AGENDA D-3(a)
DECEMBER 1986

M E M O R A N D U M

TO: Council, SSC, and AP

FROM: Jim H. Branson
Executive Director

DATE: December 3, 1986

SUBJECT: Bering Sea/Aleutian Islands Groundfish

ACTION REQUIRED

Review status of stocks and adjust 1987 ABCs as necessary. Set initial 1987 TACs for discussion purposes.

BACKGROUND

In July the plan team prepared the 1986 Resource Assessment Document (RAD) which was sent out for public review prior to the September Council meeting. On October 10 the proposed TACs were sent out for a 30-day public comment period with the caveat that the plan team would reevaluate their estimates based on new information from NMFS surveys, INPFC documents and public comments. Based on INPFC reports and new analysis by NMFS, the team is recommending several changes. Table 1 compares the team's recommendations with the 1986 TACs and with the previous estimates in the 1986 RAD. A computer spreadsheet and the enclosed worksheet (Table 2) are provided for your use. Initial TACs may be adjusted later when apportionments are made.

The RAD Supplement prepared by the team at their November meeting was sent to you in late November and has been included under item D-3(a)(1). This document contains the updated stock status information which is the primary basis for setting the ABCs. The revised ABCs total over 2 million mt and thus at least a few TACs must be adjusted downward to stay within the OY range.

Public comments received during the comment period were sent to you in recent Council mailings. A summary of those comments is provided for your review in item D-3(a)(2).

Briefly, the changes from the July RAD are as follows:

Pollock - The ABC estimate has been increased to 1,200,000 mt (up from 1,100,000 mt in July).

Pacific Cod - ABC has been increased to 400,000 mt (up from 265,000 mt in July).

Greenland turbot - ABC has been increased to 20,000 mt (from 5,000 mt in July).

Arrowtooth flounder - ABC reduced to 30,900 mt (from 33,400 mt in July).

Other flatfish - Increased to 193,300 mt (from 159,700 mt in July).

Sablefish - Bering Sea: reduced to 3,700 mt (down from 5,000 mt in July).
Aleutians: Reduced to 4,000 mt (down from 5,000 mt in July).

Pacific ocean perch - Bering Sea: increased to 3,800 mt (from 3,000 mt in July).
Aleutians: reduced to 10,900 mt (from 11,900 mt in July).

Other rockfish - Bering Sea: reduced to 450 mt (down from 500 mt in July).
Aleutians: reduced to 1,430 mt (down from 1,900 mt in July).

Other species - increased to 49,500 mt (from 36,700 mt in July).

OTHER STOCK STATUS ISSUES

Pollock - The plan team has estimated the "donut hole" catch at approximately 200,000 mt in 1986, of which 50% may be of U.S. origin. You should determine whether or not to adjust the Bering Sea and/or Aleutians TACs to account for this harvest.

Other flatfish/rockfish sole - The plan team has recommended that you consider separating rock sole from the other flatfish complex due to the increasing interest by the U.S. industry. The team feels that there is inadequate justification for making this change at this time and that it is not in line with the ecosystem management concept of the FMP. In addition, comments from the industry did not support the change.

Table 1. 1987 Total Allowable Catch Worksheet: Bering Sea/Aleutian Islands

Species	Area	86 TAC[1/]	1986 Harvest[2/]	July RAD	November Update
Pollock	BS	1,200,000	1,166,225	1,100,000	1,200,000
	AI	100,000	43,909	100,000	100,000
Pacific	BS	825	692	3,000	3,800
ocean perch	AI	6,800	15	11,900	10,900
Rockfish	BS	825	280	500	450
	AI	5,800	444	1,900	1,430
Sablefish	BS	2,250	3,071	5,000	3,700
	AI	4,200	2,861	5,000	4,000
Pacific cod	BSAI	229,000	124,428	265,000	400,000
Yellowfin sole	BSAI	209,500	200,274	187,000	187,000
Turbots-Greenland	BSAI	33,000	7,830	5,500	20,000
Arrowtooth	BSAI	20,000	6,492	33,400	30,900
Other flatfish[3/]	BSAI	124,200	76,896	159,700	193,300
Atka mackerel	BSAI	30,800	31,989	30,800	30,800
Squid	BSAI	5,000	775	10,000	10,000
Other species	BSAI	27,800	10,966	36,700	49,500
TOTAL		2,000,000	1,677,147	1,955,400	2,245,780

1/ 1986 TAC as set by the Council in December 1985.
2/ 1986 harvest from PacFIN 12/01/86.
3/ Other flatfish includes rock sole.

Table 2. 1987 Total Allowable Catch Worksheet
Bering Sea/Aleutian Islands

Species	Area	86 TAC 1/	Plan Team Recommendation	Council ABC	Initial TAC 2/
Pollock	BS	1,200,000	1,200,000		
	AI	100,000	100,000		
Pacific	BS	825	3,800		
ocean perch	AI	6,800	10,900		
Rockfish	BS	825	450		
	AI	5,800	1,430		
Sablefish	BS	2,250	3,700		
	AI	4,200	4,000		
Pacific cod	BSAI	229,000	400,000		
Yellowfin sole	BSAI	209,500	187,000		
Turbots-Greenland	BSAI	33,000	20,000		
Arrowtooth	BSAI	20,000	30,900		
Other flatfish 3/	BSAI	124,200	193,300		
Atka mackerel	BSAI	30,800	30,800		
Squid	BSAI	5,000	10,000		
Other species	BSAI	27,800	49,500		
TOTAL		2,000,000	2,245,780		

1/ 86 TAC as set by the Council in December 1985.
2/ Total cannot exceed 2,000,000mt.
3/ Other flatfish includes rock sole.

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SUPPLEMENT TO
RESOURCE ASSESSMENT DOCUMENT FOR BERING SEA-ALEUTIANS GROUNDFISH FOR 1986

Prepared by

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November 1986

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Abbreviations and Acronyms Used in this Report

ABC =	Acceptable Biological Catch
EY =	Equilibrium Yield
EBS =	eastern Bering Sea
TAC =	Total Allowable Catch
FCZ =	Fishery Conservation Zone
MSY =	Maximum Sustainable Yield
RAD =	Resource Assessment Document
POP =	Pacific ocean perch
INPFC =	International North Pacific Fisheries Commission
SRA =	Stock Reduction Analysis
NMFS =	National Marine Fisheries Service
t =	metric tons
Team =	Bering Sea groundfish plan team
DAH =	Domestic Annual Harvest
DAP =	Domestic Annual Processing

Low 5.10.1

Table 1.--Estimates of maximum sustainable yields (MSYs) equilibrium yields (EYs) or acceptable biological catches (ABCs) in metric tons for 1985 and 1987 with remarks on current condition of the resources for the eastern Bering Sea (EBS) and Aleutians. The 1987 estimates from the July Resource Assessment Document (RAD) have been updated by the Plan Team in November.

Species/Region	MSY	1985 EY	1987 EY/ABC		Condition of Stocks
			July RAD	November Update	
Pollock	...	...	...	...	Abundance relatively high, older fish dominate
EBS	1,500,000	1,100,000	1,100,000	1,200,000	
Aleutians	100,000	100,000	100,000	100,000	
Pacific cod	59,000	249,300	...	...	Near historic high, above average 1982-84 year classes
EBS	...	...	230,000	375,000	
Aleutians	...	...	35,000	25,000	
Yellowfin sole	150,000	230,000	187,000	187,000	Abundance relatively high, declined steadily from 1983 historic high
Greenland turbot	44,000	35,000	5,500	20,000	Recruitment declined for 4-5 years, abundance projected to decline
Arrowtooth flounder	22,400	20,000	33,400	30,900	Abundance high and increasing, strong recruitment
Other flatfish	146,100	137,500	159,700	193,300	High levels of abundance
Sablefish	...	...	...	...	Abundance increased but below higher historical levels
EBS	3,700	3,000	5,000	3,700	
Aleutians	4,000	4,200	5,000	4,000	
Pacific Ocean perch complex	13,200	...	...	...	Abundance stable and low, some improved recruitment
EBS	...	1,600	3,000	3,800	
Aleutians	...	15,000	11,900	10,900	
Other rockfish	...	...	...	...	Abundance stable and low
EBS	2,100	600	500	450[1/]	
Aleutians	6,900	1,900	1,900	1,430[1/]	
Atka mackerel	38,700	30,800	30,800	30,800	Lacking information. Abundance presumed average.
Squid	>10,000	10,000	10,000	10,000	Lacking information but estimates are conservative
Other species	67,200	35,900	36,700	49,500	Abundance at average levels
Total groundfish	2,167,300	1,974,800	1,955,400	2,245,780	Overall abundance increased from 1985 due largely to pollock and cod

[1/] ABC set 75% of EY to rebuild stocks.

SUPPLEMENT TO RESOURCE ASSESSMENT DOCUMENT FOR BERING SEA-ALEUTIANS GROUNDFISH FOR 1986

INTRODUCTION

This report is an update of the Resource Assessment Document (RAD) which was released for public review in July 1986 and discussed by the North Pacific Fishery Management Council at its September meeting. Since then, several analyses and documents on status of the stocks have been updated. Many of these documents were presented at the International North Pacific Fisheries Commission (INPFC) meetings in late October, primarily by U.S. and Japanese scientists. The pertinent documents are listed at the end of this report. The Plan Maintenance Team for Bering Sea-Aleutians groundfish met November 4th in Anchorage to review the status of each stock in light of the new information and public comments received.

Table 1 compares the original Team assessment reported in the July RAD and that updated in November. Estimates of maximum sustainable yields (MSYs), equilibrium yields (EYs), and acceptable biological catches (ABCs) are summarized.

A species-by-species discussion of Table 1 follows.

Pollock

EBS stock:	July RAD EY	= ABC = 1,100,000 t
	November updated EY	= ABC = 1,200,000 t
Aleutian stock:	July RAD EY	= ABC = 100,000 t
	November updated EY	= ABC = 100,000 t (No change)

The July EY estimate for the EBS represents a 14.5% exploitation rate on the population projected to equal 7.6 million t. Updated trawl surveys and data from the fishery (Bakkala and Balsiger 1986) indicated that the exploitable biomass (age 3 and older) through 1986 is as high as 8.8 million t. The size frequency data indicated that if the older age 5 to 7 pollock continue to form the principal ages in commercial catches as they have since 1982, then the strong 1982 year class should contribute to maintain the biomass at a relatively high level as it recruits to this age range in 1987.

The recruitment strength indices (age 1 pollock from trawl surveys) for recent year classes are as follows:

Year of survey	Year class	Population number estimates (billions)
1979	1978	8.2
1981	1980	1.0
1982	1981	0.8
1983	1982	3.7
1984	1983	0.3
1985	1984	4.0
1986	1985	2.2

The average of these seven estimates is 2.4 billion, therefore, the 1984 year class is fairly strong and should become an important component of the catch in 1987 as age 3 fish.

Based on the biomass estimates and patterns of recruitment, the EY or ABC for the eastern Bering Sea (EBS) pollock stock equals 1.2 million t in 1987, the same as the total allowable catch (TAC) set for 1986. This EY/ABC level would represent an exploitation rate of 13.6% of the 8.8 million t exploitable biomass. The exploitation rate is well within the historical exploitation rate range of 10-15% for the EBS pollock stock since 1977.

Prior to 1983, almost all of the TACs for pollock set for the EBS and Aleutian region were taken within the U.S. 200-mile FCZ. Since then, a fishery, primarily for roe pollock, has developed outside of the USSR and U.S. 200-mile zones in an international zone known as the "donut hole" in the Bering Sea. This fishery has generally taken place during December-early March, but is now known to start earlier (November) and end later (May). The amount of catch and effort are not well known, but more than 100 boats have been reported to have operated in the donut area in 1985 and 1986 with more anticipated to participate in 1987. The nations operating in the area are Japan, Republic of Korea (ROK), Poland, and the People's Republic of China (PRC). The total catch has been estimated to be about 200,000 t in 1986.

The pollock resource in the donut area is probably a mixture of both the eastern Bering Sea stock and the USSR stock, although the exact proportion of the mix in the catch is not known. From the observed pattern and timing of migrating pollock in the area, it appears that a major portion of the pollock harvested in the donut area are migrating in a southeasterly direction into U.S. waters. This harvest in international waters should be taken into account in setting the TAC for both the Bering Sea and Aleutian Region. If the TACs were adjusted downward to account for this outside harvest, the adjustment should be based on the proportional mix of fish in that harvest. Since the donut area catch is not made up exclusively of fish originating in the U.S. FCZ, the adjustment should not equal the catch. The actual mix, however, is probably more than 50% U.S. from the pattern of spawning migration.

Pacific Cod

July RAD ABC = 265,000 t (EBS = 230,000 t; Aleutians = 35,000 t)
November Updated ABC = 400,000 t (EBS = 375,000 t; Aleutians = 25,000 t)

In the July RAD, the procedure to calculate cod ABC was based upon an age-structured population dynamics model (Cod Model 1). It contains the following key features:

(1) The model describes the cod population structure in terms of numbers by age, biomass by age, mortality rates (natural and fishing) and recruitment rates.

(2) The model is calibrated by comparing predicted population structure and abundance with similar parameters determined from NWAFC trawl surveys.

(3) Once calibrated, the model is used to project population structure and abundance for the near future. This projected population can then be "fished" and the resultant population structure and abundance can be examined to arrive at various estimates of ABC that would not adversely affect future population status. Future population status is measured by the population abundance (numbers and biomass) by age and expected recruitment of age 0 cod.

In July, the model projected that the ABC for the cod resource in 1987 would be 265,000 t (230,000 t in the EBS and 35,000 t in the Aleutian region) in order to leave a 1987 spawning stock capable of producing the average level of recruitment observed during 1978-85.

Since the July RAD was completed, a new trawl survey was completed in the EBS which provided a new biomass estimate for cod. The trends are as follows:

Year	Mean Biomass (t)
1978	312,000
1979	792,300
1980	913,300
1981	840,100
1982	1,013,900
1983	1,126,400
1984	999,700
1985	957,600
1986	1,134,100

Within statistical error (95% confidence interval), the biomass of Pacific cod may be said to have remained high and relatively stable since 1982, although the 1986 mean estimate is the highest on record. In addition to the updated survey data, updated fishery statistics also indicated the

gradual disappearance of the strong 1977-78 year classes from the fishery and a gradual phasing in of strong year classes spawned in 1982-84. These year classes, though strong, are not quite as strong as the 1977-78 year classes.

Since the July RAD was completed, the cod model has been improved to incorporate finer details of its population dynamics and fishery. The improved model (Cod Model 2) has been described in detail in the Pacific cod section in the report edited by Bakkala and Balsiger (1986).

In broad terms, the simulation can be classified as an example of catch-age analysis with auxiliary information. More specifically, the simulation consisted of three separate programs: (1) an initial value generation (IVG) program, (2) a nonlinear parameter estimation (NPE) program, and (3) a population and fishery projection (PFP) program. The IVG program was used to obtain preliminary estimates of the simulation parameters. These were then used to seed the NPE program, which computed final parameter estimates. The final parameter estimates were then used by the PFP progam to simulate future numbers-at-age and catch-at-age data for the population.

The model's simulations are compared and calibrated against trawl estimates. The simulated population numbers for 1986 were within 4.5% of the survey estimate of 843.5 million fish. Likewise, the simulation's projection of population biomass was within 2.5% of the survey estimate of 1,134,100 t.

After projecting the population and fishery through the 1986 calendar year, the program projected the population and fishery through the 1987 calendar year and through the first month of the 1988 calendar year. Generally, the strategy was to impose the highese possible harvest without driving the projected biomass for January, 1988 below the projected biomass for January, 1987. This was accomplished subject to the constraint that DAH receive priority in harvest allocation. The resulting harvest strategy was considered to be the quilibrium yield for 1987.

The estimate of 1987 DAH was obtained by assuming that the exponential rate of growth observed over 1981-85 (and the 1986 extrapolation) would continue, giving a 1987 DAH of 185,000 t. The program iterated over varying combinations of effort until it found the combination that satisfied the following three conditions: (1) 1987 catch was maximized, (2) survey biomass in January of 1988 was maintained at the same level as survey biomass in January of 1987, and (3) DAH priority was preserved without exceeding the projected 1987 DAH capacity of 185,000 t. The following results were obtained for the EBS stock:

Numbers at time of survey (millions):	774.9
Biomass at time of survey (1000's of t):	1204.7
Catch in numbers by all gears (millions):	109.3
Catch in biomass by all gears (1000's of t):	377.8

Equilibrium yield is usually defined as the annual yield which allows a stock to finish the year at the same level of abundance found at the start of the year. In the simulation described above, however, EY entails not just

a single catch, but a harvest strategy. This strategy includes a specific mix between trawl and longline catches. Other catch levels by the two gear types, even if they summed to 377,800 t, might not constitute a true EY, because the two gear types exploit the resource in different ways. Another respect in which the EY indicated by the simulation entails an entire harvest strategy is that the projected EY is predicated on the assumption that the trawl and longline fleets will deploy their effort according to the schedules described in the model.

Since the Pacific cod resource in the EBS-Aleutians region is probably of one unit stock and the above simulation is calibrated for the EBS area only, EY for the Aleutian component has to be extrapolated from the EBS estimate. One possible basis for such an extrapolation is from the historical trend in catches for the EBS versus the two areas combined. For the years 1981-1985, the proportion of the Aleutian catch was 6.25% of the total. Therefore, the EY for the Aleutian region is estimated to be 25,000 t. The combined EY for 1987 is therefore 400,000 t (375,000 t for EBS and 25,000 t for Aleutians).

Compared to past catch levels, the projected EY is notably high. The reason for the high projection lies in the projected growth of the 1982-84 year classes and the concentration of the fishery on the older year classes. The projected age distributions for 1987 show that over 92% of the stock biomass at the time of the survey will be concentrated in ages 0-5, while over 59% of the year's catch will come from ages 6 and older. Largely unaffected by harvest mortality, the 1982-84 year classes decrease by less than 23% in terms of numbers while increasing by over 22% in terms of biomass.

The second cod model described is the more detailed of the two models used. It is more logically structured than the first, but as with all new models, needs a more thorough review of its structure and parameters. The Team believes it is the better model of the two and that the EY estimate of 400,000 t is the best estimate for the cod resource now.

Since the cod resource has great fluctuations in recruitment strength, its biomass trend can be rather variable. As such, EY would be zero or negative during periods when biomass remains stable or declining, such as during 1983-85. From 1986 to 1987, the biomass is projected to increase, with an EY of 400,000 t. Since the biomass of cod was estimated to be at a historic high in 1986 from the NMFS trawl survey (1.134 million t), the Team believes that ABC for 1987 equals EY to take advantage of the abundant resource when 59% of the catch would be comprised of older fish (ages 6 and older). At these ages, the biomass declines faster than it grows due to natural mortality. It should also be noted that Pacific cod is known to be a voracious predator on crabs. Therefore, maintaining an abnormally high abundance of cod would result in negative impacts on the crab resources in the Bering Sea that are already low in abundance.

The Team also explored views on estimating ABC for cod. The best alternative for estimating ABC is to use a frequently used concept for many other groundfish species, whereby ABC = an exploitation rate x exploitable biomass. For Pacific cod, the exploitable biomass comprises

fish aged 3 and above. The 1987 exploitable biomass for the EBS is projected to be 1,147,000 t. The average biomass of the cod aged 3 and above for 1984-86 from the NMFS trawl surveys was 843,000 t. The best estimate for calculating ABC is the 1987 projected biomass. The selection of which exploitation rate to use, however, is more difficult. This difficulty is due mainly to uncertainties with estimates of natural mortality (M) and Von Bertalanffy growth coefficient (k). Using the $F_{0.1}$ optimal fishing strategy, the following exploitation rates (E) can be calculated:

E = .21, F = .26 (when M = .22, K = .203 from cod model 2)
E = .29, F = .44 (when M = .44, K = .2 from cod model 1)

Therefore ABC for the EBS in 1987 can be calculated as follows:

ABC = .21 x 1,147,000 t = 241,000 t
ABC = .29 x 1,147,000 t = 332,630 t

The extrapolated ABC for the EBS and Aleutians combined would be 260,500 t to 359,600 t.

Yellowfin Sole

July RAD EY = ABC = 187,000 t
November updated EY = 187,000 t (no change)

The yellowfin sole resource remains in relatively good condition and is still producing slightly above the MSY level.

Greenland Turbot

July RAD ABC = 5,500 t
November updated ABC = 20,000 t (range = 16,500 t - 35,000 t)

The status of the resource is derived mainly from trawl surveys: (1) an annual survey by NMFS on the EBS shelf and (2) a U.S.-Japan cooperative survey over the EBS slope generally once every 3 years. Since the juvenile fish are distributed mainly on the shelf and the adults on the slope, the surveys provide distinct biomass estimates (in metric tons) of the two groups as indicated below:

Year	Shelf(Juveniles)	Slope(Adults)
1975	126,700	--
1979	225,600	123,000
1980	172,200	--
1981	86,800	99,600
1982	48,600	90,600
1983	35,100	--
1984	17,900	--
1985	7,700	79,200
1986	5,600	--

The slope surveys indicate a moderate decline of the adult stock from 1979-85, but a dramatic decline of the juvenile fish from 1979-86. The decline in juvenile fish indicates progressively poorer recruitment of fish, especially from 1982. There also appears to be little likelihood that the surveys would have missed the juvenile fish and that the juveniles may have been located north and west of the survey area. Since Greenland turbot recruits at age 4 into the fishery that takes place on the slope, the adult population is expected to decline progressively from 1987 to 1990 and beyond. Therefore, EY is zero.

To estimate ABC, a Stock Reduction Analysis (SRA) model was used in the July RAD. This model has been updated to reflect better estimates for (a) the average virgin biomass of 984,000 t in 1960 (instead of 810,000 t), (b) an earlier age of recruitment at age 4 (instead of age 5), and (c) the recruitment from 1986-89 to be 10% of average levels instead of zero recruitment. The new SRA analyses provide the following biomass projections when the fishery is allowed various fixed catch levels from 1987-89:

Biomass (in thousands of metric tons) of Greenland Turbot at beginning of the year after annual fixed catch levels from 1987-89 of

	10,000 t	15,000 t	20,000 t	25,000 t	30,000 t
1987	437	437	437	437	437
1988	430	424	419	413	408
1989	414	403	392	381	371
1990	392	377	361	346	330
% of virgin biomass in 1990	40	38	37	35	34

The Table above indicates that with a 15,000 t catch per year from 1987-89 (60,000 t total), the population biomass would decline 14% from 437,000 t in 1987 to 377,000 t in 1990. The decline in biomass would equal the catch and the 1990 biomass would then be 38% of the virgin level. The Table also indicates the impact to the population at higher and lower catch levels. The highest ABC feasible, however, can be calculated by ABC = 1987 biomass x the historical exploitation rate of 8% = 35,000 t. The Japanese scientists recommended ABC = 30,000 t in their INPFC documents.

It appears, therefore, that various levels of ABC can be set depending upon the importance of different biological criteria. The Team believes that ABC should be set at the low end of its range because of progressively poorer recruitment in recent years to the point of being negligible. Therefore, to assure a reasonable size adult population to support a viable Greenland turbot fishery in the near future, the Team recommends an ABC of 20,000 t.

Arrowtooth Flounder

July RAD EY = ABC = 33,400 t
November updated EY = ABC = 30,900 t

The July EY or ABC was estimated mainly from biomass estimated from the NMFS trawl survey in 1985. Since then, the 1986 survey has been completed. The updated information indicated that the abundance of the resource has remained relatively high and stable. The Team reviewed the procedure for estimating EY/ABC for this and other flatfish resources and concluded that for these relatively stable and abundant resources, the EY/ABC should be calculated from an average biomass since year-to-year variations in biomass estimation may not be statistically different. Therefore, EY = ABC = average biomass of recent years x average historical exploitation rate.

The average biomass for arrowtooth flounder for the last 3 years (1984-86) were 266,000 t in the EBS and 43,000 t in the Aleutians. The total was 309,000 t. Using an average exploitation rate of 10%, the EY or ABC for 1987 is estimated at 30,900 t.

Other Flatfish (Including Rock Sole)

The other flatfish category includes the following main species: rock sole, flathead sole, Alaska plaice, and miscellaneous flatfish species.

	Rock Sole	Others	Total
July RAD EY = ABC	70,500	89,200	159,700
November updated EY = ABC	92,100	101,200	193,300

Rock Sole Component

July RAD EY = ABC = 70,500
November updated EY = ABC = 92,100

The July EY or ABC was estimated from the 1985 NMFS trawl survey. The 1986 survey shows an increase in the biomass; and for the same reason explained in the arrowtooth flounder section, the biomass for estimation of EY/ABC was averaged. The average biomass for 1984-86 was 895,000 t for the EBS and 26,000 in the Aleutians. The average exploitation rate for this species is 10%. Therefore, EY/ABC for rock sole is estimated at 92,100 t (10% of 921,000 t).

Another viable alternative for estimating ABC is to set ABC = MSY, since the biomass is almost twice the level capable of producing MSY. In this case, ABC may be set at the high end of the MSY range of 50,000-70,000 t or at 70,000 t.

Other Flatfish Component (Excluding Rock Sole)

July RAD EY = ABC = 89,200 t
November Updated EY = ABC = 101,200 t

As in the case of rock sole and arrowtooth flounder, ABC for this flatfish group has been re-computed based upon results of the 1986 NMFS survey and averaging of its biomass. The resource remains in abundant condition and the stock is capable of producing above MSY. The EY or ABC for 1987 has been estimated at 101,200 t as follows:

EY = ABC = 10% of average biomass during 1984-86 (1,012,000 t).

Sablefish

EBS stock:	July RAD EY	= ABC = 5,000 t
	November updated EY	= ABC = 3,700 t
Aleutian stock:	July RAD EY	= ABC = 5,000 t
	November updated EY	= ABC = 4,000 t

The July EY estimates were based upon a 5% exploitation rate of the 1985 estimated biomass. The Team has noted that the biomass estimates are not very reliable. However, the status of stock have improved substantially in both regions and the stocks are capable of producing at MSY. The best estimates of MSY were derived from SRA analyses. They range from 2,200 to 3,700 t for the EBS and 2,400-4,000 t for the Aleutians.

Based upon the improved condition of the stocks, the EY and ABC were estimated to equal the upper end of the MSY range or 3,700 t for the EBS and 4,000 t for the Aleutians.

Pacific Ocean Perch

EBS stock:	July RAD EY	= ABC = 3,000 t
	November updated EY	= ABC = 3,800 t
Aleutian stock:	July RAD EY	= ABC = 11,900 t
	November updated EY	= ABC = 10,900 t

There is no significant change in the status of the POP stocks. The EY estimates reflect re-apportionments in estimates of the biomass between the two regions. In general, the status of the stocks remains stable. Abundance remain substantially below historic high levels in the early 1960's, but there are indications of some improved recruitment in recent years.

Other Rockfish

EBS stock:	July RAD EY	= ABC = 500 t
	November updated EY	= 600 t, ABC = 450 t
Aleutian stock:	July RAD EY	= ABC = 1,900 t
	November updated EY	= 1,900 t (no change),
		ABC = 1,430 t

There is no significant change in the status of the stocks. The change in EBS EY resulted from an upward rounding of the estimates. In general, the

stocks have remained relatively stable but low. As in the case last year, the Team recommended that ABC be set at 75% of EY to promote rebuilding of the stocks in both regions.

Atka Mackerel

July RAD EY = ABC = 30,800 t
November updated EY = ABC = 30,800 t (no change)

The section on Atka mackerel contained in the status of the stocks document submitted by the U.S. to INPFC (Bakkala and Balsiger 1986) noted that, for the lack of information, EY or ABC can be set equal to the 1983 estimate of 38,700 t. This level corresponded to the MSY estimate. In the 1985 RAD, the Team noted that CPUE had declined in the fishery from 1983-85, thereby inferring a decline in stock abundance. Accordingly, the EY or ABC was estimated last year at 30,800 t. Since new information is not available to update this estimate, the best estimate of EY or ABC remains the same as last year. The Status of Stocks document, however, recommended that the catch should be apportioned 60% west of 180° longitude and 40% east of 180° longitude. The Team believes that this recommendation will spread out the catches, but cannot evaluate if it will have a beneficial impact to the stock or stocks.

Squid

July RAD ABC = 10,000 t
November updated ABC = 10,000 t (no change)

Other Species

July RAD EY = ABC = 36,700 t
November updated EY = ABC = 49,500 t

The July ABC estimate was based upon a 10% exploitation rate on the 1985 estimated biomass. The biomass estimate is updated annually from the NMFS trawl surveys. Since the resource is relatively stable, the average biomass is used to estimate EY or ABC. Accordingly, the EY or ABC for 1987 is estimated to be 49,500 t (10% of average biomass for 1984-86).

LIST OF NEW INFORMATION

Document Submitted by U.S. National Section to INPFC

Bakkala, R. G., and J. W. Balsiger. 1986. (Eds). Condition of groundfish resources of the eastern Bering Sea and Aleutians region in 1986. INPFC Doc. 3085. 182 p.

Documents Submitted by Japanese National Section to INPFC

Wakabayashi, K. 1986. Stock assessment of turbots in the eastern Bering Sea and Aleutian Islands region in 1986. INPFC Doc. 3044.

Wakabayashi, K. 1986. Stock assessment of small-sized flounders in the eastern Bering Sea and Aleutian Islands region in 1986. INPFC Doc. 3045.

Sasaki, T. 1986. Preliminary report on Japan-U.S. joint longline survey by the Fukuyashi maru No. 8 in 1985. INPFC Doc. 3050.

Mito, K. 1986. Preliminary report on Japan-U.S. cooperative groundfish surveys in the Aleutian region by the Ginryu maru No. 5 in 1986. INPFC Doc. 3051.

Teshima, K. 1986. Stock assessment of Pacific cod in the eastern Bering Sea, Aleutian Islands region, and the Gulf of Alaska in 1986. INPFC Doc. 3053.

Sasaki, T. 1986. Stock assessment of sablefish in the eastern Bering Sea, Aleutian Islands region, and Gulf of Alaska in 1986. INPFC Doc. 3058.

Wakabayashi, K. 1986. Stock assessment of rockfishes and thornyheads in the eastern Bering Sea and Aleutian Islands region in 1986. INPFC Doc. 3061.

Sasaki, T. 1986. Stock assessment of pollock in the eastern Bering Sea in 1986. INPFC Doc. 3064.

OTHER REFERENCES CITED

Bakkala, R. G., and L. L. Low (Editors). 1985. Condition of groundfish resources of the eastern Bering Sea and Aleutian Islands region in 1985. 232 p. NWAFC, NMFS, Seattle (document submitted to the Int. N. Pacific Fish. Comm. Oct. 1985).

Thompson, G. G., D. H. Ito, and J. W. Balsiger. 1985. A management-oriented model of the population dynamics of Pacific cod in the eastern Bering Sea. NWAFC, NMFS, Seattle.

TAC recommendations for 1987 received during the public comment period.

Species	Person/Group Commenting						
	AJVFI	AFTA	FVOA	NRC	NPL	JDSTA/HTA	JFA
Pollock BS	1,200,000	900,000				1,200,000	1,200,000
Pollock AI	100,000	100,000				100,000	100,000
Pacific cod	229,000	162,500		235-280,000	300,000	246,000	246,000
Yellowfin Sole	187,000					209,500	209,500
Greenland Turbot		16-30,000		16,500		35,000	35,000
Arrowtooth Flndr						15,000	15,000
Other flatfish						124,200	124,200
Sablefish BS		5,000	3,000			3,700	3,700
Sablefish AI		5,000				4,000	4,000
POP BS						2,400	2,400
POP AI						6,800	6,800
Rockfish BS						600	600
Rockfish AI						1,900	1,900
Atka mackerel	30,800					30,800	30,800
Squid						5,000	5,000
Other Species						15,100	15,100
TOTAL						2,000,000	2,000,000

AJVFI = Alaskan Joint Venture Fisheries
AFTA = Alaska Factory Trawlers Association
FVOA = Fishing Vessel Owners' Association
NRC = Natural Resources Consultants
NPL = North Pacific Longline Association of Japan
JDSTA/HTA = Japan Deep Sea Trawlers Association and Hokuten Trawlers Association
JFA = Japanese Fisheries Agency

NOTES ON THE ROLE OF "EXPLOITATION RATE" IN THE E.B.S. PACIFIC COD MODEL

- PREPARED FOR LARRY COTTER, NPFMC,
BY GRANT THOMPSON, NMFS/NWAFC 12/9/86

REVIEW OF EXPLOITATION RATE THEORY:

AS USUALLY APPLIED, AN EXPLOITATION RATE DESCRIBES THE PROPORTION OF STOCK BIOMASS WHICH WILL BE LOST TO FISHING MORTALITY DURING THE COURSE OF A YEAR. THIS IMPLIES THAT RECRUITMENT OCCURS AT THE START OF THE HARVEST YEAR. IN SUCH A CASE, THE EXPLOITATION RATE IS DEFINED AS FOLLOWS:

$E = F(1-e^{-Z})/Z$, WHERE E = EXPLOITATION RATE,
F = INSTANTANEOUS RATE OF FISHING MORTALITY, AND
Z = INSTANTANEOUS TOTAL MORTALITY RATE.

FOR EXAMPLE, LET $F = .2$, $Z = .4$, AND NUMBERS AT THE START OF THE YEAR = 500 "HOLDOVERS" FROM PREVIOUS YEARS + 500 RECRUITS = 1000 TOTAL INDIVIDUALS. THEN, NUMBERS & CATCH AT 0, 6, & 12 MONTHS ARE AS SHOWN BELOW:

MONTHS:	0	6	12
NUMBERS:	1000	819	670
CATCH:	0	91	165

NOW, HOWEVER, SUPPOSE THAT RECRUITMENT OCCURS IN

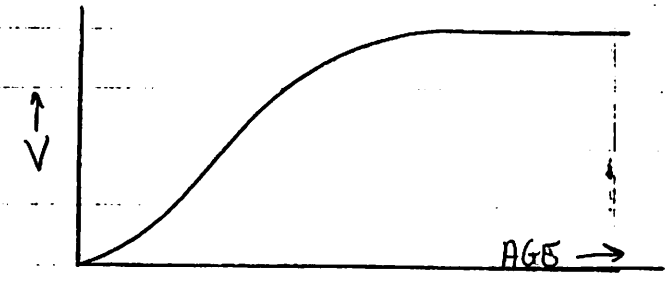
MONTH 6 INSTEAD OF MONTH 0. THEN, THE FOLLOWING RESULTS ARE OBTAINED:

MONTHS:	0	6	12
NUMBERS:	500	409	745
CATCH:	0	45	128

NOTE THAT "E," DEFINED AS $F(1-e^{-Z})/Z$, IS 0.165 IN BOTH EXAMPLES. HOWEVER, WHEN DEFINED AS CATCH DIVIDED BY INITIAL NUMBERS, "E" IS 0.165 IN THE FIRST EXAMPLE, BUT 0.256 IN THE SECOND EXAMPLE. THUS, THE CONCEPT OF EXPLOITATION RATE IS STRICTLY VALID ONLY WHEN RECRUITMENT OCCURS AT THE BEGINNING OF THE HARVEST YEAR.

VIEWING THE E.B.S. COD MODEL IN TERMS OF EXPLOITATION RATE:

RECRUITMENT DOES NOT OCCUR AT THE BEGINNING OF THE HARVEST YEAR IN THE E.B.S. COD MODEL. UPDATING OF AGES DOES NOT OCCUR AT THE BEGINNING OF THE HARVEST YEAR, EITHER. THEREFORE, CALCULATING AN EXPLOITATION RATE FOR THE MODEL IS HIGHLY PROBLEMATIC. COMPLICATING THE SITUATION EVEN MORE IS THE FACT THAT FISHING MORTALITY IS NOT CONSTANT THROUGHOUT THE YEAR, BUT IS A FUNCTION OF GEAR TYPE, AGE GROUP, AND MONTH. THE EFFECT OF AGE ENTERS THE FISHING MORTALITY COEFFICIENT BY WAY OF GEAR-SPECIFIC "VULNERABILITY" SCHEDULES, SHAPED AS FOLLOWS:



THUS, THE BIOMASS OF A GIVEN COHORT AT THE START OF A GIVEN MONTH IS EXPLOITED BY A GIVEN GEAR TYPE AT AN AGE-SPECIFIC EXPLOITATION RATE, WITH YOUNGER COHORTS BEING EXPLOITED LESS INTENSELY THAN OLDER COHORTS.

ALTHOUGH ANNUAL EXPLOITATION RATES CANNOT BE APPLIED VALIDLY IN THE E.B.S. COD MODEL, IT IS POSSIBLE TO DEVELOP RATES WHICH ARE ANALOGOUS TO EXPLOITATION RATES IN THE SENSE THAT THEY CAN BE MULTIPLIED BY PROJECTED 1987 MID-YEAR BIOMASS TO OBTAIN PROJECTED 1987 CATCH BY AGE GROUP. THIS ANALYSIS IS SHOWN BELOW:

AGE GROUP:	0-2	3	4	5+	ALL
*BIOMASS :	56.9	419.5	225.5	502.8	1,204.7
RATE :	3.3%	4.2%	10.9%	66.3%	31.3%
*CATCH :	1.9	17.6	24.6	333.4	377.5 → EBS portion only

*MEASURED IN 1000'S OF METRIC TONS.

APPLYING THE 66.3% RATE TO INDIVIDUAL AGE GROUPS WITHIN THE (5)-(9+) RANGE GIVES THE FOLLOWING RESULTS:

AGE GROUP:	5	6	7	8	9+	ALL (Ages 5+)
BIOMASS :	401.3	69.9	26.8	4.7	0.1	502.8
RATE :	66.3%	66.3%	66.3%	66.3%	66.3%	66.3%
CATCH :	266.1	46.3	17.8	3.1	0.1	333.4 ← EBS only

AN ALTERNATIVE WAY TO APPROACH THE PROBLEM WOULD BE TO SELECT VARIOUS AGES AS THE AGE OF "KNIFE-EDGE" RECRUITMENT, AND CALCULATE THE CORRESPONDING VALUE OF THE RATIO OF PROJECTED 1987 CATCH TO PROJECTED 1987 MID-YEAR BIOMASS. THIS ANALYSIS

IS SHOWN BELOW:

KNIFE-AGE RECRUITMENT

RECRUITMENT AGE :	0	1	2	3	4	5
EXPLOITABLE BIOMASS:	1204.7	1204.6	1184.9	1147.8	728.3	502.8%
RATE :	31.3%	31.3%	31.9%	32.9%	51.8%	75.1%

IT MAY BE NOTED THAT THE ABOVE RATES ARE RELATIVELY INSENSITIVE TO RECRUITMENT AGE UP THROUGH AGE 3, SINCE THE PROPORTION OF TOTAL BIOMASS CONTRIBUTED BY AGE GROUPS 0-3 IS SMALL (4.7%).

PLEASE NOTE ALSO THAT PROJECTED CATCHES AND BIOMASSES IN THE ABOVE CALCULATIONS REFER TO THE E.B.S. PORTION OF THE STOCK ONLY, ADDITIONAL CATCH AND BIOMASS WOULD BE CONTRIBUTED BY THE ALEUTIAN ISLANDS COMPONENT OF THE STOCK.