.37	0.27
Pacific cod	BSAI	1,590,000	418,000	0.38	0.27
Yellowfin sole	BSAI	2,530,000	339,000	0.16	0.11
Greenland turbot	BSAI	118,000	25,100	0.56	0.35
Arrowtooth flounder	BSAI	587,000	167,000	0.34	0.22
Rock sole	BSAI	2,390,000	427,000	0.22	0.15
Flathead sole	BSAI	632,000	145,000	0.23	0.16
Other flatfishes	BSAI	616,000	150,000	0.31[e]	0.20[e]
Sablefish	EBS	17,900	2,750	0.18	0.076
	AI	18,600	2,860	0.18	0.076
POP complex					
True POP	EBS	72,500	5,400	0.079	0.049
Other red rockfish[f]	EBS	29,700	1,400	0.047	0.035
True POP	AI	324,000	25,300	0.10	0.049
Sharp/Northern[g]	AI	96,800	5,810	0.060[h]	0.045[h]
Short/Rougheye[i]	AI	45,600	1,250	0.028[h]	0.021[h]
Other rockfish	EBS	7,100	497	0.070[j]	0.053[j]
	AI	13,600	952	0.070[j]	0.053[j]
Atka mackerel	AI	450,000	81,600	0.50	0.36
Squid	BSAI	n/a	2,620	n/a	n/a
Other species	BSAI	688,000	138,000	0.20	0.038

a/ 1998 biomass for the age+ range reported in summary section.
b/ Maximum 1998 catch level allowable under overfishing definition (the `overfishing level').
c/ Maximum fishing mortality rate allowable under overfishing definition.
d/ Fishing mortality rate corresponding to acceptable biological catch.
e/ Alaska plaice rate shown as an example.
f/ Sharpchin, northern, shortraker, and rougheye rockfish.
g/ Sharpchin and northern rockfish.
h/ Weighted average of species-specific rates.
i/ Shortraker and rougheye rockfish.
j/ Shortspine thornyhead rate shown as an example.

Table 7-- Total allowable catch (TAC) and acceptable biological catch (ABC) for 1996 (as established by the Council) and preliminary 1998 (as recommended by the Plan Team) for groundfish in the eastern Bering Sea (EBS), Aleutian Islands (AI), and Bogoslof district. Figures are in metric tons.

Species	Area	TAC (1997) Council	ABC(1997) Council	ABC(1998) Plan Team
Walleye pollock	EBS	1,130,000	1,130,000	1,130,000
	AI	28,000	28,000	28,000
	Bogoslof	1,000	32,100	58,800
Pacific cod		270,000	306,000	306,000
Yellowfin sole		230,000	233,000	233,000
Greenland turbot		9,000	12,350	12,350
Arrowtooth flounder		20,760	108,000	108,000
Rock sole		97,185	296,000	296,000
Flathead sole		43,500	101,000	101,000
Other flatfish		50,750	97,500	97,500
Sablefish	EBS	1,100	1,308	1,308
	AI	1,200	1,367	1,367
POP complex				
True POP	EBS	2,800	2,800	2,800
Other red rockfish	EBS	1,050	1,050	1,050
True POP	AI	12,800	12,800	12,800
Sharp/Northern	AI	4,360	4,360	4,360
Short/Rougheye	AI	938	938	938
Other rockfish	EBS	373	373	373
	AI	714	714	714
Atka mackerel		66,700	66,700	66,700
Squid		1,970	1,970	1,970
Other species		25,800	25,800	25,800
Groundfish complex		2,000,000	2,464,130	2,490,830

Table 8-- Preliminary summary of stock biomass, harvest strategy, 1998 recommended acceptable biological catch (ABC), and stock condition for groundfish in the eastern Bering Sea (EBS), Aleutian Islands (AI), and Bogoslof district. Biomass and ABC are in metric tons, reported to three significant digits. Fishing mortality rates are reported to two significant digits.

Species	Area	Biomass[a]	Rate[b]	ABC	Relative abundance, trend[c]
Walleye pollock	EBS	6,120,000	$F_{40\%}$	1,130,000	Average, declining
	AI	100,000	$F_{40\%}$	28,000	Low, declining
	Bogoslof	280,000	$F_{40\%}$	58,800	Low, declining
Pacific cod		1,590,000	$F_{40\%}$	306,000	Average, declining
Yellowfin sole		2,530,000	$F_{40\%}$	233,000	High, declining
Greenland turbot		118,000	$F_{40\%}$	12,350	Low, declining
Arrowtooth flounder		587,000	$F_{40\%}$	108,000	High, declining
Rock sole		2,390,000	$F_{40\%}$	296,000	High, increasing
Flathead sole		632,000	$F_{40\%}$	101,000	High, declining
Other flatfish		616,000	$F_{40\%}$[d]	97,500	High, declining
Sablefish	EBS	17,900	F_{EA}[e]	1,308	Low, declining
	AI	18,600	F_{EA}[e]	1,367	Low, declining
POP complex					
True POP	EBS	72,500	$F_{44\%}$[f]	2,800	Low, stable
Other red rockfish	EBS	29,700	$F=M$	1,050	Not available
True POP	AI	324,000	$F_{44\%}$[g]	12,800	High, stable
Sharp/Northern	AI	96,800	$F=M$	4,360	Not available
Short/Rougheye	AI	45,600	$F=M$	938	Not available
Other rockfish	EBS	7,100	$F=M$[d]	373	Not available
	AI	13,600	$F=M$[d]	714	Not available
Atka mackerel	AI	450,000	$F_{40\%}$	66,700	Average, declining
Squid	BSAI	n/a	F_{his}[h]	1,970	Not available
Other species		688,000	F_{his}[h]	25,800	Not available
Groundfish Complex Total		17,004,800		2,490,830	Above average, declining

a/ Projected Jan. 1997 biomass for the age+ range reported in summary section.
b/ Harvest strategy used to compute ABC.
c/ Relative abundance based on long-term average, trend based on short-term projection.
d/ Proxy values used for some species.
e/ `Equilibruim adjusted' fishing mortality rate: see sablefish chapter.
f/ Adjusted on the basis of the relationship between projected biomass and $B_{40\%}$.
g/ Adjusted so as to set ABC equal to the equilibrium catch corresponding to $F_{44\%}$.
h/ Fishing mortality rate implied by setting ABC equal to historic average catch.

Table 3 **Recommended 1997 BSAI Trawl Fisheries PSC Apportionments and Seasonal Allowances**

Fishery Group	Halibut Mortality Cap (mt)		Herring (mt)	Red King Crab (animals) Zone1	C. bairdi Zone1	C. bairdi Zone2
Yellowfin sole	930		267	10,000	276,316	1,071,000
January 20 - March 31		210				
April 1 - May 10		210				
May 11 - August 14		100				
August 15 - Dec 31		410				
Rocksole/other flatfish	795			75,000*	296,052	357,000
January 20-March 29		485				
March 30 - June 28		130				
June 29-December 31		180				
Turbot/sablefish/ Arrowtooth	0					0
Rockfish	100		7			7,000
Jan. 1 - Mar. 31		30				
May 1 - June 30		45				
July 1 - Dec. 31		25				
Pacific cod	1,600		20	7,500	133,224	195,000
Pollock/mackerel/o.species	350		143	7,500	44,408	470,000
January 20-April 15		300				
April 16-December 31		50				
Pelagic Trawl Pollock			1,142			
TOTAL		3,775	1,579	100,000	750,000	2,100,000

Note: unused PSC allowances may be rolled into the following seasonal apportionment.

Red king crab PSC for the rock sole fishery is apportioned 26,250 inside the 56 - 56°10' slice, and 48,750 outside.

Table 4 **Recommended 1997 BSAI Non-Trawl Fisheries PSC Bycatch Allowances and fixed gear Pacific cod seasonal apportionements**

Fishery Group	Halibut Mortality (mt)		Seasonal Apportion of cod ITAC (mt)
Pacific Cod	840		
Jan 1 - April 30		495	85,000
May 1 - September 15		40	26,500
Sept. 15 - Dec. 31		305	5,545
Other Non-Trawl*	60		
Groundfish Pot	Exempt		
TOTAL	900 mt		117,045

Note: unused PSC halibut from first trimester will be rolled into the third trimester.

Any unused cod TAC from first trimester will go into third trimester.

Reserves of 20,655 mt to be apportioned as above, 77% to first and third trimester, 23% to second.

* Includes hook & line fisheries for rockfish and Greenland turbot.
Sablefish hook & line fisheries will be exempted from the halibut mortality cap.
Jig gear will also be exempted from the halibut mortality cap.

NMFS/AKR
09/04/97
16:15:36

1997 BERING SEA/ALEUTIAN ISLANDS FISHERIES
PROHIBITED SPECIES BYCATCH
Week Ending: 08/30/97

TRAWL HERRING, BSAI

Fishery group	Herring (mt)	Cap (mt)	%
Midwater pollock	49	1,142	4%
Pacific cod	1	20	5%
Yellowfin sole	127	267	48%
Rockfish	0	7	0%
Other	0	143	0%
Total:	177	1,579	11%

TRAWL SALMON, BSAI

Fishery group	Chinook (#'s)	Other (#'s)	Total (#'s)
Midwater pollock	10,448	4,905	15,354
Pacific cod	5,737	101	5,838
Yellowfin sole	259	49	308
Rock sole/Other flatfish	2	147	149
Rockfish	71	0	71
Other	422	292	714
Seasonal Total:	16,939	5,494	22,432

TRAWL BAIRDI TANNER CRAB

	ZONE 1			ZONE 2		
Fishery group	Crabs (#'s)	Cap (#'s)	%	Crabs (#'s)	Cap (#'s)	%
Rock sole/Other flatfish	367,048	296,052	124%	132,809	357,000	37%
Pacific cod	164,426	133,224	123%	88,320	195,000	45%
Yellowfin sole	292,249	276,316	106%	401,580	1,071,000	37%
PLCK/AMCK/OTHER	10,686	44,408	24%	2,884	470,000	1%
Rockfish	0	0	0%	0	7,000	0%
Rockfish	0	0	0%	352	7,000	5%
GTRB/ARTH/SABL	0	0	0%	0	0	0%
Total:	834,408	750,000	111%	625,945	2,107,000	30%

TRAWL RED KING CRAB

	ZONE 1		
Fishery group	Crabs (#'s)	Cap (#'s)	%
Rock sole/Other flatfish	37,205	48,750	76%
Pacific cod	4,834	7,500	64%
Yellowfin sole	4,856	10,000	49%
PLCK/AMCK/OTHER	137	7,500	2%
Total:	47,033	73,750	64%

NMFS/AKR
09/04/97
16:18:19

1997 BERING SEA / ALEUTIAN ISLANDS FISHERIES
TRAWL HALIBUT BYCATCH MORTALITY (METRIC TONS)

WED	PACIFIC COD	YELLOWFIN SOLE	ROCK SOLE/ FLATHEAD SOLE/ OTHER FLATFISH	PLCK/AMCK/ OTHER	ROCKFISH	ARROWTOOTH/ SABLEFISH/ TURBOT
01/25/97	28	0	51	15	0	0
02/01/97	52	0	45	29	0	0
02/08/97	38	0	97	55	0	0
02/15/97	33	0	139	23	0	0
02/22/97	73	2	116	48	1	0
03/01/97	164	36	0	4	10	0
03/08/97	117	39	0	2	0	0
03/15/97	136	74	0	5	0	0
03/22/97	75	49	0	15	0	0
03/29/97	129	4	0	1	3	0
04/05/97	72	8	58	3	1	0
04/12/97	86	17	69	0	0	0
04/19/97	101	66	0	6	0	0
04/26/97	75	67	0	0	0	0
05/03/97	96	9	0	0	0	0
05/10/97	38	11	0	0	0	0
05/17/97	0	18	0	0	0	0
05/24/97	1	24	0	0	0	0
05/31/97	0	24	0	0	0	0
06/07/97	0	40	0	0	0	0
06/14/97	0	87	0	0	0	0
06/21/97	6	20	0	0	0	0
06/28/97	1	0	0	0	0	0
07/05/97	0	0	13	0	0	0
07/12/97	0	0	40	0	0	0
07/19/97	0	0	173	0	0	0
07/26/97	1	0	100	0	0	0
08/02/97	10	0	1	0	0	0
08/09/97	2	0	0	0	0	0
08/16/97	1	22	0	1	0	0
08/23/97	0	57	0	3	0	0
08/30/97	0	43	1	1	0	0
	1,334	716	901	211	14	0
SEASONAL CAP:	1,600	930	795	350	100	0
% OF CAP:	83%	77%	113%	60%	14%	0%
REMAINING:	266	214	-106	139	86	0
ANNUAL CAP:	1,600	930	795	350	100	0
% OF CAP:	83%	77%	113%	60%	14%	0%

TOTAL HALIBUT MORTALITY : 3,176
TOTAL ANNUAL HALIBUT CAP: 3,775

NMFS/AKR
09/04/97

1997 BERING SEA / ALEUTIAN ISLANDS FISHERIES
FIXED GEAR HALIBUT BYCATCH MORTALITY (METRIC TONS)

	PACIFIC COD HOOK & LINE		OTHER SPECIES HOOK & LINE, JIG		ALL GROUNDFISH POT GEAR	
WED	WEEKLY	TOTAL	WEEKLY	TOTAL	WEEKLY	TOTAL
01/04/97	17	17	0	0	0	0
01/11/97	18	36	0	0	0	0
01/18/97	21	57	0	0	0	0
01/25/97	18	75	0	0	0	0
02/01/97	13	88	0	0	0	0
02/08/97	12	100	0	0	0	0
02/15/97	9	109	0	0	0	0
02/22/97	6	115	0	0	0	0
03/01/97	8	123	0	0	0	0
03/08/97	10	133	0	0	0	0
03/15/97	12	145	0	0	0	0
03/22/97	16	161	0	0	0	0
03/29/97	18	179	0	0	0	0
04/05/97	17	196	1	1	0	0
04/12/97	12	207	0	1	0	0
04/19/97	18	226	0	1	0	0
04/26/97	27	252	0	1	0	0
05/03/97	10	263	10	11	0	1
05/10/97	7	270	24	35	1	1
05/17/97	13	283	5	40	1	2
05/24/97	23	306	1	41	1	3
05/31/97	27	333	4	45	1	3
06/07/97	0	333	0	45	1	4
06/14/97	2	334	6	52	2	7
06/21/97	0	335	0	52	1	7
06/28/97	0	335	0	52	0	8
07/05/97	0	335	0	52	1	8
07/12/97	0	335	0	52	0	9
07/19/97	0	335	1	53	1	9
07/26/97	0	335	0	53	1	11
08/02/97	0	335	0	53	0	11
08/09/97	0	335	0	53	0	11
08/16/97	0	335	0	53	0	11
08/23/97	0	335	0	53	0	12
08/30/97	1	336	0	53	0	12

PCOD SEASONAL CAP: 305
% OF SEASONAL CAP: 110%

REMAINING PCOD: -31

OTHER SEASONAL CAP: 60
% OF SEASONAL CAP: 88%

REMAINING OTHER: 7

Pot gear is exempt from bycatch allowances

1997 BSAI NON-TRAWL PACIFIC COD FISHERY HALIBUT BYCATCH ALLOWANCES

(Jan 01 - Apr 30)	495 MT
(May 01 - Aug 31)	40 MT
(Sep 15 - Dec 31)	305 MT
Annual Total	840 MT

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

AGENDA D-3(c)(1)
SEPTEMBER 1997

September 11, 1997

RECEIVED SEP 12 1997

Mr. Richard B. Lauber
Chairman, North Pacific Fishery
Management Council
605 W. 4th Avenue
Anchorage, Alaska 99501-2252

Dear Rick,

Bycatch rate standards for trawl fisheries under the Pacific halibut and red king crab vessel incentive program during the first half of 1998 are scheduled to be published in the Federal Register by January 1, 1998. A summary of 1993 - 1997 observer data on fishery bycatch rates is listed in the attached table for review by the Council. Recent halibut and crab bycatch rates in the groundfish trawl fisheries do not appear to warrant a change in the bycatch rate standards recommended by the Council during the past several years. Unless the Council recommends a change in these standards, we will continue to use the halibut and red king crab bycatch rate standards listed in the attached table for the first half of 1998.

Sincerely,

Ronald J. Berg
For Steven Pennoyer
Administrator, Alaska Region

Attachment

1993 - 1997 (through mid August 1997) observed bycatch rates, by quarter, of halibut and red king crab in the fishery categories included in the vessel incentive program. Also listed are the bycatch rate standards established since 1995.

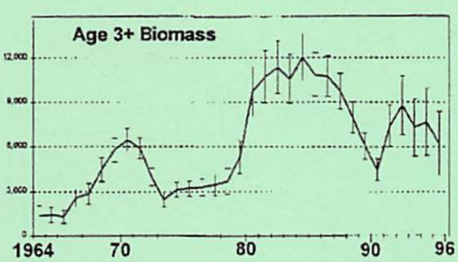
Halibut Bycatch (Kilograms Halibut/metric ton Allocated Groundfish Catch

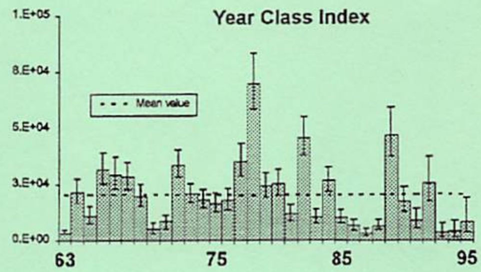
Fishery and quarter	Bycatch Rate Standards	Observed Bycatch Rates				
		1993	1994	1995	1996	1997
BSAI Midwater Pollock						
QT 1	1.0	0.95	0.17	0.05	0.10	0.09
QT 2	1.0	0.20	0.01	0.07	0.02	0.43
QT 3	1.0	0.06	0.30	0.12	0.09	0.07
QT 4	1.0	0.12	0.06	0.19	0.21	
Year to date		0.43	0.22	0.09	0.12	0.09
BSAI Bottom Pollock						
QT 1	7.5	7.49	2.71	1.93	2.22	1.35
QT 2	5.0	2.72	29.67	5.50	12.84	0.00
QT 3	5.0	0.84	2.61	1.98	0.41	0.11
QT 4	5.0	25.28	0.38	0.14	0.64	
Year to date		6.86	2.66	1.92	1.40	1.33
BSAI Yellowfin sole						
QT 1	5.0	****	2.70	3.67	2.89	6.06
QT 2	5.0	13.02	5.93	4.54	4.19	5.02
QT 3	5.0	1.82	1.15	2.93	6.86	4.51
QT 4	5.0	3.34	4.57	4.49	12.41	
Year to date		6.18	3.92	3.67	5.25	5.28
BSAI Other Trawl Fisheries						
QT 1	30.0	8.80	9.02	11.27	10.66	8.90
QT 2	30.0	13.69	19.94	16.93	12.71	10.13
QT 3	30.0	4.66	3.30	10.33	6.37	26.29
QT 4	30.0	3.91	4.00	21.23	34.24	
Year to date		9.25	12.04	12.96	11.18	10.34
GOA Midwater Pollock						
QT 1	1.0	0.01	0.06	0.34	0.26	0.02
QT 2	1.0	0.02	0.07	0.05	0.04	0.33
QT 3	1.0	0.03	0.55	0.54	0.03	
QT 4	1.0	0.05	0.04	0.13	0.47	
Year to date		0.03	0.17	0.24	0.12	0.14
GOA Other Trawl fisheries						
QT 1	40.0	34.49	19.97	16.55	14.65	20.29
QT 2	40.0	26.80	42.78	63.93	49.01	63.71
QT 3	40.0	33.90	26.49	18.48	24.71	27.20
QT 4	40.0	37.81	43.76	48.33	46.90	
Year to date		33.04	29.91	28.45	27.36	29.52

Zone 1 Red King Crab Bycatch Rates
(number of crab/mt of allocated groundfish

Fishery and quarter	Bycatch Rate Standards	1993	1994	1995	1996	1997
BSAI yellowfin sole						
QT 1	2.5	****	0.68	0.28	0.00	0.07
QT 2	2.5	2.19	0.23	0.02	0.01	0.13
QT 3	2.5	0.00	0.00	0.00	0.00	
QT 4	2.5	0.27	0.00	****	0.00	
Year to date		1.30	0.33	0.18	0.00	0.11
BSAI Other Trawl						
QT 1	2.5	1.78	1.78	0.31	0.14	0.40
QT 2	2.5	0.02	0.02	0.00	0.00	0.02
QT 3	2.5	0.00	0.00	0.00	0.08	0.00
QT 4	2.5	****	0.00	0.00	0.00	
Year to date		1.18	1.18	0.30	0.10	0.33

A Guide to Stock Assessment of Bering Sea and Aleutian Islands Groundfish





Prepared by

David Witherell[1] and James Ianelli[2]

[1]North Pacific Fishery Management Council

[2]Alaska Fisheries Science Center, NMFS

September 1997

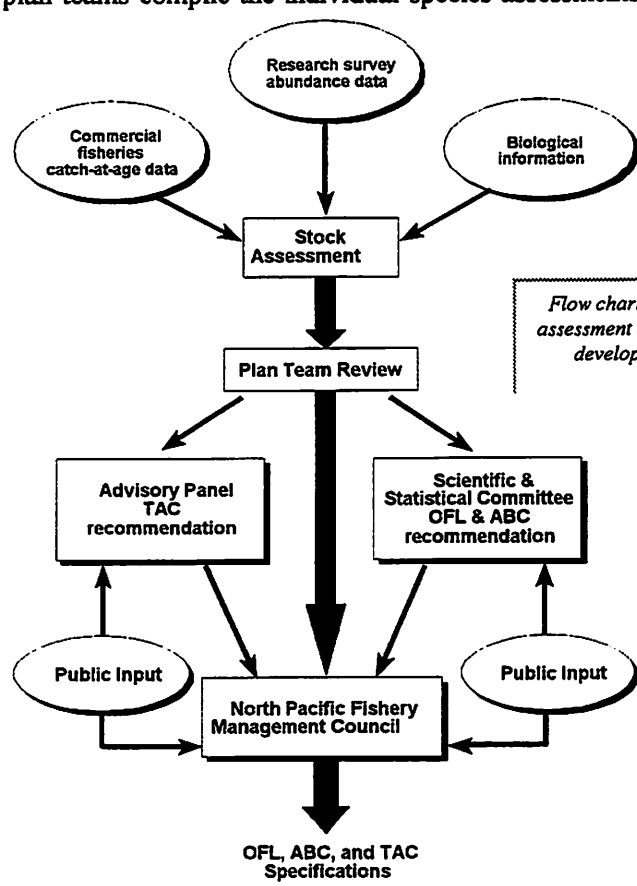
North Pacific Fishery Management Council
605 West 4th Ave., Suite 306
Anchorage, Alaska 99501

A Guide to Stock Assessment of Bering Sea and Aleutian Islands Groundfish

How many times have your heard comments like "Those scientists don't know what they are talking about", "Stock assessment is a bunch of hocus-pocus", and "How the heck did those guys come up with those numbers anyway?" The mystery surrounding the stock assessment process has left fishermen, environmentalists, and others with serious questions and concerns about biomass estimates and established harvest rates. In this article we don't attempt to teach all there is to know about fish stock assessment (that's a Ph.D. program and then some!), but wish to provide the layman with a general understanding of how quotas for groundfish in the Bering Sea and Aleutian Islands are established. As a result, we hope to improve communication among fishermen, managers, and scientists.

Stock assessment is essentially a way to estimate how many fish there are and predict how fish populations will respond to harvesting. Assessment scientists use survey and fishery information in mathematical calculations to estimate how many fish are out there (abundance or biomass). Further, information about the life history (growth, maturity, and mortality) of individual fish species is used to estimate how many fish can be caught without impacting future production of young fish. Fishery managers then use the assessment information about biomass and fishing rates to make decisions about the allowable amount of fish that can be caught during the next fishing season. Managers weight economic and social considerations along with biological advice. Stock assessment scientists, on the other hand, are primarily concerned with biological limits and variability of stock production.

Assessments of Bering Sea and Aleutian Islands (BSAI) groundfish stocks are prepared by scientists at the National Marine Fisheries Service (NMFS), Alaska Fisheries Science Center in Seattle. The assessments are reviewed annually by the BSAI groundfish plan team, which is composed of biologists, economists, and mathematicians from various government agencies and academic institutions. The plan teams compile the individual species assessments into a Stock Assessment and Fishery Evaluation (SAFE) document. The SAFE contains information on historical catch trends, biomass estimates, preliminary estimates of Acceptable Biological Catch (ABC), assessments of harvest impacts, and alternative harvesting strategies. The plan team's recommendations are then passed on to the Council and it's advisory committees. To understand the basis for these recommendations, it is necessary to have some basic knowledge of fishery biology and assessment methodology.



Flow chart of stock assessment and quota development.

Assessing fish stock abundance is not an easy task. You can't simply count them because the fish are out of sight below the water surface. And counting is further complicated because fish move around. Its like trying to estimate the number of worms living in the soil in a schoolyard. How would you go about it? Do you dig up all the grass (a Herculean task) in order to physically count each one, or do you conduct a survey by taking a sample shovel-full of soil here and there to get an estimate? For oceanic fish stocks, the survey sampling method is the only feasible option (of course, we don't use shovels!).

There are several different surveys conducted in the BSAI area, including a bottom trawl survey, a hydroacoustic (sonar type) survey, and longline surveys. Each survey has its strengths and weaknesses for estimating abundance of different fish species. For example, the bottom trawl survey does a good job of estimating rock sole biomass, but does a poorer job with pelagic fishes such as herring and squid. Nevertheless, assessments for most stocks rely on bottom trawl survey data.

The Bering Sea bottom trawl survey is conducted annually during the months of July and August. The survey is based on a grid of fixed survey stations to allow for equal sampling across all habitat types. Each station is located approximately 20 nautical miles apart, giving a sampling intensity of one station for every 1,314 square kilometers (or about 383 square nautical miles). The gear is an Eastern type otter trawl having a 31.4 m long footrope, and is equipped with a small mesh liner (3.2 cm stretched) to retain juvenile fish and crabs. The catch from each tow is first sorted by species then weighed and counted to come up with total values. Each species component is then sampled for sex determination, lengths, individual weights, and biological samples as needed. Fish scales and otoliths (ear bones used for balance and orientation) may be collected for age and growth information (annual rings are formed on these structures similar to growth rings on a tree stump). Gonads are examined for maturity stage. This information is used to evaluate the reproductive activity of fish at different sizes and age. Stomach samples are also collected to provide food habits data (who's eating who, and how much?).

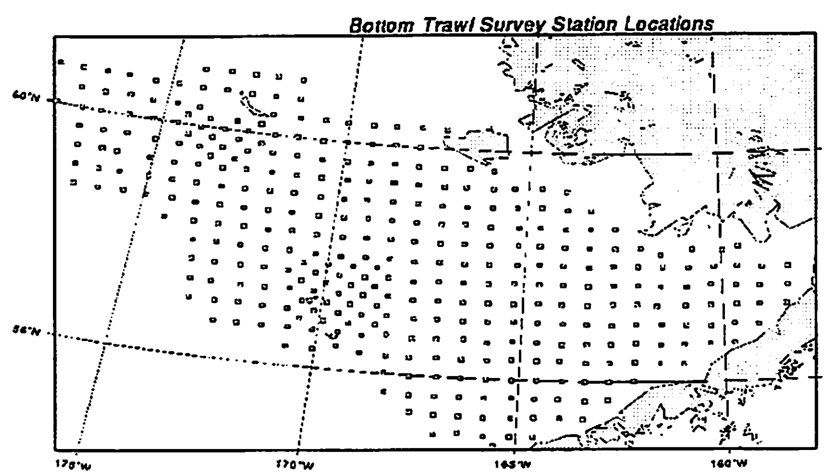
Current research surveys conducted for Bering sea and Aleutian Islands groundfish, by species and area.

Species	Area	EBS Trawl Survey 1979-	EBS Acoustic Survey 1979-	Bogoslof Acoustic Survey 1988-	EBS+AI Longline Survey 1996-	AI Trawl Survey 1980-
Pollock	BS	annual	triennial	-	-	-
	AI	-	-	-	-	triennial
	Bog	-	-	annual	-	-
Pacific cod	BSAI	annual	-	-	-	-
Yellowfin sole	BSAI	annual	-	-	-	-
Gr. Turbot	BSAI	annual	-	-	-	-
Arrowtooth	BSAI	annual	-	-	-	-
Rock sole	BSAI	annual	-	-	-	-
Flathead sole	BSAI	annual	-	-	-	-
Other flatfish	BSAI	annual	-	-	-	-
Sablefish	BS	annual	-	-	biennial	-
	AI	-	-	-	biennial	triennial
P. Ocean Perch	BS	annual	-	-	-	-
	AI	-	-	-	-	triennial
Sharp/Northern	AI	-	-	-	-	triennial
Short/Rougheye	AI	-	-	-	-	triennial
O. Red rockfish	BS	annual	-	-	-	-
Other rockfish	BS	annual	-	-	-	-
	AI	-	-	-	-	triennial
Atka mackerel	AI	-	-	-	-	triennial
Squid	BSAI	annual	-	-	-	-
Other species	BSAI	annual	-	-	-	-

Artist drawing of a cross-sectioned otolith

In the eastern Bering Sea bottom trawl survey, total biomass is estimated using an area-swept method. That is, the length of the net opening multiplied by the distance the net is towed provides a density index for each species at that survey station. The density of fish from all survey stations is averaged and extrapolated to the surveyed area of the Bering Sea to provide a total biomass estimate.

Location of stations sampled during the NMFS eastern Bering Sea bottom trawl surveys



Survey tows made in areas where a species is not abundant often provide better information about relative stock conditions than samples taken in areas with large aggregations of fish. This is one of the primary reasons why data collected aboard fishing vessels is not exclusively used for estimating biomass; quite simply, fishermen try to fish in areas with the most fish! Also the same survey gear (whether it be trawl, longline, or sonar) is used at each station, year after year. Survey gear is generally designed to catch fish of all sizes, rather than just catching larger fish like the gear used by commercial fishing vessels. Hence, surveys provide a consistent sample of fish from year-to-year, and provide information on pre-recruit sized fish that would otherwise not be available for stock assessment.

Another important source of information comes from commercial fisheries through the observer program. Observers collect size and age data (more otoliths!), in addition to determining total catch of each species. This provides assessment scientists with critical information on removals of fish by age. Commercial samples improve estimates of stock structure and year-class strength (numbers of fish at each age).

Life history characteristics for BSAI groundfish used in 1997 stock assessments, including natural mortality rate (M), length and age at 50% maturity (females), growth parameters (Linf and k or von Bertalanffy equation where $L=L_{inf}\{[_1-\exp(-k(t-t_0)]\}$, and weight parameters ($W=alpha*L^{beta}$) for both sexes combined. Length is measured in centemeters (cm) and weight in grams (g).

Species	Area	M	Growth Parameters L_{inf}	Growth Parameters k	Maturity Indicators $L_{50\%}$	Maturity Indicators $A_{50\%}$	Weight Parameters alpha	Weight Parameters beta
Pollock	BS	0.30	59.0	0.228	n/a	n/a	1.14E-05	2.877
	AI	0.30	52.8	0.368	n/a	n/a	2.73E-05	2.651
	Bog	0.20	55.7	0.171	n/a	n/a	1.29E-06	3.436
Pacific cod	BSAI	0.30	98.2	0.227	67	5.7	5.29E-06	3.206
Yellowfin sole	BSAI	0.12	35.8	0.147	30	10.5	9.72E-04	3.056
Gr. Turbot	BSAI	0.18	n/a	n/a	60	9.0	2.69E-06	3.309
Arrowtooth	BSAI	0.20	59.0	0.170	n/a	n/a	5.68E-06	3.103
Rock sole	BSAI	0.20	45.1	0.180	n/a	n/a	7.61E-03	3.120
Flathead sole	BSAI	0.20	42.6	0.165	n/a	n/a	3.96E-03	3.259
Other flatfish	BSAI	0.20	72.2	0.053	n/a	n/a	8.84E-03	3.111
Sablefish	BS	0.10	70.7	0.275	n/a	n/a	3.23E-03	3.294
	AI	0.10	77.6	0.206	n/a	n/a	3.23E-03	3.294
P. Ocean Perch	BS	0.05	39.9	0.135	n/a	n/a	1.19E-05	3.037
	AI	0.05	39.6	0.167	n/a	n/a	1.22E-05	3.030
Sharp/Northern	AI	0.06	n/a	n/a	n/a	n/a	n/a	n/a
Short/Rougheye	AI	0.03	n/a	n/a	n/a	n/a	n/a	n/a
O. Red rockfish	BS	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Other rockfish	BS	0.07	n/a	n/a	n/a	n/a	n/a	n/a
	AI	0.07	n/a	n/a	n/a	n/a	n/a	n/a
Atka mackerel	AI	0.30	43.5	0.449	31.1	3.6	5.05E-06	3.240
Squid	BSAI	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Other species	BSAI	n/a		n/a	n/a	n/a	n/a	n/a

Life history data (particularly growth and maturity data) are also used to determine appropriate harvest rates. Average growth and maturity can be accurately described by equations with parameters developed from these observations, as shown in the figures below. Life history parameters for BSAI groundfish stocks are listed in the adjacent table. From this information, we can calculate length or weight for any age fish.

Figure of a length-weight relationship

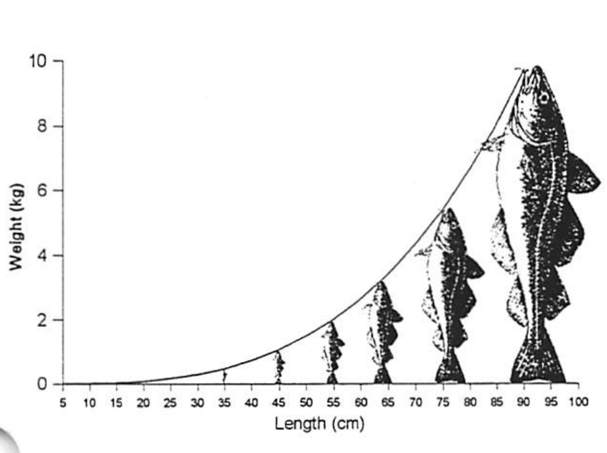
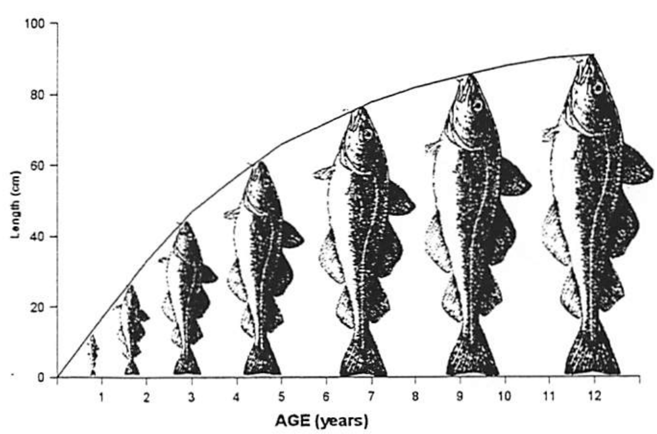


Figure of a growth curve.



One of the basic parameters used in stock assessment calculations is the natural mortality rate, designated as M in equations. Like people and all other living things, a portion of the population dies each year. With good information, we can determine a mortality rate for each age. This forms the basis of life expectancy charts for people used by insurance companies. For fish, this is more difficult because the numbers of natural deaths is unobserved for most marine species. Instead, natural mortality is often assumed constant once they reach maturity. To estimate mortality, other life history information is used. For example, we know mortality is related to longevity; when mortality is high, life spans are short. Examination of numerous fish species have provided a general relationship of mortality and longevity (Hoenig's equation: $\ln(M) = 1.46 * \ln(t_{max})$). Because numerous age samples are taken during surveys and commercial fisheries, we have information on longevity that consequently provides us with an estimate of M. For example, if maximum age observed (t_{max}) for a fish species is 15 years, M = 0.28 based on Hoenig's formula.

Assessment scientists use instantaneous rates, rather than percentages, in calculating mortality assuming that mortality occurs throughout the year. This allows mortality due to natural causes (M) and mortality due to fishing (F) to be used together in equations. The instantaneous total mortality rate is denoted as Z; hence F+M=Z. To convert instantaneous rates to annual rates (A), the formula $A = 1\text{-}e^{-z}$, where e is a standard mathematical constant equal to 2.718. A quick chart comparing annual rates with instantaneous rates is shown in the adjacent table.

Comparison of annual mortality rates and instantaneous mortality rates (F, M, Z).

Annual Rate (%)	Instantaneous Rate
0	0
5	0.0513
10	0.1054
15	0.1625
20	0.2231
25	0.2877
30	0.3567
35	0.4308
40	0.5108
45	0.5978

Tiers used to determine ABC and OFL.

(1) Information available: Reliable point estimates of B and B_{MSY} and reliable pdf of F_{MSY}.
- *1a)* *Stock status:* $B/B_{MSY} > 1$
  - $F_{OFL} = m_A$, the arithmetic mean of the pdf
  - F_{ABC} m_H, the harmonic mean of the pdf
- *1b)* *Stock status:* $a < B/B_{MSY}$ 1
  - $F_{OFL} = m_A \times (B/B_{MSY} - a)/(1 - a)$
  - F_{ABC} $m_H \times (B/B_{MSY} - a)/(1 - a)$
- *1c)* *Stock status:* B/B_{MSY} a: $F_{OFL} = 0$, $F_{ABC} = 0$

(2) Information available: Reliable point estimates of B, B_{MSY}, F_{MSY}, $F_{30\%}$, and $F_{40\%}$.
- *2a)* *Stock status:* $B/B_{MSY} > 1$
  - $F_{OFL} = F_{MSY} \times (F_{30\%}/F_{40\%})$
  - F_{ABC} F_{MSY}
- *2b)* *Stock status:* $a < B/B_{MSY}$ 1
  - $F_{OFL} = F_{MSY} \times (F_{30\%}/F_{40\%}) \times (B/B_{MSY} - a)/(1 - a)$
  - F_{ABC} $F_{MSY} \times (B/B_{MSY} - a)/(1 - a)$
- *2c)* *Stock status:* B/B_{MSY} a: $F_{OFL} = 0$, $F_{ABC} = 0$

(3) Information available: Reliable point estimates of B, $B_{40\%}$, $F_{30\%}$, and $F_{40\%}$.
- *3a)* *Stock status:* $B/B_{40\%} > 1$
  - $F_{OFL} = F_{30\%}$
  - F_{ABC} $F_{40\%}$
- *3b)* *Stock status:* $a < B/B_{40\%}$ 1
  - $F_{OFL} = F_{30\%} \times (B/B_{40\%} - a)/(1 - a)$
  - F_{ABC} $F_{40\%} \times (B/B_{40\%} - a)/(1 - a)$
- *3c)* *Stock status:* $B/B_{40\%}$ a: $F_{OFL} = 0$, $F_{ABC} = 0$

(4) Information available: Reliable point estimates of B, $F_{30\%}$, and $F_{40\%}$.
  - $F_{OFL} = F_{30\%}$
  - F_{ABC} $F_{40\%}$

(5) Information available: Reliable point estimates of B and natural mortality rate M.
  - $F_{OFL} = M$
  - F_{ABC} $0.75 \times M$

(6) Information available: Reliable catch history from 1978 through 1995.
  - *OFL= the average catch from 1978 through 1995, unless another value is established by the SSC with best available scientific information*
  - *ABC* $0.75 \times OFL$

The primary foundation of fisheries management has been to provide for long-term maximum sustainable yield (MSY) of fish resources. Unfortunately, information has not generally been available to determine the fishing mortality rate that produces MSY, particularly in variable environments. Instead, other surrogate fishing mortality rates have been used. The harvest rate set for each species depends on available information; in general, the less information available, the higher the uncertainty, and the more conservative the harvest rate used (as shown in the adjacent table). Reference fishing mortality rates of $F_{30\%}$ and $F_{40\%}$ are generated when maturity, growth and natural mortality data are available. For most BSAI stocks, our benchmark fishing mortality rates are $F_{30\%}$ to define overfishing, and $F_{40\%}$ to define ABC (tiers 2 through 4). $F_{40\%}$ is the fishing mortality rate that reduces spawning biomass per recruit to 40% of its unfished value. For stocks with very limited information, ABC is based on fishing rates that equal M or just average catches (tiers 5 and 6).

The $F_{40\%}$ exploitation rate was based on analysis of a range of life history parameters and spawner recruit relationships observed for North Pacific and Atlantic groundfish stocks (Clark 1991, 1993). A preliminary analysis indicated that for a range of spawner-recruit relationships, a fishing mortality rate that reduced spawning biomass per recruit to 35% of it unfished value (denoted F_{35}%) would produce yields of at least 75% of maximum sustainable yield. A subsequent analysis that incorporated recruitment variability suggested that $F_{40\%}$ would be a more conservative fishing rate without reducing long-term yield.

So how do we know the unfished value of a population? As long as we have an estimate of M, average weight at age, and proportion mature at age, we can generate spawner-per-recruit (SPR) reference mortality rates. Calculation of SPR is shown in the table below, by illustrating what happens to 1,000 recruits during their lifetime. In an unfished stock, mortality is due only to "natural" causes (for example predation, starvation, disease). The number of spawners at each age is the product of number alive at age, weight at age, and proportion mature at age. Percent SPR at each age is simply the number of spawners at age divided by the initial number of recruits (1,000 in this example).

Spreadsheet illustrating the calculation of spawner-per-recruit (SPR) in an unfished population and a fished population of Atka mackerel. Calculations begin with 1,000 recruits, reduced over time by natural mortality (M) and fishing mortality (F). Average weight at age (kg) and proportion mature at age comes from direct observations. SPR is the biomass of spawners produced by that age, divided by the number of recruits (1,000). The total for all ages is the SPR for that level of fishing mortality. In this example, we have calculated that $F_{40\%}$ is 0.36.

Unfished Population

AGE	M	F	# of fish	Ave. wt.	Prop. mature	Wt. Of Spawn	SPR
1	0.3	0.0	1000	0.23	0.00	0.0	0.00
2	0.3	0.0	741	0.40	0.04	11.98	0.01
3	0.3	0.0	549	0.52	0.22	62.23	0.06
4	0.3	0.0	407	0.59	0.69	164.49	0.16
5	0.3	0.0	301	0.63	0.94	178.84	0.18
6	0.3	0.0	223	0.66	0.99	145.92	0.15
7	0.3	0.0	165	0.68	1.00	112.25	0.11
8	0.3	0.0	122	0.69	1.00	84.60	0.08
9	0.3	0.0	91	0.70	1.00	63.36	0.06
10	0.3	0.0	67	0.70	1.00	47.26	0.05
11	0.3	0.0	50	0.71	1.00	35.16	0.04
12	0.3	0.0	37	0.71	1.00	26.12	0.03
13	0.3	0.0	27	0.71	1.00	19.39	0.02
14	0.3	0.0	20	0.71	1.00	14.38	0.01
15+	0.3	0.0	15	0.71	1.00	10.66	0.01
						Total	1.00

Fished Population (F=0.36)

AGE	M	F	# of fish	Ave wt.	Prop. mature	Wt. of spawn	SPR
1	0.3	0	1000	0.23	0.00	0.00	0.00
2	0.3	0	741	0.40	0.04	11.98	0.01
3	0.3	0.05	522	0.52	0.22	59.19	0.06
4	0.3	0.25	301	0.59	0.69	121.86	0.12
5	0.3	0.36	156	0.63	0.94	92.44	0.09
6	0.3	0.36	80	0.66	0.99	52.62	0.05
7	0.3	0.36	42	0.68	1.00	28.24	0.03
8	0.3	0.36	22	0.69	1.00	14.85	0.01
9	0.3	0.36	11	0.70	1.00	7.76	0.01
10	0.3	0.36	6	0.70	1.00	4.04	0.00
11	0.3	0.36	3	0.71	1.00	2.10	0.00
12	0.3	0.36	2	0.71	1.00	1.09	0.00
13	0.3	0.36	1	0.71	1.00	0.56	0.00
14	0.3	0.36	0	0.71	1.00	0.29	0.00
15	0.3	0.36	0	0.71	1.00	0.15	0.00
						Total	0.40

Reference fishing mortality rates established for Bering Sea and Aleutian Islands groundfish, 1997.

Species	Area	Assessment Method	Tier	ABC strategy	ABC rate	OFL strategy	OFL Rate
Pollock	BS	VPA	2	$F_{40\%}$	0.30	$F_{msy(adj)}$	0.46
	AI	VPA	4	$F_{40\%}$	0.38	$F_{30\%}$	0.57
	Bogoslof	Index	4	$F_{40\%}$	0.27	$F_{30\%}$	0.37
Pacific Cod	BSAI	Synthesis	3	$F_{40\%}$	0.27	$F_{30\%}$	0.38
Yellowfin sole	BSAI	Synthesis	4	$F_{40\%}$	0.16	$F_{30\%}$	0.11
Greenland turbot	BSAI	Synthesis	4	$F_{40\%}$	0.35	$F_{30\%}$	0.56
Arrowtooth flounder	BSAI	Synthesis	4	$F_{40\%}$	0.22	$F_{30\%}$	0.34
Rock sole	BSAI	Synthesis	4	$F_{40\%}$	0.15	$F_{30\%}$	0.22
Flathead sole	BSAI	Index	4	$F_{40\%}$	0.16	$F_{30\%}$	0.23
Other flatfish	BSAI	Synthesis	4	$F_{40\%}$	0.20	$F_{30\%}$	0.31
Sablefish	BS	Synthesis	3	$F_{40\%}$(adjusted)	0.088	$F_{30\%}$	0.16
	AI	Synthesis	3	$F_{40\%}$(adjusted)	0.088	$F_{30\%}$	0.16
Pacific Ocean Perch	BS	Synthesis	3	$F_{44\%}$	0.049	$F_{30\%(adj)}$	0.079
	AI	Synthesis	3	$F_{44\%(adjusted)}$	0.049	$F_{30\%}$	0.10
Sharpchin/Northern	AI	Index	5	F=0.75M	0.045	F=M	0.060
Shortraker/Rougheye	AI	Index	5	F=0.75M	0.021	F=M	0.028
Other red rockfish	BS	Index	5	F=0.75M	0.035	F=M	0.047
Other rockfish	BS	Index	5	F=0.75M	0.053	F=M	0.070
	AI	Index	5	F=0.75M	0.053	F=M	0.070
Atka mackerel	AI	Synthesis	3	$F_{40\%}$	0.36	$F_{30\%}$	0.50
Squid	BSAI	n/a	6	$F=0.75F_{hist}$	na	$F=F_{hist}$	Na
Other species	BSAI	Index	5	$F=0.75F_{hist}$	0.038	$F=F_{hist}$	0.20

There are two primary types of assessment methods used for BSAI groundfish, and they are an index and age structured models. The most basic assessment is an index of population based on survey data. For an index assessment, biomass is estimated solely from the trawl surveys area-swept extrapolation.

Age structured models include virtual population analysis (VPA) and stock synthesis. An assessment based on VPA uses estimates of catch at age data from the fishery to determine the numbers at age. The critical catch at age estimates come from the otolith samples collected by observers during the fisheries. The age samples are then combined with the (typically) large number of length frequency samples and aggregate catch estimates to come up with estimates of the total catch numbers at age. Given these estimates of catch, the total stock biomass and population composition for prior years can thus be determined. The VPA computations simply involve transforming the catch-at-age estimates into historical population estimates through a series of equations. Here, the survey data are typically compared for consistency with results coming from the VPA. If there is poor consistency between the survey and the results from the VPA (or any other "model" for that matter) then the stock assessment scientist must change assumptions made in the VPA or conclude that, given the inherent "noise" from the survey data, the inconsistency is acceptable. The process of changing assumptions typically involves "tuning" population parameter[1] values much like a radio dial is tuned. As the parameter values change, the VPA (or other model) becomes more or less consistent with survey observations.

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[1] A parameter is a value representing an unknown quantity taking on values either as assumed or estimated.

A computer program called "stock synthesis" is used for most BSAI groundfish assessments. This program is fundamentally set up as a tool for easily incorporating complex fishery and survey data in a single framework. It is structured such that it is less demanding than the VPA methods and requires fewer assumptions about the types of data that are entered. By fewer assumptions we mean that quantities in the model that we know are uncertain are treated appropriately. For example, the foundation of VPA methods requires *the assumption* that the catch-at-age data are measured without error. The key philosophy of the model is to treat our observations, say the estimates we make on the catch-at-age in a given year, as *random* quantities about some true underlying values. This simply involves treating the estimation using appropriate statistical methods.

How does the stock synthesis program work?

One way to think about how the program is designed is to imagine trying to say something about a stock of fish *before* looking at any data. What can one do? Well, given that you know the species of fish, and some general biological characteristics, you could *synthesize* the abundance of that stock given some crude approximations. Given guesses about: a) how much harvest has been taken over the past several years, b) the rate these fish grow with age, and c) how fast they die off due to natural causes. One could come up with a simulated or *synthesized* level of abundance with this information alone.

Leaving out some details, the essence of our initial data-less or synthesized population model can be illustrated in the following example. First lets say we think that the fishery had average catches of about 500 tons of catch for the past 10 years (before then removals were insignificant). Then lets say we guess that in year 10 the harvest represented about 10% of the total stock. Given some assumptions about the rate fish die due to natural causes (*natural mortality*) and the average weight at age, the abundance trend can be sketched out (see table below). This result might be completely wrong but the calculations for the construction of population numbers is complete. Now all that is left is to add some realism to this synthesized stock. This is where the data (finally!) come in.

Hypothetical sketch of how numbers-at-age values might appear from back-of-the-envelope type computations. (Note that here we have made some simplifying assumptions and present annual rates of fishing and natural mortality instead of the instantaneous values used in most models).

Age	4	5	6	7	8	10+			
Natural Mortality	20%	20%	20%	20%	20%	20%			
Average weight	1.0	1.5	1.9	2.1	2.4	2.6			
	Numbers						Biomass	Catch	F
Year 0 (no fishing)	1,000	800	640	512	410	328	6,300		0%
Year 1	1,000	737	589	471	377	302	5,900	500	8%
Year 2	1,000	732	539	431	345	276	5,600	500	8%
Year 3	1,000	729	533	393	314	251	5,300	500	9%
Year 4	1,000	725	528	387	285	228	5,200	500	9%
Year 5	1,000	723	524	382	279	206	5,100	500	10%
Year 6	1,000	722	522	378	275	202	5,000	500	10%
Year 7	1,000	720	520	376	272	198	5,000	500	10%
Year 8	1,000	720	518	374	271	196	5,000	500	10%
Year 9	1,000	720	518	373	269	195	5,000	500	10%
Year 10	1,000	720	518	373	269	194	5,000	500	10%

In our numerical model, we want to replace values describing our synthesized stock with numbers that best match our observations. This is analogous to the sculptor chiseling a stone to the desired likeness. First we replace our biological guesses (such as average weights at age) with estimates based on real data. Similarly, we use information on the longevity and reproductive output of the species under consideration to come up with initial estimates of natural mortality rates. Information on the type of gear used in the fishery and surveys provide background on the selectivity patterns we might expect. Running the model at this point improves the realism over our original guesses and scales the population values in general terms. Further refinements occur as age or size composition data are added and provide critical information on the variability of year-class strengths and historical pattern of age structure of the population.

These refinements reveal the great utility of computers in the final estimation process. For example, we could enter a model into a spreadsheet and manipulate a few key values until the "model" fit our observations. With several hundred parameters, however, doing this by hand is impractical so specialized automatic "tuners" to do the model fitting. This simply changes parameter values until our "simulation" becomes most consistent with our observations. Tuning computer models is also called optimization. Optimization is an active area of computer science research and is applied for solving a wide variety of problems from business decisions to analyses of quantum mechanics. In our fisheries applications we attempt to take advantage of these rapid technological developments to help improve our ability to provide useful advice to fisheries managers. These steps are incremental and, as with other sciences, hotly debated and always evolving.

What about uncertainty?

One concern about how fisheries stock assessments can fail is in providing harvest guidelines without consideration of how robust or resilient a model result is to harvest recommendations. Dealing with uncertainty is an extremely difficult task. In most stock assessments around the world, the magnitude of the uncertainty (if this is presented at all) is probably largely under-estimated. Terms like *precautionary principle* and *risk averse policy* are becoming increasingly common and for good reason. These terms are most applicable where effective management practices are in place (e.g., quotas in the North Pacific). The amount of precaution and risk aversion recommended based on stock assessment analyses is irrelevant if there are no means to control the level of fishing. The idea of risk aversion is problematic since the concept of risk is different for different people or fisheries sectors. For example, most commercially exploited species of fish are unlikely to face the risk of extinction since

The amount of precaution and risk aversion recommended based on stock assessment analyses is irrelevant if there are no means to control the level of fishing.

economic factors will be generally prohibitive to catching the very last fish. There are real risks of economic collapses of fisheries or ecosystem imbalances caused by fisheries. Studies on ecosystems is difficult since there are so many factors involved, prediction is probably more difficult than predicting the weather. Recent advances that have been made (and are currently part of the quota tier system presented above) reflect the fact that when there is greater uncertainty about key quantities, the *risk averse* policy generally results in lower quotas. Fisheries scientists enjoy this result since the need for better information can translate to more accurate understanding of fish population dynamics while providing a real service to the management of these fisheries.[2]

Appendix Table 2. Exploitable biomass and harvest specifications (mt) of Bering Sea and Aleutian Islands groundfish, 1997. Biomass listed is that projected for 1997.

Species	Area	Biomass	OFL	ABC	TAC
Pollock	BS	6,120,000	1,980,000	1,130,000	1,130,000
	AI	100,000	38,000	28,000	28,000
	Bogoslof	558,000	43,800	32,100	1,000
Pacific Cod	BSAI	1,590,000	418,000	306,000	270,000
Yellowfin sole	BSAI	2,530,000	339,000	233,000	230,000
Greenland turbot	BSAI	118,000	22,600	12,350	9,000
Arrowtooth flounder	BSAI	587,000	167,000	108,000	20,760
Rock sole	BSAI	2,390,000	427,000	296,000	97,185
Flathead sole	BSAI	632,000	145,000	101,000	43,500
Other flatfish	BSAI	616,000	150,000	97,500	50,750
Sablefish	BS	17,900	2,750	1,308	1,100
	AI	18,600	2,860	1,367	1,200
Pacific Ocean Perch	BS	72,500	5,400	2,800	2,800
	AI	324,000	25,300	12,800	12,800
Sharpchin/Northern	AI	96,800	5,810	4,360	4,360
Shortraker/Rougheye	AI	45,600	1,250	938	938
Other red rockfish	BS	29,700	1,400	1,050	1,050
Other rockfish	BS	7,100	497	373	373
	AI	13,600	952	714	714
Atka mackerel	AI	450,000	81,600	66,700	66,700
Squid	BSAI	n/a	2,620	1,970	1,970
Other species	BSAI	688,000	138,000	25,800	25,800
TOTAL (all species)	BSAI	17,004,800	3,998,839	2,464,130	2,000,000

Putting it all together...

The stock assessment results and projections for 1997 were summarized in the SAFE document released in November 1996. The SSC reviewed the SAFE, and for many species, concurred with the plan team's estimate of biomass and recommended harvest rates. For Bogoslof pollock, the SSC disagreed with the team, and recommended that the OFL and ABC be reduced by current biomass. A similar adjustment was recommended for Greenland turbot. The Council's Advisory Panel recommended the total allowable catches (TACs) for 1997, which were adopted by the Council. In all cases, TAC is less than or equal to ABC that is less than OFL. The 1997 specifications are shown in the adjacent table.

[2] *The Precautionary Principle in North Pacific Groundfish Management*, by Dr. G. Thompson (AFSC NMFS, Seattle WA) Available at: http://www.refm.noaa.gov/grant/precaut.html

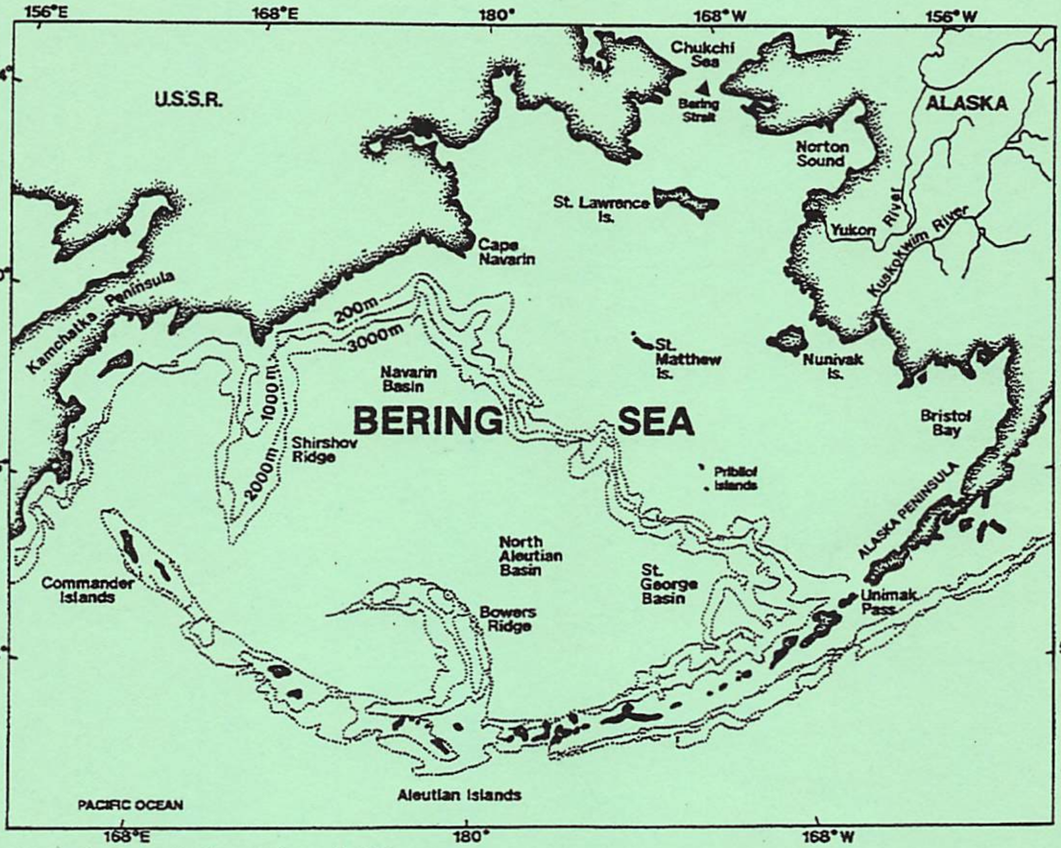

FIG. 1. The Bering Sea (from Sayles et al. 1979).