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**WALLEYE POLLOCK (*Theragra chalcogramma*)  
INVESTIGATIONS IN 1987**

by

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# REVIEW OF ASSESSMENTS FOR WALLEYE POLLOCK IN ALASKAN WATERS

## Introduction

In this report we review the methodologies used to derive recommended levels of acceptable biological catch (ABC) of walleye pollock in 1988 in the Bering Sea and the Gulf of Alaska. Our review relied heavily on documents prepared by the respective Plan Teams, and on personal communications with team members and other staff of the Northwest and Alaska Fisheries Center. There are two key factors that determine an ABC level: (1) An assessment of the current (in this case, 1988) condition of a stock, and (2) the harvesting policy adopted to manage the stock. Both aspects are covered in this review.

## Bering Sea

The Bering Sea assessment is limited to two areas: The Eastern Bering Sea and the Aleutian Islands region. The Basin area (including the International Zone or "donut hole") is excluded. Sources of information used in developing this section include Wespestad and Traynor (1987), Anon. (1987), and personal observations and communications during the Bering Sea Plan Team meeting on November 16, 1987.

### Eastern Bering Sea

#### Biomass and MSY Estimates

For the Eastern Bering Sea, the 1988 exploitable biomass is estimated to be 6.5 million t. This estimate is derived in the following manner. Cohort analysis is used to derive numbers of age 4-9 fish in 1986. The cohort analysis relies on commercial catch-at-age data, and is also "tuned" (adjusted) based on survey information. The 1986 population is then projected forward in time using an age-structured simulation model. Numbers of age 3 individuals (recruits) in each year (1986-1988) are derived from a regression of age 1 abundance (from bottom trawl surveys) versus age 3 abundance (from cohort analysis).

A stock-recruitment relationship is derived from data generated by the cohort analysis and incorporated into the simulation model. According to the authors, the model produces estimates of MSY of 2.3 million t. However, when we ran the model with data given in the report, we obtained different results.

#### ABC Calculations

One method of setting ABC discussed in the Resource Assessment Document (RAD, Anon 1987) is to harvest the stock down to the replacement level as indicated by the stock recruitment

function. We question this procedure for a number of reasons. First, there is a lot of scatter in the stock-recruitment data and a number of interpretations of these data are possible. Second, the replacement level given in the report is inaccurate. In a multiple-age spawning stock, replacement occurs at the point where abundance of recruits over the course of their lifetime (i.e., the sum of abundances at each age of a single cohort) equals abundance of spawning stock. In the report, replacement is inaccurately portrayed to occur at the point where the number of age 3 recruits equals the number of spawners. Thus, the true replacement level occurs at a higher spawning stock abundance than shown in the report. Finally, we do not think that the replacement level is a meaningful goal for management. By definition, it is a point at which no surplus production occurs; thus, no harvest is sustainable at that level of spawning stock abundance. If the stock-recruitment paradigm is to be used, then a more meaningful management target needs to be developed, which would clearly occur at a spawning stock abundance below replacement level.

The second method used to calculate ABC is to harvest the projected 1988 stock at the  $F_{0.1}$  exploitation rate. This yields an ABC of 1.5 million t. The Team recommends using this latter method of estimating ABC because it is a more conservative procedure and there are indications that the stock will be declining in the near future.

#### Other Comments on Assessment Methodology

In order to fully evaluate the assessment, further documentation of cohort analysis procedures and results would be required. At minimum, this should include tables of catch-at-age, F, and age specific abundance data, as well as details of survey data and "tuning" procedures.

The sensitivity of the results to M or other parameters was not addressed.

It is not clear whether the changing nature of the fishery (changing mix of fleets over time, each with different selectivity characteristics) was accounted for in the cohort analytic procedures.

We cannot account for one of the five data points used in the age 1 - age 3 regression.

It was not always clear what type of biomass (i.e., total, exploitable, total biomass of exploitable age groups) was being referred to in various sections of the report.

The value of the bottom trawl survey data is questionable since a large and variable fraction of the stock occurs in midwater.

#### Aleutian Region

The assessment for the Aleutian region rests on the assumption that the Aleutian region stock has the same dynamics as the Eastern Bering Sea (EBS) stock. The most recent bottom trawl survey estimate of biomass for the Aleutians area was expanded upwards on the basis of the ratio of the bottom to midwater components observed in the most recent EBS hydroacoustic and bottom

trawl survey. This yields a total biomass estimate of 1.0 million t for 1986. This biomass estimate is then reduced to account for the non-exploitable portion and the decline in abundance projected for the EBS stock in recent years. Finally, the EBS  $F_{0.1}$  exploitation rate is applied to the resultant biomass estimate to obtain an ABC of 160,000 t.

This seems to be a reasonable and logically consistent procedure, given very limited data. We do question why a catch-at-age analysis was not performed for this stock.

### The Basin and International Zone

At present the relationship between Basin, EBS and Aleutian region stocks is unclear. Existing information is summarized in the appendix. In the unlikely event that the Basin stock is independent of the shelf stock, then the fact that this area has been excluded from the assessments would have no bearing on the ABC calculations for the EBS and Aleutian stocks. Because there are several plausible hypotheses regarding the linkage between Basin and shelf stocks, it is not possible to determine the effect an interdependence would have on ABC recommendations. The Team has decided to treat the EBS and Aleutian stocks as independent stocks until more information is available.

## **Gulf of Alaska**

### Biomass Estimation and ABC Calculation

In the Gulf of Alaska pollock assessment, the 1986 hydroacoustic survey is used to estimate 1986 biomass and the CAGEAN model is used to obtain other parameter estimates. In one run of the CAGEAN model (Deriso et al., 1985, 1987), the catch data are used alone, and in another the hydroacoustic survey data are used as auxiliary information. The latter method results in a much higher estimate of 1986 biomass than the former. A range of forward projections is made based on four different recruitment scenarios and five catch schedules. The conclusion reached is that catch levels between 90,000 and 120,000 t would leave the 1989 population biomass in the range of 857,000-1,222,000 t, no matter which recruitment scenario is used. These biomass levels are above the minimum spawning biomass level of 768,000 t proposed by Megrey and Alton (1986).

It is difficult to determine whether the procedures used in the Gulf of Alaska assessment over- or under-estimate biomass, and hence ABC, levels. Two elements of the approach would tend to yield overestimates of biomass. First, the value of  $M$  (natural mortality rate) used for the Gulf of Alaska assessment ( $M = 0.4$ ) is higher than that used in the Bering Sea assessment ( $M = 0.3$ ). Input of too high a value of  $M$  in the CAGEAN model would lead to overestimates of biomass. Second, the hydroacoustic survey-derived 1986 biomass estimate of 490,000 t (which is much

greater than the CAGEAN-derived estimates of 128,000-181,000 t) was used to initiate the forward projections of biomass.

The following factors would tend to counterbalance the above tendencies. Use of too high a value of  $M$  would yield underestimates of projected biomass in the forward simulation model runs. Also, the practice of recommending an ABC level that is projected to keep biomass above the threshold level, even under the most pessimistic recruitment scenario, is a conservative one.

In an addendum to the status of stocks document, Megrey (1987b) uses two different procedures (yield-per-recruit and spawner-recruit analysis) to examine maximum sustained yield. The conclusion drawn is that very high levels of exploitation are needed to obtain MSY. For a variety of reasons, Megrey rejects these approaches in favor of the standard approach used to date to obtain ABC.

### Harvesting Policies

It is evident from our review that the harvesting policy used to determine ABC levels has not been firmly established for either Bering Sea or Gulf of Alaska pollock stocks. Recent guidelines published by NMFS state that the MSY exploitation rate should be used to derive ABC unless an alternative method can be justified. A constant harvest rate policy such as that proposed tends to stabilize population abundance and allows for greater catches when the stock is high in abundance, and yet protects the stock by allowing lower catches in years of low abundance. The  $F_{0.1}$  policy, which was adopted this year by the Bering Sea Plan team is a constant rate policy, but is more conservative than an  $F_{MSY}$  exploitation policy. It thus affords added protection to the stocks and also may be economically more efficient than an  $F_{MSY}$  policy.

Another type of policy that can be adopted is a constant catch policy. One example of this would be to harvest the MSY level of biomass from the stock each year. Constant catch policies tend to be destabilizing influences on populations. They result in the removal of a very high proportion of the stock when it is at low levels of abundance. Further, they are wasteful of available production when the stock is high in abundance.

A third type of policy is a constant stock size policy. This type of policy results in stabilization of the population but provokes a great deal of variability in catch levels. The Gulf of Alaska policy resembles a constant stock size policy more closely than it does the other major types of policies discussed above. Specifically, the Gulf of Alaska policy appears to be to maintain the stock at or above a minimum threshold level. Illustrations of the consequences of constant harvest rate, constant catch and constant stock size policies are given (for example) in Francis et al. (1983), Getz et al. (1986), and Hollowed et al. (1987).

Harvest policies, biomass estimates and recommended ABC levels for various areas in Alaska are summarized in Table 1.

### **General Comments on Assessment Procedures**

The current time frame for production of assessment documents and calculation of ABC levels does not allow for adequate review by outside parties. Apparently, the current time frame has been established in order to allow the most recent survey data to be incorporated. We recommend that a change in time frame be considered. This would require making do with less than the most recent data or changing the management year to allow the latest survey data to be fully incorporated and reviewed.

The status of stocks documents should give more complete documentation on both data and methods used. It would be preferable to have the documents be complete each year, rather than referring the reader to earlier documents which are often difficult to obtain. The sensitivity of the results to parameters which are poorly known (particularly M) should be explored. Finally, the consequences of a number of alternative harvesting policies should be explored to enable the Council to make an informed decision regarding harvesting strategies.

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Table 1. Summary of biomass estimates and recommended ABC levels for walleye pollock in Alaskan waters.

		Biomass estimates			Recommended ABC level(s)	
	Amount (mt)	Year(s)	Method of derivation	Amount (mt)	Basis for recommendation (harvest policy)	
<b>Bering Sea</b>						
Eastern Bering Sea	6.7 million	1986	Cohort analysis			
	6.5 million	1987-1988	Project 1986 biomass forward based on estimated natural mortality and recruitment levels, with fishing mortality set at F <sub>0.1</sub> level	1.5 million	Set fishing mortality at F <sub>0.1</sub> level, a relatively conservative harvest rate policy	
Aleutian Region	890,000	1986	Bottom trawl survey expanded upwards by ratio of total to bottom abundance for EBS			
	690,000	1988	Use same ratio of 1988:1986 biomass as for EBS	160,000	Use EBS F <sub>0.1</sub> harvest level	
International Zone (Donut Hole)	None		Not included in stock assessments	None	Not included in harvest policy decisions	
<b>Gulf of Alaska</b>						
	496,000	1986	Survey estimate			
	Variable, depends on catch and recruitment levels	1987-1989	Project biomass forward using 4 plausible recruitment levels and 5 different catch levels (i.e., 20 projections considered)	90,000-120,000	Choose catch level that leaves 1989 biomass in the range of 857,000-1,222,000 t even under the most pessimistic recruitment scenario	

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**APPENDIX**  
**POLLOCK OF THE ALEUTIAN BASIN**

We have reviewed all of the available literature on Aleutian Basin pollock and would like to emphasize the following points.

(1) The international zone or so-called "donut hole" is only a part of the Aleutian Basin. There is no reason to assume that fish harvested in the donut hole are distinct from those harvested in other parts of the Basin.

(2) The Aleutian Basin fishery has significantly expanded in the past four years (Sasaki and Yoshimura 1987). Of particular importance, the location of the fishery has changed, spreading from the southeast corner of the donut hole in 1984 to the west in 1986 and 1987 (northwest of Bowers Ridge) (Fig. 1). The foreign catch in the Aleutian Basin has increased from around 250,000 t in 1984 to an estimated 1,000,000 t in 1987, most of that coming from the donut hole.

(3) The Aleutian Basin fishery is concentrated on pre-spawning and spawning adults. The fishery peaks in January and February.

(4) The size and age distribution of fish surveyed and harvested in the Basin has remained remarkably constant from 1977 to 1987. Figure 2 is drawn from Shimada (1982) and shows the length frequency of pollock surveyed in the summer of 1979. He reports that 46-48 cm pollock were first seen in the Basin in 1977. Figure 2 also shows the length frequency of pollock harvested in the Basin (donut hole) in 1987 (Sasaki and Yoshimura 1987) with the same mode. Using the length-age relationships reported by Lynde et al. (1986, Table 2), for the Aleutian Basin, We estimate these fish to be 8-10 years old. All authors note the lack of pre-adult pollock in the surveys and fisheries of the Basin.

(5) When you come down to it, very little is known about the stock structure of pollock in the Basin. Based on an analysis of age-length distributions of catches and surveys of the E. Bering Sea (EBS) shelf and Basin (east of 180°), Lynde et al. (1986) speculate that there are two "production units" of pollock within the region: A northern, slow-growing unit inhabiting the north slope (northwest of Pribilof I.), north shelf and Basin; and a southern, faster-growing unit inhabiting the south slope (southeast of Pribilof I.) and south shelf regions. They also present circumstantial evidence for linkages between the Basin and the EBS slope and shelf. They hypothesize that juveniles produced from spawning in the Basin inhabit the EBS slope and shelf areas (primarily the northwest slope), and then as adults migrate back into the Basin. A two-page report from Japan (Anon 1987) speculates that there are remnants of six subpopulations of pollock occupying the Basin. The report is difficult to evaluate since no scientific information is presented to support this hypothesis.

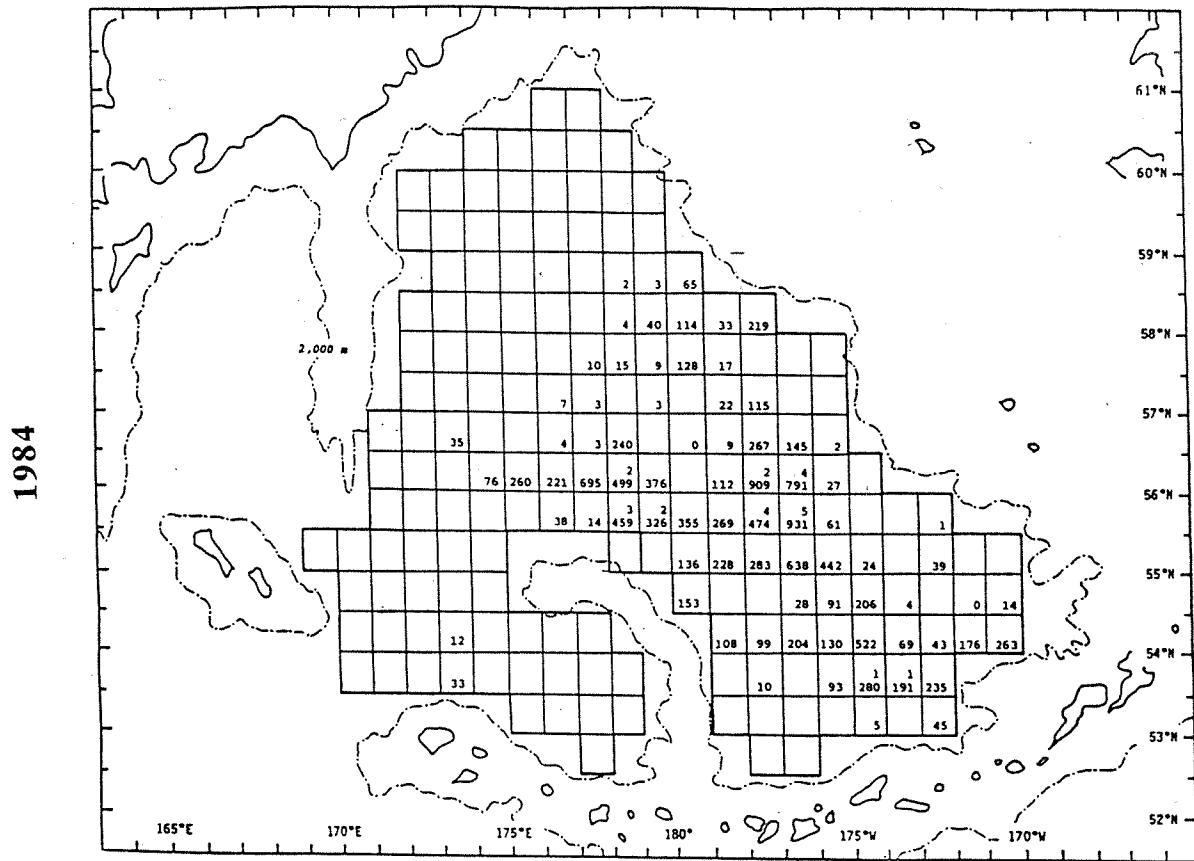


Fig. 1. Geographic distributions of pollock catches, in tons, by Japanese North Pacific trawl fishery in the Aleutian Basin, 1984-1986.





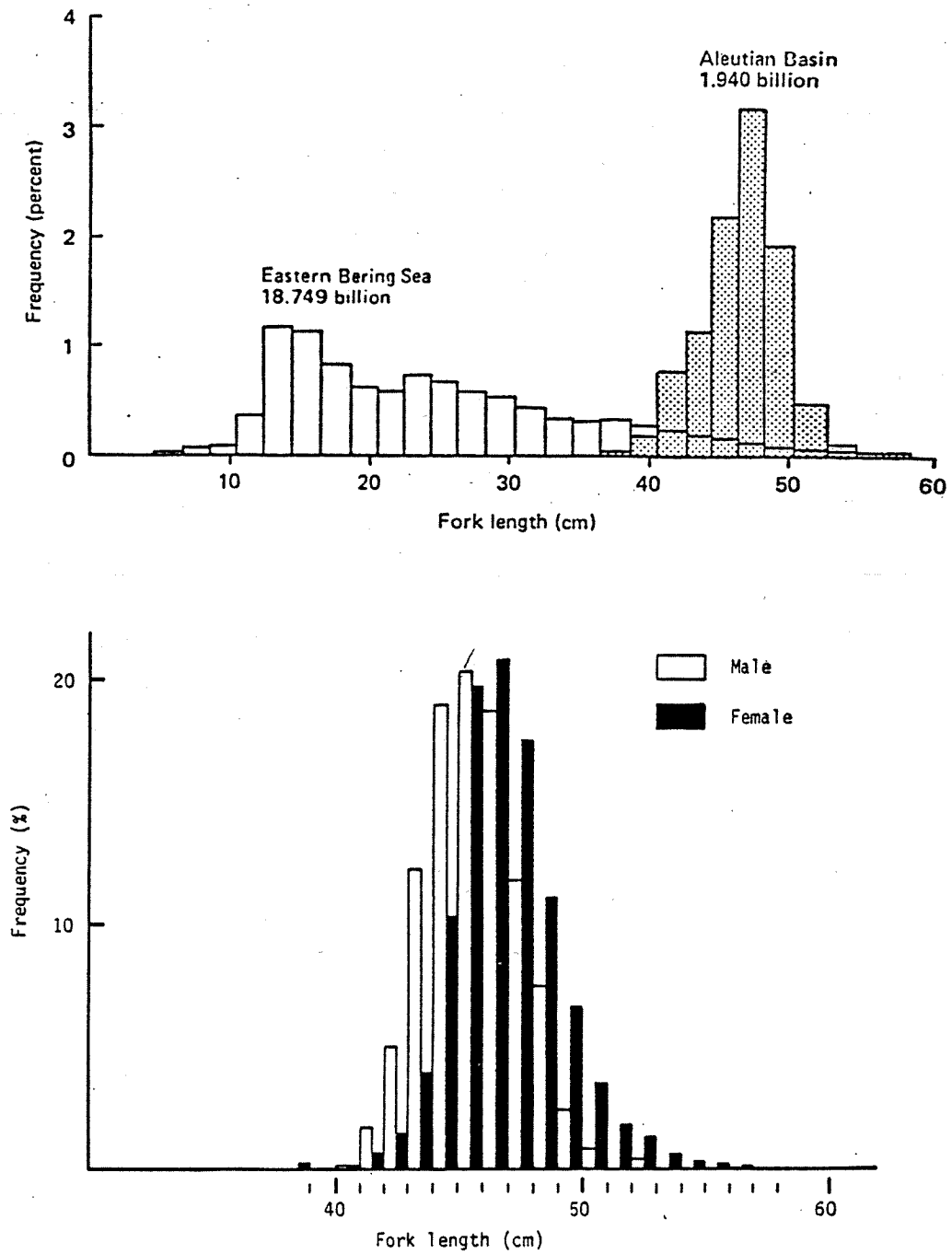


Fig. 2. Length-frequency distributions of pollock from 1979 summer surveys (top) and 1987 donut hole fishery (bottom).

(6) Basin fish are not included in the survey assessments used to support the EBS status of stocks estimates. The implication is that Basin fish form a distinct production unit from EBS slope and shelf fish.

(7) Okada (1983) presents a summary of 1977 and 1979 (summer) and 1983 (winter) Japanese surveys of the Aleutian Basin area (east of 180°). Highlights of his conclusions are as follows:

- (a) Basin pollock exhibit lower growth rates than EBS slope and shelf pollock.
- (b) Dense (spawning) concentrations of Basin pollock are found in the winter only and occur deeper than 300 m, females predominating in the upper layers of these aggregations. In the summer, pollock are "thinly distributed" and tend to occur at 30-150 m depth.
- (c) Basin spawning peaks in February. The work of Hinckley (1985) gives a much more detailed description of spawning in the Basin and EBS slope and shelf.

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