ASSESSMENT OF THE

STATUS OF FIVE STOCKS OF PUGET SOUND CHINOOK AND COHO

AS REQUIRED UNDER THE
PFMC DEFINITION OF OVERFISHING

SUMMARY REPORT

For The
Pacific Fisheries Management Council

Prepared By
Puget Sound Salmon Stock Review Group

September 9, 1992

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Executive Summary

The Puget Sound Salmon Stock Review Group (PSSSRG) was appointed by the Pacific Fishery Management Council to investigate the reasons the escapement objectives were not achieved for the Skagit spring chinook, Stillaguamish summer/fall chinook, Snohomish chinook, Skagit coho, and Hood Canal coho stocks for the years 1988 through 1990. Conclusions and recommendations of the review group are summarized below.

Chinook Salmon

The chronically depressed status of the chinook stocks considered in this report is likely due to a combination of exploitation rates which are too great and reduced productivity due to degradation of habitat. The excessive exploitation rates may stem in part from the lack of a consistent management objective and the absence of a comprehensive management forum for Puget Sound chinook. The PSSSRG recommends:

- **Create an annual management forum for Puget Sound chinook which establishes a common management objective for troll, sport, and net fisheries in Puget Sound.**
- **Utilize a consistent analytic tool for assessing the impacts of all fisheries upon Puget Sound stocks of chinook.**
- **Evaluate enhancement options which are consistent with natural stock management and can be used to speed rebuilding of depressed chinook stocks.**

Coho Salmon

The primary factors which resulted in the failure of the Hood Canal and Skagit natural coho stocks to achieve escapement objectives were 1) underestimates of the exploitation of these stocks in Puget Sound terminal net fisheries outside of the terminal areas for the Skagit and Hood Canal stocks, 2) preseason forecasts for the Hood Canal stock in 1989 and 1990 which were too great, and 3) underestimates of the exploitation of the Skagit stock in the west coast Vancouver Island (WCVI) troll fishery. Other factors which contributed to the failure to achieve escapement objectives are discussed in the text. The PSSSRG recommends:

- **Establish a management framework, such as the "Stepped Harvest Management Approach", which streamlines the preseason planning process and reduces its dependence upon preseason estimates of abundance and exploitation.**
- **Conduct annual postseason assessments of stock abundance and exploitation rates and use these to improve the run prediction database.**
- **Evaluate and update the Coho Assessment Model based upon the results from the**

annual postseason evaluation particularly with respect to the level of temporal and fishery stratification used in the model.

Freshwater Habitat

Specific recommendations of the PSSRG for each of the four rivers or salmon producing areas are discussed in Chapter 2 of this report. Four generally applicable recommendations for actions to correct the declines in freshwater habitat quality are:

- **Develop a comprehensive resource and habitat assessment for all watersheds that includes a general inventory of current habitat and the identification of factors limiting fish production and survival.**

- **Tribal and state fisheries management agencies should develop a coordinated long-term program to monitor the status of fish populations, stream habitat, and the effectiveness of habitat protection and restoration efforts. The program should be established with the goal of improving our knowledge regarding the quantitative relationship between land use, habitat condition, and fish production.**

- **Local, tribal, state, and federal governments should develop a comprehensive coordinated approach to habitat protection and restoration on a watershed and regional basis.**

- **The PFMC should request specific action from local, tribal, state, and federal governments to protect and restore critical habitat for stocks of concern.**

General Data Needs

The PSSSRG identified the following data needs for both chinook and coho salmon.

- **Identify and quantify those factors in the freshwater and marine habitat which limit the productivity of chinook and coho salmon stocks. Initiate programs to protect, rehabilitate, and enhance critical habitat with particular emphasis on the limiting factors.**

- **Insure that stocks representative of the "overfished" stocks are tagged on an annual basis.**

- **Review escapement estimation methods, including the stray rates of tagged hatchery indicator stocks, and recommend improvements to the methods as necessary.**

- **Review the appropriateness of the current escapement goals.**

- **Continue development of improved preseason forecasts with an emphasis on obtaining direct estimates of total recruitment which include indicators of marine survival.**

Introduction

NOAA's recently published "Guidelines for Fishery Management Plans" (FMP) 50 CFR Part 602 (July 24, 1989) required that the FMPs for each management council contain a definition of overfishing for each managed stock or stock complex covered by the FMP. To meet this requirement, the Pacific Fishery Management Council (PFMC) incorporated an overfishing definition into its salmon FMP by adopting the 10th amendment to the plan.

> **Classification of a stock as "overfished" is best viewed as an initial indicator that the stock may be in a state of decline and that a through review of its status is warranted.**

According to the definition, overfishing is indicated if a salmon stock fails to meet its annual spawning escapement goal or management objective for three consecutive years and if changes in the fishery management regime offer the primary opportunity to improve stock status. The latter provision of the definition was included because it was recognized that the failure to meet escapement goals can result from factors other than those related to fishing. Classification of a stock as "overfished" is therefore best viewed as an initial indicator that the stock may be in a state of decline and that a thorough review of its status is warranted. To facilitate this review, Amendment 10 requires that the Council appoint a work group to investigate the causes of the apparent shortfall in escapement.

Amendment 10 was implemented in April 1991. The first assessment of chinook and coho stocks specified in the salmon FMP indicated that five stocks in Puget Sound met the definition criterion including Skagit and Hood Canal coho, Skagit spring chinook, Stillaguamish summer/fall chinook, and Snohomish summer/fall chinook (Table 1). The Puget Sound Salmon Stock Review Group (PSSSRG) was appointed by the Council and asked to examine the causes which led to the failure in meeting annual spawning escapement objectives for the five specified stocks.

The following report summarizes the results and recommendations of the analysis. Details of the analyses may be found in a separate technical report which includes an "Assessment of Stock Status" and "Status and Trends of Fish Habitat".

Table 1. Comparison of preseason predictions of escapement and postseason estimates for five Puget Sound natural stocks of chinook and coho salmon.

STOCK	PREDICTED ESCAPEMENT	ESTIMATED ESCAPEMENT	ESCAPEMENT GOAL
Stillaguamish Summer/Fall Chinook			
1988	547	717	2,000
1989	2,000	811	2,000
1990	1,600-2,050	842	2,000
Snohomish Summer/Fall Chinook			
1988	5,250	4,513	5,250
1989	6,341	3,138	5,250
1990	6,205	4,209	5,250
Skagit Spring Chinook			
1988	1,400	2,008	3,000
1989	2,000-4,000	1,853	3,000
1990	3,478	1,902	3,000
Skagit Coho			
1988	24,000 [1]	19,000	30,000
1989	19,200 [1]	17,000	30,000
1990	23,400 [1]	15,000	30,000
Hood Canal Coho			
1988	15,500 [1]	11,610	19,100
1989	19,100	15,310	19,100
1990	19,100	6,800	19,100

1/ Annual escapement objective identified during the PFMC process.

Conceptual Framework

To provide a framework for the review, the PSSSRG hypothesized that the reason for the failure to achieve the escapement objective was either:

1) The number of fish available after Alaskan and Canadian fisheries was less than the escapement objective; or

2) Errors in management or assessment models resulted in an overharvest of the stock.

If insufficient fish were available to achieve the escapement objective, then subsequent analyses attempted to discern why the stock was depressed. For example, was survival unusually poor, were exploitation rates on the previous brood(s) too great, or has habitat degradation reduced the productivity of the stock? Conversely, if the escapement objective was not met despite adequate recruitment, the focus of the analysis was the current management system and models. Was the preseason forecast in error, were fisheries not managed as expected, were model predictions of fishery impacts in error, or were the management tools inadequate?

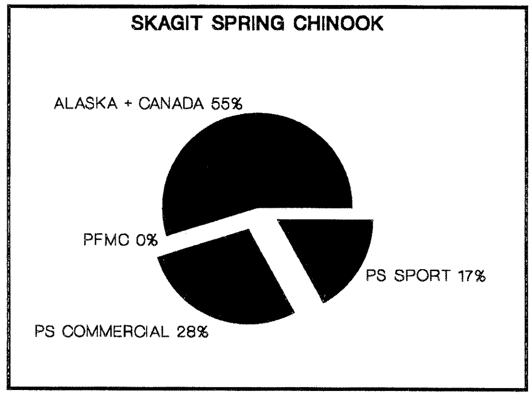
Whether or not there was sufficient recruitment to meet the escapement objective, productivity for these stocks has been reduced below historical levels. In Chapter 2, the PSSRG characterizes the current status of fish habitat in the systems where these stocks are produced and the trends in factors which are indicators of the future status of this habitat. To the degree possible, given available information, the PSSRG related the status of fish habitat to trends in salmon production.

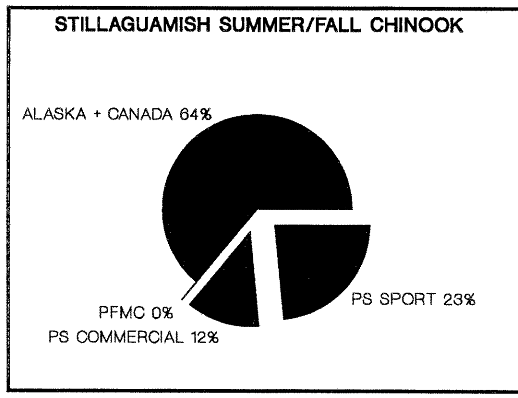
It is recognized that prior harvests in Canadian and Alaskan fisheries constrain the management options available for southern U.S. fisheries. However, the dichotomy of the review framework allowed the review group to distinguish between cases where recruitment was clearly inadequate and those where aspects of the management system in southern U.S. fisheries were problematic and provided opportunity for improvement.

Chinook Salmon

The Skagit River, Stillaguamish River, and Snohomish River originate in the Cascade Mountains of Washington and drain into north Puget Sound (Fig. 1). These rivers provide an important source of natural production of chinook salmon in Puget Sound. The spring chinook run in the Skagit River is the largest remaining natural spring chinook stock in Puget Sound and had an average terminal run size of 2,100 fish from 1986-1990. The Snohomish River supports the third largest natural stock of summer/fall chinook in Puget Sound. From 1986-1990, terminal run sizes averaged 7,600 fish. The average terminal run for the Stillaguamish summer/fall stock during the same time period was 1,800 fish.

Fisheries under the jurisdiction of the PFMC have a minor impact upon the three chinook stocks assessed (Fig. 2). The PFMC fisheries account for less than 1 percent of the catch related mortality for any of the stocks. The majority of fishing related mortality occurs in the Alaskan and Canadian fisheries. The Puget Sound fisheries also account for a significant proportion of the mortality, ranging from about 35 to 50 percent, depending on the stock.





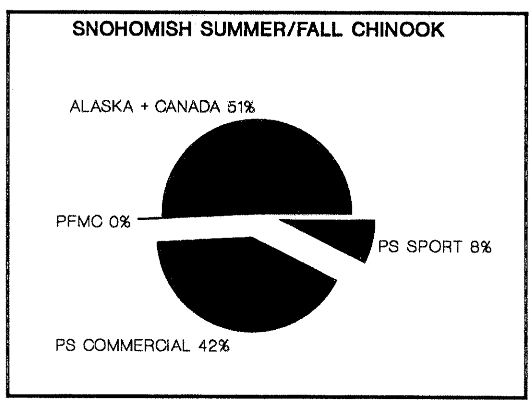


Figure 2. Distribution of total adult equivalent fishing mortality for Skagit spring, Stillaguamish summer/fall, and Snohomish summer/fall chinook.

Stock Assessment

As discussed in the "Conceptual Framework", the first objective of the review was to determine if sufficient fish were present to achieve the escapement objective after accounting for mortality in Alaskan and Canadian fisheries. To address this question, a measure of abundance called the "potential escapement" was developed. The potential escapement is the escapement which would be predicted to occur in the absence of fisheries in the southern U.S.

Potential escapements for the Skagit and Snohomish

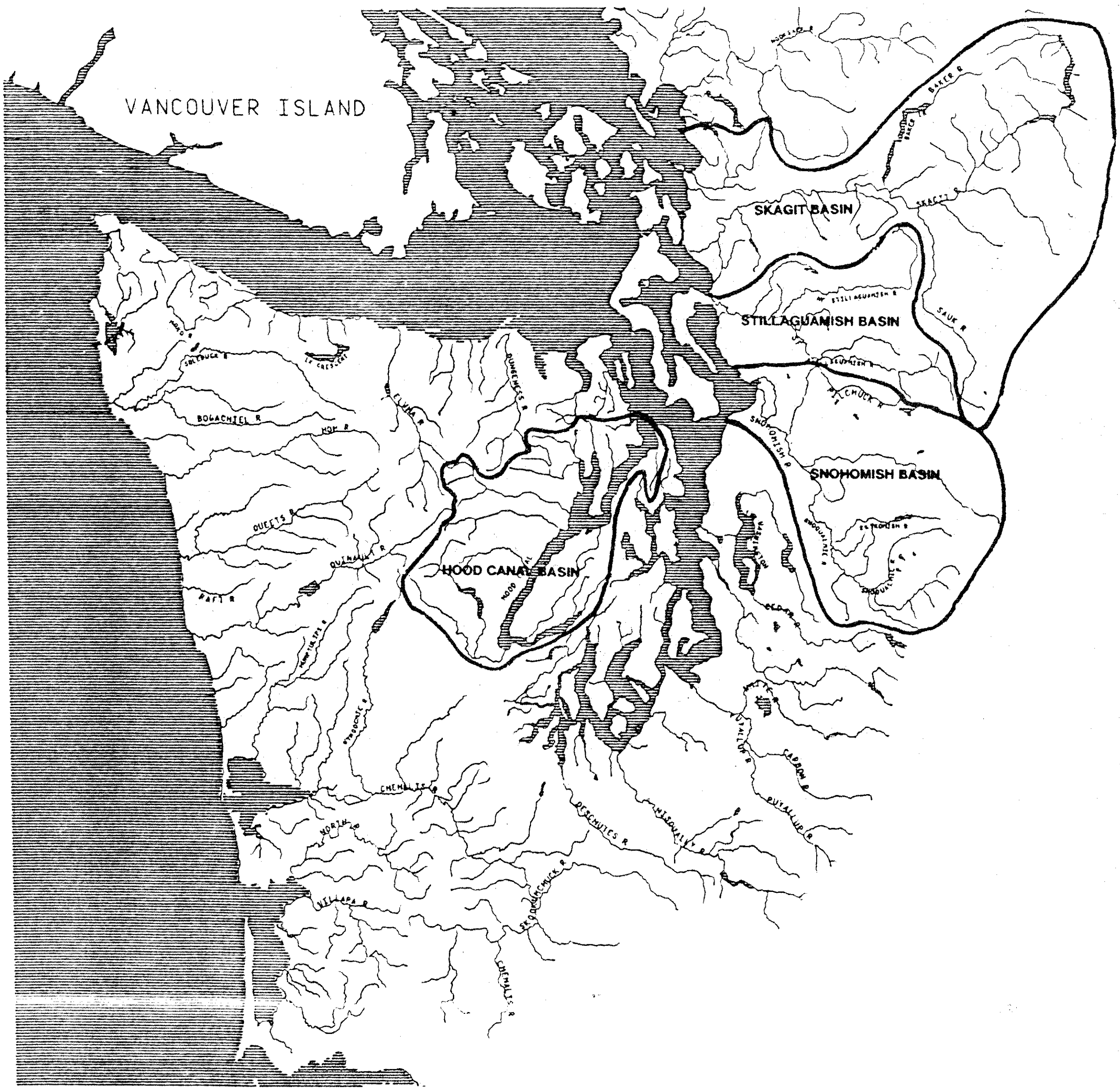


Fig. 1. Location of Skagit, Stillaguamish, Snohomish, and Hood Canal drainages within Puget Sound.

stocks were generally greater than the escapement goal. The potential escapement of the Snohomish fall stock exceeded the escapement goal (5,250) in each of the three years during the overfishing review period (Fig. 3). During this period, the potential escapement ranged from 6,500 to 8,500 fish. The potential escapement of the Skagit River spring chinook stock exceeded the escapement goal (3,000) in two of the three years during the overfishing review period (Fig. 4). The potential escapement ranged from 4,700 fish in 1988 and 1989 to 2,900 fish in 1990; however, there is a problem accounting for Skagit spring chinook because the distinction between spring and summer/fall chinook is not clear.

In contrast, the potential escapement of the Stillaguamish stock was approximately 50 percent of the escapement goal (2,000) in the years 1988 through 1990 (Fig. 5). The potential escapement ranged from 906 fish in 1988 to 1,042 fish in 1990.

Management Planning

Since the potential escapement of the Skagit and Snohomish stocks generally exceeded the escapement objective, subsequent analyses for these stocks attempted to discern what limitations in the current management system resulted in a greater than allowable harvest.

The failure of the Skagit and Snohomish stocks to meet their escapement objectives despite adequate potential escapement may stem in part from the absence of a comprehensive management forum for Puget Sound chinook. Management plans for mixed stock fisheries in the southern U.S. are based upon a variety of criteria, but a consistent management objective and linkage between the fisheries is lacking. Only in terminal net

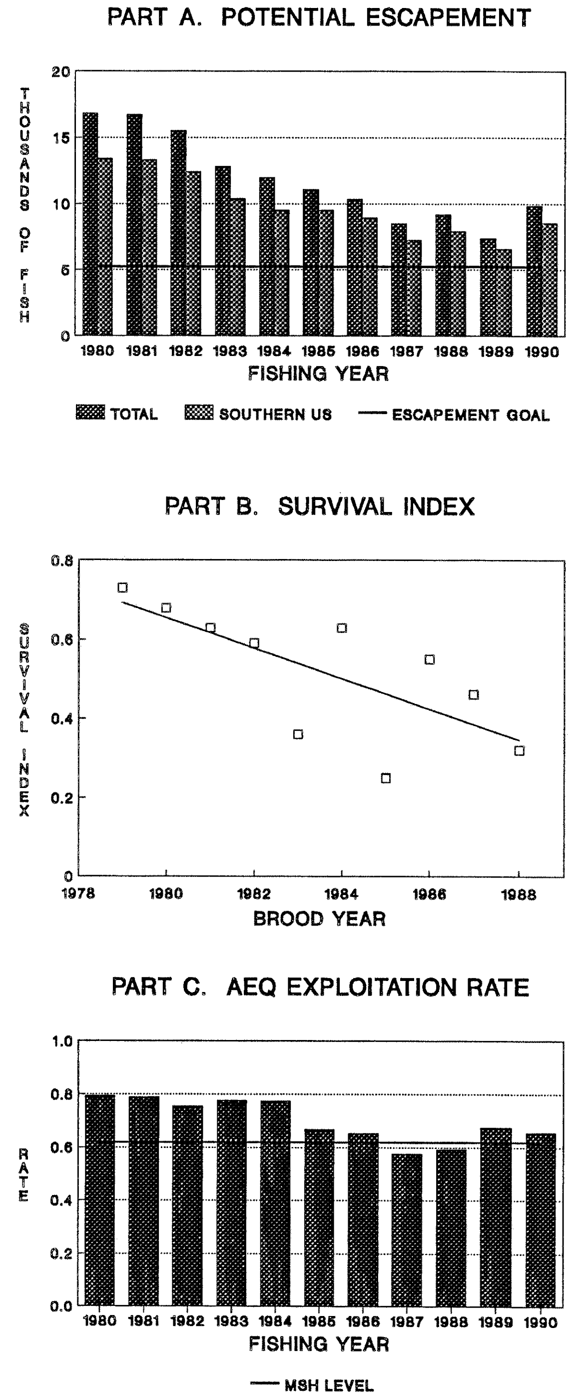


Figure 3. Potential escapement, survival index, and adult equivalent exploitation rates for the Snohomish summer/fall chinook stock.

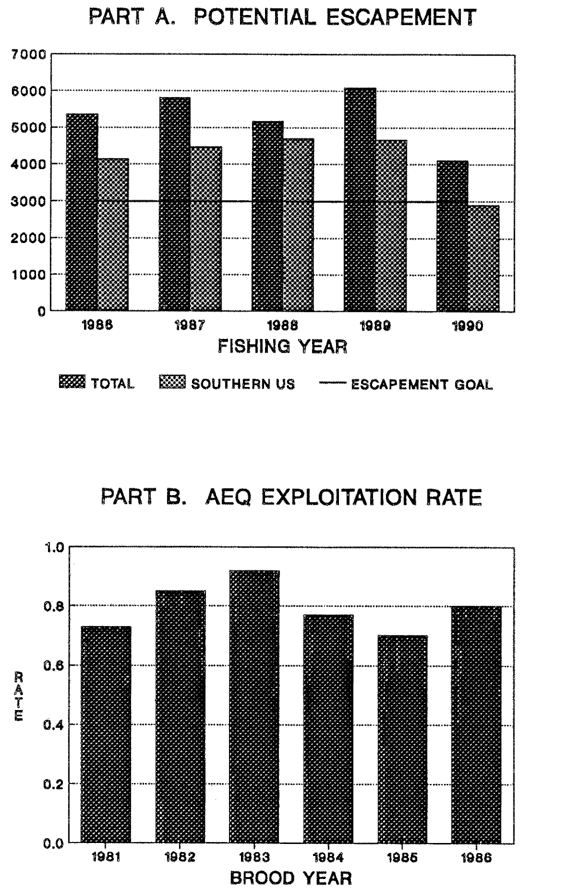


Figure 4. Potential escapement and total adult equivalent exploitation rates for the Skagit spring chinook stock.

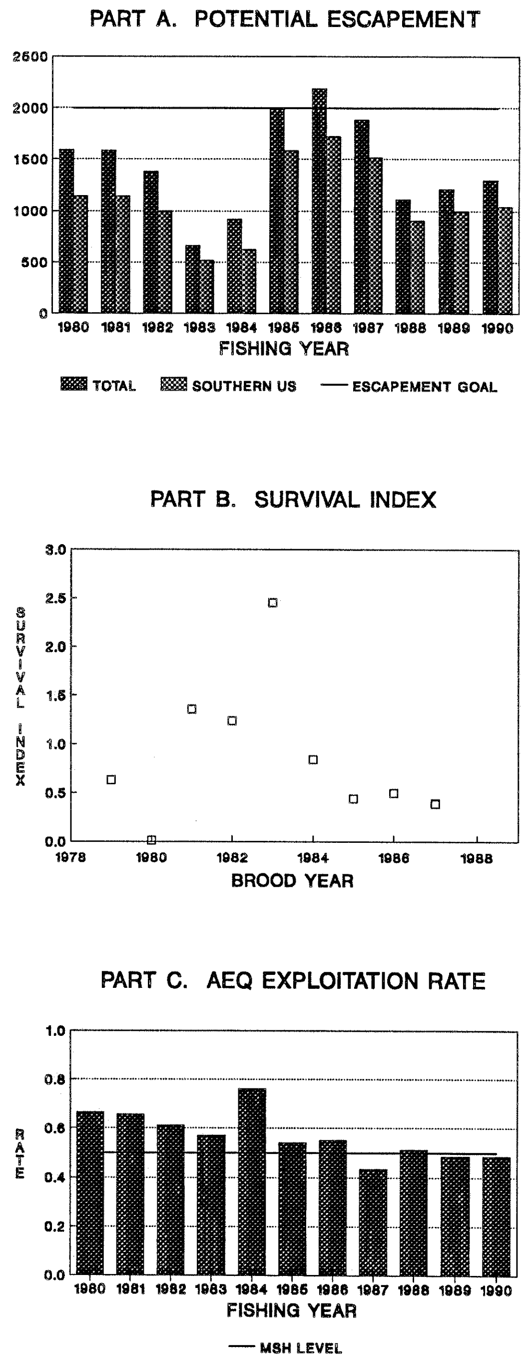


Figure 5. Potential escapement, survival index, and total adult equivalent exploitation rates for the Stillaguamish summer/fall chinook stock.

fisheries is stock specific management action taken in response to in-season stock abundance estimates.

The patchwork of management planning has made it difficult to obtain an understanding of the total effect of all fisheries upon a stock. For example, planning of Puget Sound sport and troll fisheries is typically done at different times of the year, with different analytic tools, and with different management objectives.

The failure of the Skagit and Snohomish stocks to meet their escapement objectives despite adequate potential escapement may stem in part from the absence of a comprehensive management forum for Puget Sound chinook.

Perhaps as a result of the lack of comprehensive planning, exploitation rates for the Snohomish and Skagit stocks have frequently exceeded the level associated with maximum sustainable harvest (MSH). The estimated adult equivalent exploitation rate for the Snohomish chinook stock exceeded the MSH level for 9 of the 11 years during the period 1980 through 1990 (Fig. 3). Although data for the Skagit stock is less conclusive, preliminary estimates indicate that exploitation rates for this stock have exceeded the MSH level as well (Fig. 4). Adult equivalent exploitation rates for the Stillaguamish stock have been near the MSH level since 1985 (Fig. 5). Prior to that time, the exploitation rates exceeded the MSH level by approximately 20 percent.

Stock Productivity

A negative trend has existed in the potential escapement for the Snohomish summer/fall chinook stock since 1980. The potential escapement in the period 1988-1990 was approximately 50 percent of the potential escapement in 1980. The reduction in abundance during this time period may be attributed to 1) exploitation rates in excess of the MSH level and 2) reductions in survival rates. Reductions in the exploitation rate of the Snohomish stock in recent years have been offset to some extent by lower survival rates. Survival rates may be affected by freshwater, estuarine, and ocean rearing conditions.

The potential escapement for the Stillaguamish summer/fall stock has not increased substantially despite reductions in the exploitation rates to near or below the MSH level. Part of the cause for the lack of a response may be reductions in survival rates. The average survival rate for brood years 1984 through 1987 was approximately 70 percent less than the estimated average for the 1981 through 1983 broods. Reasons for this are unknown. The natural stock supplementation program initiated in 1985 has the potential to accelerate rebuilding of this stock. Further consideration should be given to means to maximize the benefits from the program, including the magnitude of production and the selection of broodstock. Initial indications from the 1991 return are that a substantial portion of the natural escapement originated from the supplementation program.

A major limitation of the present review is our inability to provide an index of habitat quality and quantity within the Snohomish basin (and other basins as well) which can be directly related to fish production. The human population within the Puget Sound region has increased rapidly in recent years, and this growth has the potential to severely impact fishery resources. For example, estuaries provide an important feeding and nursery area for juvenile chinook in transition between fresh and saltwater. However, dredging and filling has resulted in a 74 percent reduction in wetlands in the Snohomish River delta and an 80 percent reduction in wetlands at the Stillaguamish delta (Table 2). Despite the large number of agencies involved in some aspect of habitat management, there are currently no programs for widespread ongoing monitoring and evaluation of fisheries habitat within Washington.

> **A major limitation of the present review is our inability to provide an index of habitat quality and quantity...which can be directly related to fish production.**

Table 2. Comparison of historical and present wetland areas at selected river deltas (acres).

River	Historical	Present	% Change
Snohomish	9,635	2,470	-74%[A]
Stillaguamish			-80%[B]
Skagit			-90%[C]
Skokomish	520	345	-34%[A]

[A] (PSWQA 1988)

[B] Tulalip Tribes estimate (D. Somers, Tulalip Fisheries Dept.)

[C] (PSWQA 1990)

Coho Salmon

The Hood Canal region and the Skagit River system are two of the four stocks within Puget Sound which are primarily managed for natural production. The Hood Canal is a 61 mile long fishhook shaped fjord that is bordered on the west by the steep and heavily forested Olympic Mountains and on the east by the low rolling hills of the Kitsap Peninsula (Fig. 1). The Skagit River is located in northwestern Washington and is the largest drainage basin in Puget Sound (Fig. 1).

There are eight key naturally producing coho stocks that are used during the annual PFMC process for planning coho fisheries north of Cape Falcon including four from the Washington Coast and four from Puget Sound. At the beginning of each year, the controlling stock or stocks which limit the allowable harvest are identified based on preseason forecasts of abundance. In three out of the last five years, the Skagit stock was limiting (1987, 1989, and 1990). The Hood Canal stock was the controlling stock in 1988, 1991, and 1992.

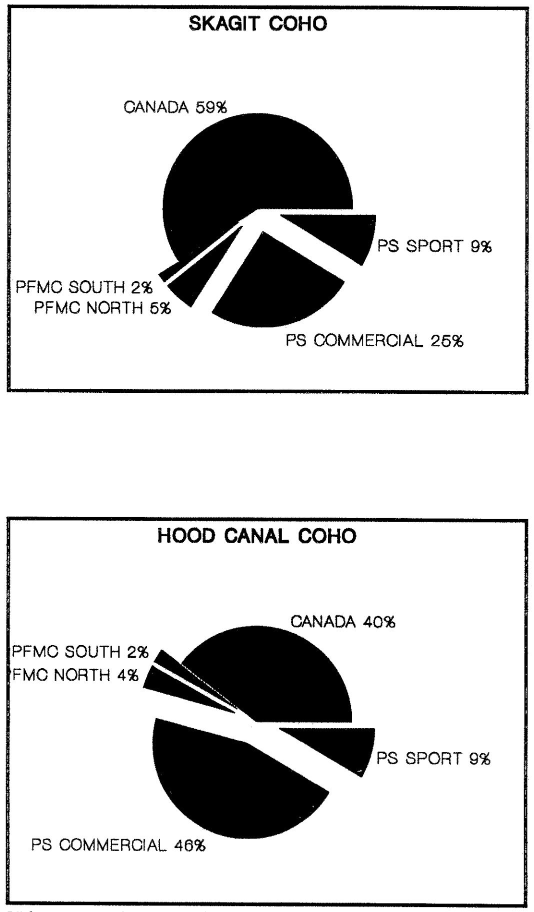


Figure 6. Catch distribution for Skagit and Hood Canal coho.

Most of the catch of Hood Canal and Skagit coho occurs in Canadian fisheries, primarily the WCVI troll fishery, the Area 20 net fishery, and Georgia Strait sport and troll fisheries. Significant catches also occur in U.S. North of Cape Falcon ocean troll and sport fisheries, Puget Sound sport fisheries, and Puget Sound net fisheries (Fig. 6). In some years, for example 1988, South of Cape Falcon catches are also significant.

Stock Assessment

The first step in the review framework was to determine if sufficient fish were available to achieve the escapement objective after accounting for mortality in Canadian fisheries. For coho salmon, this question was addressed by simply comparing a postseason estimate of the catch plus escapement of each stock in southern U.S. fisheries with the escapement objective for the stock.

Sufficient fish were present in each year to achieve the escapement objective for each stock

(Table 3). Postseason estimates of the catch (in southern U.S. fisheries) plus escapement for the Skagit stock were 2.2 to 2.7 times greater than the escapement objective. Sufficient fish were also present for the Hood Canal stock, although the ratio of catch plus escapement to the escapement objective was not generally as great (range 1.9 to 2.0).

Table 3. Postseason estimates of the total catch in southern U.S. fisheries plus escapement (US RUN) compared with the escapement objective for the Hood Canal and Skagit natural coho stocks in 1988 through 1990.

YEAR	HOOD CANAL		SKAGIT	
	US RUN	ESCAPEMENT OBJECTIVE	US RUN	ESCAPEMENT OBJECTIVE
1988	28,789	15,500	51,843	24,000
1989	35,453	19,100	47,510	19,200
1990	37,671	19,100	62,934	23,400

Although this analysis indicates that there were sufficient fish in U.S. waters to provide for escapement, it is also clear that the substantial harvest in Canadian fisheries limit the options for managing U.S fisheries to provide adequate fishing opportunities and meet the escapement objectives. However, this review focuses on improvements that could be made in the U.S. fishery management system that are independent of problems created by the level of Canadian fisheries.

Sources of Error

Since sufficient fish were present to achieve the escapement objective, the second task of the review team was to attempt to ascertain what factor or combination of factors resulted in the escapement deficit. The review team attempted to identify those factors which frequently resulted in significant deviations from the preseason predictions of catch of the Skagit and Hood Canal stocks. An error of 5 percent of the escapement objective was arbitrarily set as a criteria to identify a significant deviation. Deviations from preseason predictions were computed based upon cohort analysis of coded-wire-tag groups representing natural production of coho from Hood Canal and the Skagit River. Significant errors which were identified in this analysis are given in Table 4.

Table 4. Primary factors which resulted in a deviation from the preseason prediction for the escapement of the Hood Canal and Skagit natural stocks of coho salmon in 1988, 1989, and 1990.

SOURCE OF ERROR	SKAGIT			HOOD CANAL		
	1988	1989	1990	1988	1989	1990
PREDICTED RECRUITMENT					X	X
WCVI TROLL						
Predicted Catch		X			X	
Model/Forecast Error	X	X	X			
GEORGIA STRAIT SPORT AND TROLL						
Predicted Catch	X					
AREA 20 NET						
Predicted Catch		X				
Model/Forecast Error		X				
SOUTH OF CAPE FALCON TROLL AND SPORT						
Model/Forecast Error	X			X		
NORTH OF CAPE FALCON TROLL						
Model/Forecast Error			X			
PUGET SOUND PRETERMINAL SPORT						
Predicted Catch			X			X
Model/Forecast Error			X	X		X
AREA 6B/9 NET						
Predicted Catch						X
Model/Forecast Error					X	
OTHER TERMINAL NET						
Predicted Catch	X		X	X		X
Model/Forecast Error			X	X	X	X
HOOD CANAL TERMINAL NET						
Model/Forecast Error				X		
SKAGIT TERMINAL NET						
Predicted Catch	X					
Model/Forecast Error	X					

The most consistent source of deviation from the preseason prediction for escapement of both Hood Canal and Skagit stocks was the predicted catch and exploitation rates in Puget Sound terminal net fisheries directed at other stocks. Net fisheries included in this group include South Puget Sound (primarily areas 10 and 11), Stillaguamish/Snohomish (primarily Area 8A), and Nooksack/Samish (primarily areas 7B and 7C). Fisheries in these areas have typically been managed to harvest surplus production of local stocks. However, these fisheries also harvest non-local stocks, such as the Skagit and Hood Canal stocks of coho. Errors in the predicted catch and exploitation rates for these fisheries could result from a number of factors which include 1) in-season estimates of abundance which exceeded preseason predictions and led to increased exploitation rates, 2) changes in fishing patterns which increased the exploitation rate on non-local stocks, or 3) errors in modeling procedures or parameters. All three of these factors are currently under review by the technical staffs of WDF, the NWIFC, and Puget Sound treaty tribes.

Failure of the Skagit stock to achieve the escapement objective may also be partially attributed to inaccurate predictions of exploitation in the WCVI troll fishery. The exploitation rate of the Skagit fish in the WCVI troll fishery was higher than the preseason prediction in the years 1988 through 1990. The estimates of the exploitation rates by the WCVI troll fishery on Hood Canal stocks were relatively accurate or overestimated. A review of the base period exploitation rates used to model the Skagit stock in the Coho Assessment Model will need to occur before the cause of this is determined.

Inaccurate preseason estimates of abundance (and resulting high exploitation rates) were the primary factor which resulted in the failure of the Hood Canal stock to achieve its escapement objective in 1989 and 1990. The relative error of the preseason prediction was -43 percent in 1989 and -59 percent in 1990. Preseason estimates of abundance for the Skagit stock were less than the postseason estimate in each of the three years, with relative errors of 8 to 37 percent.

One promising method to improve preseason predictors would be to forecast the abundance of Puget Sound stocks in terms of total recruitment rather than terminal run size. Attention should also be focused on developing valid indicators of marine survival. An alternative approach to the problem of forecast accuracy is to reduce dependence on preseason forecasts by considering alternative management strategies. This option is discussed in greater detail in the Coho Management Planning section of this report.

Stock Productivity

Comparison of estimated exploitation rates with the rate associated with the maximum sustainable harvest (MSH) provides a useful means to evaluate if overharvest is occurring. The rate associated with the MSH will differ between stocks as a result of variation in the quality of habitat and the characteristics of the stock. In general, MSH exploitation rates for coho salmon are believed to be in the range of 60-70 percent, although for Puget Sound stocks the rate may be as high as 85 percent under favorable environmental conditions.

Exploitation rates for Hood Canal coho likely were near or exceeded the MSH level in two of the three years considered. The observed exploitation rates were 50 percent in 1988, 79 percent in 1989, and 90 percent in 1990. Harvest rates on the Hood Canal stock in 1989 and 1990 were likely greater than the MSH level. Harvest rates on the Skagit stock ranged from 65 percent in 1988 to 73 percent in 1989.

Degradation of habitat has the potential to reduce both the allowable harvest rate and the number of fish produced. Unfortunately, there is currently no general quantified measure of habitat in the Hood Canal region which can be used to evaluate the quantity and quality of habitat available to coho salmon. Some estimates of production losses due to specific habitat impacts are available for the Skagit system. For example, the Skagit System Cooperative estimates that flood control measures in the lower Skagit River have resulted in losses of approximately 300,000 smolts per year. If this level of production could be replaced, we could anticipate meeting the full escapement goal of 30,000 wild spawners on an annual basis, a doubling of the terminal area harvest, and the removal of Skagit wild coho from the current list of weak stocks that chronically limit PFMC and other preterminal fisheries. Skagit wild coho have been the primary limiting stock in 3 of the last 6 years. Had Skagit not been limiting in those years, ocean harvest quotas might have increased substantially depending on constraints imposed by other weak stocks. Development of an integrated fish/habitat database would provide a means to identify key habitat areas, evaluate land use management actions, and monitor longterm trends in the quality and quantity of habitat.

Management Planning

Insufficient preseason planning is not the factor which resulted in the failure of the Skagit and Hood Canal stocks to achieve their annual escapement objectives. Puget Sound coho stocks are the subject of a comprehensive planning process which encompasses all fisheries which operate south of the Canadian border. The planning process utilizes preseason estimates of abundance and a computer model of coho fisheries to predict the escapement of each key stock. Fisheries are then planned with the goal of allowing sufficient escapement for that year.

The current preseason planning process requires a degree of accuracy and precision which is not consistent with current technical capabilities. Errors in preseason predictions of abundance ranged from -8 to -37 percent for the Skagit and +1 to -59 percent for Hood Canal. Evaluation of total exploitation rates revealed that the relative error of preseason predictions was approximately 10 percent (Hood Canal - 2 to 8 percent; Skagit 10 to 13 percent). Predictions of exploitation rates in individual fisheries were significantly less accurate.

The current preseason planning process requires a degree of accuracy and precision which is not consistent with current technical capabilities.

The results from the Overfishing Review could be profitably used to improve the preseason planning process. Suggestions are summarized below:

1) Develop a management system with reduced reliance on preseason abundance forecasts.

The magnitude of the errors in preseason forecasts indicate that it may be preferable to consider a number of key stocks (rather than a single stock) when setting ocean catch quotas.

2) Plan and manage fisheries at a level of detail consistent with the appropriate use of available data. Given the annual variability in the distribution of coho, and the magnitude of errors in estimates, the value of micromanagement (e.g., Area 3 versus Area 4) needs to be reevaluated in light of the available information.

3) Develop a mechanism to account for management uncertainty. Except for in-season adjustments made in terminal areas, the current system (including agreements for non-PFMC fisheries) is generally unresponsive if abundance is less than the preseason prediction. Because of natural variability in the predictions, escapements below the target levels would be expected to occur approximately half the time. If managers consider this undesirable, then a "buffer" could be established to account for uncertainty, or escapement predictions could be expressed as a range rather than a point estimate.

Viable alternatives exist which could streamline the preseason planning process for coho and reduce its dependence upon preseason estimates.

Viable alternatives exist which could streamline the preseason planning process for coho and reduce its dependence upon preseason estimates. An option presented by the U.S. Southern Panel at the Coho Workshop (a Pacific Salmon Commission forum), called the "Stepped Harvest Management Approach", ties fishery quotas to the stock status of key natural stocks. Among the cited advantages of the approach are 1) a reduced sensitivity to data uncertainty and 2) a reduction in the time and resources required for annual management planning.

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SIXTH AMENDMENT

TO THE

NORTHERN ANCHOVY FISHERY MANAGEMENT PLAN

Incorporating the Environmental Assessment,
Regulatory Impact Review/Initial Regulatory Flexibility Analysis
and
Requirements of Other Applicable Law

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April 1990

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ES.0 Executive Summary

ES.1 Background and Current Management Regime

The central subpopulation of Northern anchovy (*Engraulis mordax*) is a stock that occurs in both U.S. and Mexican waters. It ranges from approximately San Francisco, California to Punta Baja, Baja California. The subpopulation is harvested by both U.S. and Mexican fisheries. The harvests are used: 1) for reduction to meal and oil, 2) as live bait in recreational fisheries, and 3) for other non-reduction uses, largely dead bait and pet food. Anchovy are subject to predation in all of their life stages by numerous marine fishes, mammals and birds, including the endangered California brown pelican (*Pelecanus occidentalis californicus*).

The central subpopulation is the management unit for the Northern Anchovy Fishery Management Plan (FMP). The FMP was approved by the Pacific Fishery Management Council (PFMC) in June of 1978 and was implemented by the Secretary of Commerce on September 13, 1978. The FMP was most recently amended in 1983. Current regulations impose no numeric limit on live bait catch and provide a 7,000 mton quota for other non-reduction uses. The regulations also specify an optimum yield (OY) for the reduction fishery of 1) zero when the spawning biomass is less than or equal to 300,000 mtons, and 2) the difference between the spawning biomass and 300,000 mtons, up to a limit of 200,000 mtons, when the spawning biomass is greater than 300,000 mtons.

The biological rationale for the 300,000 mton threshold is to prevent depletion of the resource and to provide an adequate forage reserve for marine fishes, mammals and birds. Implicit in this approach is the judgment that relatively small catches (for non-reduction uses) can be allowed when the spawning biomass is below 300,000 mtons without significantly impacting the resource's long-term reproductive potential.

ES.2 Issues and Need for Amendment

The Council developed and analyzed a variety of options for:

1) amending the OY formula in the current FMP to allow a small reduction fishery when the spawning biomass falls below 300,000 mtons. This action is a follow-up to an emergency rule allowing a modest reduction quota in the 1989/90 season despite a spawning biomass of 214,000 mtons (which would normally result in no quota for the reduction fishery). The rationale for the rule was that a small reduction harvest in 1989/90 would pose no danger to the stock because total biomass, in contrast to spawning biomass, was high (in excess of one million mtons). Spawning biomass was low during 1989/90 despite the high level of total biomass, due to unusually cold water temperatures during the spawning season.

2) amending the FMP to include a definition of overfishing that is consistent with recently revised guidelines for National Standard 1 of the Magnuson Fishery Management and Conservation Act.

ES.3 Specification of Options

The Council devised three options for amending the reduction OY formula and two options for the definition of overfishing.

ES.3.1 Reduction OY Options

The three reduction OY options are as follows:

1) Status Quo. The Status Quo involves no modification to the current FMP and OY formulas. Under this option, the reduction OY is 1) zero when the spawning biomass is less than or equal to 300,000 mtons, and 2) the difference between the spawning biomass and 300,000 mtons, up to a limit of 200,000 mtons, when the spawning biomass is greater than 300,000 mtons.

2) Unconditional Option. Under the Unconditional Option, the reduction OY is 1) 7,000 mtons when the spawning biomass is less than or equal to 307,000 mtons, and 2) the difference between the spawning biomass and 300,000 mtons, up to a limit of 200,000 mtons, when the spawning biomass is greater than 307,000 mtons.

3) Conditional Option. Under the Conditional Option, the reduction OY depends on the level of total, as well as spawning, biomass. Under this option, the reduction OY formula is a) the same as the Status Quo formula when total biomass is less than 375,000 mtons, and b) the same as the Unconditional Option formula when total biomass is greater than or equal to 375,000 mtons. The Conditional Option is meant to provide the reduction fishery with a small quota when unusual circumstances

similar to those in 1989/90 prevail (i.e., high total biomass but low spawning biomass). This option is a hybrid of the Status Quo and Conditional options. It is less restrictive than the Status Quo but more restrictive than the Unconditional Option.

ES.3.2 Overfishing Options

The two overfishing options are as follows:

1) No-Lower-Cutoff Option. The No-Lower-Cutoff Option defines overfishing as any harvest in excess of OY, where OY is determined according to the harvest formula in the FMP. It allows unlimited live bait harvests and a 7,000 mton quota for other non-reduction uses, regardless of the level of spawning biomass. Its effect on the reduction fishery at low levels of abundance will depend on which reduction OY option is chosen. If the Status Quo is chosen, the No-Lower-Cutoff Option will disallow all reduction fishing when the spawning biomass is less than or equal to 300,000 mtons. If the Unconditional Option is chosen, it will allow a 7,000 mton reduction harvest when the spawning biomass is less than or equal to 307,000 mtons. If the Conditional Option is chosen, it will a) disallow all reduction fishing when the spawning biomass is less than or equal to 300,000 mtons and total biomass is less than

375,000 mtons, and b) allow a 7,000 mton reduction harvest when the spawning biomass is less than or equal to 307,000 mtons and total biomass is greater than or equal to 375,000 mtons.

2) Lower-Cutoff Option. The Lower-Cutoff Option defines overfishing: a) in the same manner as the No-Lower-Cutoff Option when the spawning biomass is greater than or equal to 50,000 mtons, and b) as harvests of any kind when the spawning biomass falls below 50,000 mtons. Unlike the No-Lower-Cutoff Option, this option disallows all harvests (for reduction, live bait and all other non-reduction uses) at low levels of spawning biomass.

ES.3.3 Combining Reduction OY and Overfishing Options

The reduction OY options and overfishing options were combined to yield a total of six options (Table ES.3-1). Options 1L-3L are combinations of the three reduction quota options with the Lower-Cutoff overfishing option. Options 1-3 are combinations of the Status Quo, Conditional and Unconditional reduction quota options with the No-Lower-Cutoff option.

Table ES.3-1. Summary of options. The maximum reduction OY for all options is 200,000 mtons.* All figures expressed in mtons. Abbrevations "SB" used for spawning biomass and "TB" for total biomass.

Option	Conditions	Optimum Yield		
		Reduction	Live Bait	Other Non-Red
Reduction quota options combined with Lower-Cutoff Option for overfishing:				
1L. Status Quo	SB<50K	0	0	0
	50K≤SB≤300K	0	Unlim	7K
	SB>300K	SB-300K	Unlim	7K
2L. Unconditional	SB<50K	0	0	0
	50K≤SB≤307K	7K	Unlim	7K
	SB>307K	SB-300K	Unlim	7K
3L. Conditional	TB≥375K and			
	SB<50K	0	0	0
	50K≤SB≤307K	7K	Unlim	7K
	SB>307K	SB-300K	Unlim	7K
	TB<375K and			
	SB<50K	0	0	0
	50K≤SB≤300K	0	Unlim	7K
	SB>300K	SB-300K	Unlim	7K
Reduction quota options combined with No-Lower-Cutoff Option for overfishing:				
1. Status Quo	SB≤300K	0	Unlim	7K
	SB>300K	SB-300K	Unlim	7K
2. Unconditional	SB≤307K	7K	Unlim	7K
	SB>307K	SB-300K	Unlim	7K
3. Conditional	TB≥375K and			
	SB≤307K	7K	Unlim	7K
	SB>307K	SB-300K	Unlim	7K
	TB<375K and			
	SB≤300K	0	Unlim	7K
	SB>300K	SB-300K	Unlim	7K

* Reduction and non-reduction quotas for U.S. fishermen are 70% of the figures shown for "Reduction" and "Other Non-Red" fishing.

ES.4. Summary of Impacts

ES.4.1 Biological/Economic Impacts

A simulation model was used to analyze the long-term effects of each of the options on total biomass, reduction catch and profit, frequency of reduction fishery closures, and breeding success of brown pelicans. The effects of the various options on these variables were virtually identical. Several factors contributed to this outcome:

1) The simulation results and economic analysis suggest that reduction fishing becomes unprofitable at low levels of biomass, i.e., that economic constraints tend to protect the stock from overfishing by the reduction fleet when biomass is low. Thus, the largest component of the potential total catch (i.e., the reduction harvest) is eliminated at low levels of spawning biomass. This general picture is consistent with the recent history of the reduction fishery. Harvests have been low in recent years due to low ex-vessel prices.

2) Unlike the reduction fishery, the non-reduction fisheries are potentially profitable even at low levels of abundance. However, spawning biomass levels below 50,000 mtons occurred very infrequently in the course of the simulations, so the potential effect of modest non-reduction harvests at low levels of biomass was not well represented in the results.

Additional simulations were run in order to determine the possible effects of a 50,000 mton spawning biomass cutoff for all fishing. This analysis focussed on the time it would take for the stock to recover from low levels of spawning biomass to 300,000 mtons under the Lower-Cutoff and No-Lower-Cutoff options for overfishing. Mean time to recovery was 7.9 years with the cutoff and 8.6 years without it, a difference of 0.7 years. In other words, the results suggest that it would take 0.7 fewer years, on average, for the stock to recover from 25,000 mtons to 300,000 mtons with the cutoff than without it.

These results appear to be supported by historical data, which indicate that the stock was able to rebound from low levels of abundance in the mid-1950's, despite annual harvests of 25,000 to 30,000 mtons. It should also be noted, however, that the parameters in the simulation model were estimated from data for 1964-1985, which were medium to high biomass years (Jacobson and Thomson 1989). Thus the estimates of mean recovery times are extrapolations and possibly unreliable. The true difference in mean recovery times with and without a 50,000 mton cutoff may be larger.

Although biological effects and economic effects on the reduction fishery appear to be the same for all options, the lower-cutoff overfishing options (Options 1L-3L) could have an adverse economic impact on the non-reduction fleet and on the recreational fishery in low biomass years. Anchovy are the major source of bait for the recreational fishery; the next best substitute is sardines. The sardine population, however, collapsed in the early 1950's and has only recently shown signs of recovery. Therefore, sardines are currently not available in sufficient quantities to serve as a substitute for anchovy as bait, and the timetable for their recovery is highly uncertain at this time.

ES.4.2 Administrative Implications

Implementation of each of the six options requires that spawning biomass, or spawning biomass and total biomass, be estimated annually. Costs of biomass estimation are expected to be the same for all six options.

Monitoring of reduction and non-reduction landings, as required by the FMP, is accomplished via landings receipts, which are provided by fish processors to the California Department of Fish and Game. Because the State of California uses these receipts as the basis for its "use tax" on commercial landings, this recordkeeping requirement would continue even in the absence of the FMP. None of the options considered in this amendment adds to this paperwork burden or imposes any additional compliance costs on the fishing industry.

The costs to the government of monitoring reduction and non-reduction (other than live bait) landings are expected to be the same for all options. Options 1L-3L, however, do impose additional responsibilities with regard to monitoring live bait catch when the spawning biomass is less than or equal to 50,000 mtons. Unless adoption of Options 1L-3L is accompanied by an incidental catch allowance for anchovies in other fisheries, the possibility of substituting other baits for anchovies when anchovy biomass is low would be very limited. This is because anchovy are taken incidentally during fishing for other species that might be used as bait. In the absence of an incidental catch allowance, the harvest of other species for bait may be restricted as well.

Monitoring and enforcing incidental harvest would be difficult, since it would require sampling of catches that are alive and highly motile. Accurate estimation of incidental take may not be possible without causing some mortality to the fish in baitwells and receivers.

ES.5 Absence of Bilateral Management Agreement

Although the central subpopulation of northern anchovy is a transboundary stock, there is no bilateral agreement between the U.S. and Mexico regarding its management. The FMP addresses the issue of unilateral management by specifying OY for the stock as a whole, then allocating 70% of it to the U.S. and 30% to Mexico. The allocation formula is based on the observation that 70% of anchovy larvae (and presumably, the spawning biomass) during 1951-1975 were found in U.S. waters. Because Mexico is not bound by this formula, it is possible that combined U.S. and Mexican harvests will exceed OY in some years. This may have the effect of decreasing the stock level and total OY in subsequent years.

ES.6 Recommended Options

ES.6.1 Reduction Optimum Yield Formula

Of the three reduction OY formulas considered, the Council recommends adoption of the Unconditional Option (i.e., a reduction OY of 7000 mtons when the spawning biomass is less than or equal to 307,000 mtons). This option is the least restrictive on the reduction fishery, but is not expected to adversely affect the anchovy stock.

ES.6.2 Definition of Overfishing

The Council recommends that the No-Lower-Cutoff Option for the definition of overfishing be adopted. The basis for this recommendation is that: 1) low levels of spawning biomass are unlikely to occur, 2) harvests by the reduction and non-reduction fisheries (including live bait) are expected to be modest when spawning biomass levels are low, 3) modest levels of harvest at low levels of spawning biomass are not expected to significantly affect the stock's ability to recover from low levels of biomass, and 4) potential economic and logistic problems are associated with implementation of a lower cutoff.

1.0 CONTENTS AND SPECIAL INDEXES

1.1 TABLE OF CONTENTS

1.2 INDEX FOR USE IN ENVIRONMENTAL ASSESSMENT

1.3 INDEX FOR USE AS REGULATORY IMPACT REVIEW

1.4 DEFINITIONS OF ACRONYMS

CalCOFI - California Cooperative Oceanic Fisheries Investigations

CDFG - California Department of Fish and Game

EA - Environmental Assessment

RIR - Regulatory Impact Review

EEZ - Exclusive Economic Zone

EPM - Egg Production Method

FMP - Fishery Management Plan

IRFA - Initial Regulatory Flexibility Analysis

MFCMA - Magnuson Fishery Conservation and Management Act

NOAA - National Oceanic and Atmospheric Administration

OY - Optimum yield

PFMC - Pacific Fishery Management Council

2.0 Introduction

2.1 Geographic Range and Relationship to Marine Ecosystem

The population of northern anchovy (*Engraulis mordax*) is distributed from the Queen Charlotte Islands, British Columbia to Magdalena Bay, Baja California. The population is divided into northern, central and southern subpopulations. The central subpopulation, which is the management unit of the Northern Anchovy Fishery Management Plan, ranges from approximately San Francisco, California to Punta Baja, Baja California. The bulk of the central subpopulation is located in the Southern California Bight, an approximate 20,000 square nautical mile area bounded by Point Conception, California in the north and Point Descanso, Mexico in the south. The subpopulation is harvested by both U.S. and Mexican fisheries.

The anchovy is subject to natural predation throughout all of its life stages: egg, larval, juvenile, adult. Anchovy eggs and larvae, as part of the zooplankton complex, fall prey to an assortment of invertebrate and vertebrate planktivores, including adult anchovies. As juveniles in nearshore areas, anchovies are vulnerable to a variety of predators, including some recreationally and commercially important species of fish.

As adults offshore, anchovies are fed upon by numerous marine fishes (some of which have recreational and commercial value), mammals, and birds (including the endangered California brown pelican *Pelecanus occidentalis californicus*). Anderson *et.al.* (1980) and Anderson *et.al.* (1982) document a link between brown pelican breeding success and anchovy abundance. In general, however, very little is known about the actual quantities of anchovy consumed or the percentage of anchovies in predator diets relative to other forage species.

2.2 History of Northern Anchovy Fishery Management Plan

The Pacific Fishery Management Council (PFMC) initiated the development of a Fishery Management Plan (FMP) for northern anchovy in January of 1977. A final draft of the Plan was approved and submitted to the Secretary of Commerce in June of 1978. Regulations implementing the FMP were published in the Federal Register on September 13, 1978. Subsequently, the Council has considered five amendments to the FMP.

2.2.1 Amendment 1

The first amendment changed the method of specifying the domestic annual harvest and added a requirement for an estimate of domestic processing capacity and expected annual level of domestic processing. Approval for this amendment was published in the Federal Register on July 18, 1979.

2.2.2 Amendment 2

The second amendment, which became effective on February 5, 1982, was published in the Federal Register on January 6, 1982. The purpose of this amendment was to increase the domestic fishing fleet's opportunity to harvest the entire optimum yield from the U.S. Exclusive Economic Zone (EEZ). This was to be accomplished by reallocating all or part of the northern area reduction quota reserve if the northern fishery had not harvested or demonstrated an intent to harvest the full reserve by the end of the fishing season.

2.2.3 Amendment 3

During the spring of 1982, the Council considered a third amendment that divided the quota into two halves and made release of the second half conditional on the results of a mid-season review of the status of the stock. The methods proposed for the mid-season assessment were considered too complex to implement, and the amendment was not approved.

2.2.4 Amendment 4

The fourth amendment, which had two clauses, was published in the Federal Register on August 2, 1983 and became effective on August 13, 1983. The first clause abolished the 5-inch size limit in the commercial fishery and established a minimum mesh size of 5/8 inch. The mesh size requirement did not become effective until April 1986 in order to give the fleet additional time to comply without undue economic hardship. The second clause established a mid-season quota evaluation that was simpler in design than the method proposed in Amendment 3. The annual quota was split in half. The first half would be allocated at the beginning of the season. The second half would be allocated unless available evidence indicated that its harvest would reduce the following year's spawning biomass below the level of one million short tons.

2.2.5 Amendment 5

The fifth amendment incorporated advances in scientific information concerning the size and potential yield of the central subpopulation of northern anchovy. When the original FMP was developed, scientists had estimated that the subpopulation ranged up to about 3.6 million mtons (four million short tons) and could support an average annual catch of about 454,000 mtons (500,000 short tons). These estimates were based on the larva census method of stock assessment. New estimates, based upon an egg production method of assessment, were developed and showed that the population has a maximum size of only about 2.5 million mtons and a maximum average yield of about 340,000 mtons per year. Since annual fishery catch quotas are based upon measurements of population size, the FMP had to be revised to incorporate optimum yield formulas consistent with the new scientific assessments.

In addition, the fifth amendment included changes to a variety of other management measures. Two or more alternative actions were considered in each of seven general categories: 1) optimum yield and harvest quotas, 2) season closures, 3) area closures, 4) quota allocation between areas, 5) the reduction quota reserve, 6) minimum fish size or mesh size, and 7) foreign fishing and joint venture regulations. The alternatives for the fifth amendment were reviewed by the PFMC during 1983. The final rule, on the fifth amendment measures adopted, was published in the Federal Register on March 14, 1984.

2.3 Current Management Regulations

2.3.1 Reduction Quota

The reduction quota from the central subpopulation of northern anchovies is equal to: 1) zero, if the estimated spawning biomass is less than or equal to 300,000 mtons, and 2) 100% of the spawning biomass above 300,000 mtons, up to a limit of 200,000 mtons, if the spawning biomass is greater than 300,000 mtons.

2.3.2 U.S.-Mexico Optimum Yield Allocation

The overall harvest quota in the U.S. EEZ is equal to 70% of the total OY.

2.3.3 Non-Reduction Allocation

There is no numeric limit on live-bait catch, and 7,000 mtons are reserved for other non-reduction uses (e.g., dead bait and animal food).

2.3.4 Geographic Allocation of Reduction Quota

A portion of the U.S. reduction quota equal to the smaller of 9,072 mtons or 10% of the quota is reserved for the fishery north of Point Buchon, but may be reallocated on June 1 if necessary.

2.3.5 Reduction Fishing Seasons

The seasons are August 1-June 30 in the northern area and September 15-June 30 in the southern area.

2.3.6 Area Closures

Certain portions of the EEZ are closed to anchovy reduction fishing (Figure 1).

2.3.7 Mesh Restrictions

Nets used in the reduction fishery must have a minimum wet mesh size of 5/8 inch.

2.4 History of the Fishery

2.4.1 Early History: 1916-1964

Reliable records of U.S. landings of northern anchovy date from 1916 (Table 2.3-1). Anchovy landings during 1916-1921 averaged 458 mtons per year and were used largely for reduction to meal and oil. In 1919 a law was passed prohibiting the reduction of whole fish except by permit. Landings fell after the law was passed and averaged only 144 mtons per year during 1922-1938. During 1939-1946, landings averaged 1,319 mtons per year.

Scarcity of Pacific sardine caused processors to begin canning anchovies in quantity during 1947, when landings increased to 8,591 mtons. In order to lower the quantity of anchovies being reduced, the California Fish and Game Commission required each processor to can a large proportion of the harvest (40-60% depending on can size). Anchovy landings declined with the temporary resurgence of sardine landings through 1951. Following the collapse of the sardine fishery in 1952, anchovy landings increased to 38,935 mtons in 1953. Anchovy landings declined to 5,263 mtons by 1958, largely as a result of low consumer demand for canned anchovy and increased sardine landings. Landings remained below 3,500 mtons per year through 1964.

Live bait catch is distinguished from other uses of anchovy by the fact that it is not landed. Transactions between buyers and sellers of live bait take place either at sea or from receivers that are tied up at dock. The anchovy live bait catch, which was 1,364 mtons in 1939, dropped to zero during the World War II years. It increased to 3,469 mtons in 1950 and has ranged from 3,729 to 6,178 mtons per year from 1951 to 1964 (Table 2.3-1).

During the early years of the fishery (1916-1964), anchovy was harvested almost exclusively by U.S. fishermen. Mexico did not begin harvesting anchovy until 1962 (Table 2.3-1).

2.4.2 Recent History: 1965-1988

Beginning in 1965, the California Fish and Game Commission managed the U.S. fishery on the basis of a reduction quota, and separate reduction and non-reduction landings statistics have been kept ever since. Although Table 2.3-1 describes landings on the basis of calendar years, it should be noted that both state and federal regulations established since 1965 have pertained to fishing seasons that extend from July 1 through June 30.

2.4.2.1 U.S. Reduction Fishery

In recent years, northern anchovy have been harvested for reduction by a fleet of approximately forty small purse seine vessels known collectively as the "wetfish" fleet. The fleet also fishes for Pacific mackerel (*Scomber japonicus*), jack mackerel (*Trachurus symmetricus*), Pacific bonito (*Sarda chiliensis*), bluefin tuna (*Thunnus thynnus*), market squid (*Loligo opalescens*) and Pacific sardine (*Sardinops sagax*). Market squid have been the dominant components of the wetfish catch in recent years, while landings of northern anchovy have been insignificant (Thomson et.al., 1989, Table 1).

Reduction landings increased from 155 mtons in 1965 to 24,810 mtons in 1966. They ranged from 12,515 mtons per year to 84,328 mtons per year during 1966-1972. Landings increased to 118,432 mtons in 1973 and ranged from 73,400 mtons per year to 141,586 mtons per year during 1973-1977. In response to decreases in fish meal prices, landings declined to an annual average of 46,500 mtons during 1979-1982. Reduction landings have been extremely low since 1983, largely as a result of low ex-vessel prices rather than low anchovy abundance (Thomson et.al. 1989).

2.4.2.2 U.S. Non-Reduction Fishery

The non-reduction fleet consists of approximately eighteen boats that are distributed along the California coast to service the principal sportfishing markets conveniently. Sixteen of the boats operate in southern California (six in the San Diego area alone). Sixteen of the boats derive most of their revenue from live bait, although they may also fish anchovy for other non-reduction uses (largely dead bait and pet food). The remaining two boats fish largely for non-reduction uses other than live bait. A handful of other vessels occasionally target on anchovies when their preferred target species is not available or land anchovies incidentally with other species. However, these vessels derive only a small proportion of their income from anchovies and are not considered to be part of the non-reduction fleet.

Two types of gear are used in the non-reduction fishery: 1) the lampara net, which is set in shallow waters and cannot be used effectively in deeper water offshore; and 2) the more versatile drum seine, which can be set in deep as well as shallow water, and can be used to harvest mackerel as well as anchovies. The drum seine is of more recent origin, and six boats in the non-reduction fleet currently use this gear.

The live bait boats fish for a variety of species other than anchovy, such as squid, sardine, mackerel, white croaker and queenfish. Anchovies, however, comprise approximately 85% of the live bait catch. From 1965 to 1988, the anchovy live bait catch ranged from 3,572 to 6,978 mtons per year and averaged 5,244 mtons annually (Table 2.3-1).

Other anchovy non-reduction landings (which include harvests for non-reduction uses other than live bait) averaged about 1,973 mtons per year from 1965 to 1988. Since 1985, non-reduction landings have exceeded reduction landings. This has been due to a dramatic decline in reduction landings rather than to any increase in non-reduction landings (which have actually been lower than average since 1985).

2.4.2.3 Mexican Reduction Fishery

Anchovy landed in Mexico are used primarily for reduction, although a small amount may be taken for use as bait. Table 2.3-1 describes landings by the Mexican fleet at Ensenada, Baja California. Ensenada is more than 60 miles north of Punta Baja, which is the northern boundary of the southern subpopulation.

While the bulk of the Ensenada landings comes from the central subpopulation, a small but unknown proportion probably also comes from the southern subpopulation.

Mexico's harvesting and processing capacity increased significantly in the late 1970's, due to the addition of several large seiners to the fishing fleet and the construction of a large reduction plant in Ensenada. Mexican landings reached a high of 258,700 mtons in 1981, fell to 178,000 mtons in 1982, and have ranged from 79,000 mtons to 124,000 mtons per year since 1983 (Table 2.3-1). Mexican landings have surpassed U.S. landings in every year since 1977 and have comprised more than 90% of total landings since 1983.

3.0 Issues and Need for Amendment

3.1 Reduction Quota at Low Levels of Spawning Biomass

The spawning biomass of anchovy during February of 1989 was estimated to be 214,000 mtons. By contrast, total biomass during February was estimated to be 1,008,000 mtons. The unusually large discrepancy between spawning and total biomass estimates (Table 3.1-1) has been attributed to the effect of unusually cold water temperatures during the peak spawning period on the sexual maturity of one-year-old fish (Jacobson and Lo 1989).

Currently, the FMP requires that the anchovy reduction fishery be closed when the spawning biomass falls below 300,000 mtons. Because of the high level of total biomass, however, the Council's Scientific and Statistical Committee concluded that a modest domestic reduction fishery during the 1989/90 season would produce no significant adverse effect on anchovy abundance. Therefore, the Council requested and the Department of Commerce approved an emergency rule allowing a domestic reduction harvest of 5,000 mtons in the 1989/90 season. The rule, which was to be effective from September 25, 1989 to December 23, 1989, was published in the Federal Register on September 29, 1989. An extension was later granted until March 23, 1990.

The Council followed up on this emergency rule by considering an amendment to the FMP that would allow a small reduction fishery when the spawning biomass falls below the current 300,000 mton threshold.

3.2 Definition of Overfishing

3.2.1 Revision of Guidelines for National Standard 1

National Standard 1 of the Magnuson Fishery Conservation and Management Act (MFCMA) states that "Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry." Revision of the guidelines for National Standard 1 was precipitated, in part, by recommendations from the NOAA Fishery Management Study (June, 1986). A series of workshops, draft revisions, and public comment periods followed, resulting in publication of the final rule in the Federal Register on July 24, 1989, effective August 23, 1989.

In order to assure that the Councils give appropriate consideration to long-term reproductive potential of fish stocks, the revised guidelines require each existing and future FMP to specify, to the maximum extent possible, an objective and measurable definition of overfishing, with an explanation of how the definition was determined and how it relates to biological potential. The intended effect of the revised guidelines is to assure that the long-term reproductive capacity of managed stocks is not jeopardized, that depleted stocks are rebuilt, and that the possibility for economically viable future harvests is maintained on a continuing basis.

The guidelines require that a definition of overfishing be prepared as an amendment to all existing FMP's and submitted to the Secretary of Commerce on or before November 23, 1990. The Council decided to address this requirement at the same time as the amendment to allow a small reduction fishery when the spawning biomass falls below 300,000 mtons.

3.2.2 Consistency of Current FMP with National Standard 1

This section provides background information regarding the current Anchovy FMP, as it relates to National Standard 1 of the MFCMA. Because the anchovy population is both a major forage stock and a commercial resource, the OY formula in the current FMP includes a threshold level of spawning biomass (300,000 mtons) at or below which only fishing for live bait and other non-reduction uses are allowed. Live bait harvests are not regulated but are modest in amount, the average for the nine seasons beginning with

1979/80 being 4,078 mtons. Harvests for other non-reduction uses are limited to 7,000 mtons per fishing season but have typically been much less than this, averaging 1,188 mtons for the nine seasons beginning with 1979/80 (Table 3.2-1).

The biological rationale for this threshold is to prevent depletion of the resource and to provide an adequate forage reserve for marine fishes, mammals, and birds. Implicit in this approach is the judgment that relatively small catches can be allowed when the spawning biomass is below 300,000 mtons without significantly affecting the resource's long-term reproductive potential (PFMC, 1983, Section 9.3.1).

In 1983 the Council considered and rejected cutoffs for all fishing at spawning biomass levels of 90,700 mtons and 20,000 mtons. An initial preference for the 20,000 mton minimum was reconsidered and rejected by the PFMC after discussions indicated that: 1) low levels of abundance are difficult to measure, 2) specification of incidental catch allowances in other fisheries would have become necessary, and 3) the stock has recovered from such low levels in the early 1950's despite a small fishery at the time (PFMC, 1983, Section 10.2.2)(see Table 3.1-1).

3.3 Trans-boundary Considerations

An important consideration in establishing a management regime for northern anchovy is inclusion of all major fishing operations under one management program. In fact, the MFCMA requires that a fishery resource be managed as a unit stock throughout its range.

At the present time, Mexico and the United States do not have an effective means of managing stocks, like anchovy, that are present in the coastal zones of both nations. Consequently, Mexico harvests northern anchovy from the central subpopulation independently of management regulations established in the U.S. under the MFCMA.

The current anchovy FMP addresses the issue of unilateral management of this trans-boundary stock by specifying OY for the stock as a whole, and then allocating 70% of it to the U.S. and 30% to Mexico. The allocation formula is based on the observation that 70% of anchovy larvae (and presumably, the spawning biomass) during 1951-1975 were found in U.S. waters (PFMC, 1983, Section 4.1.2). This approach will continue if the plan is amended to provide a small reduction fishery when the spawning biomass is below 300,000 mtons. For example, if OY for the reduction fishery is 7,000 mtons, then 4,900 mtons (70%) will be allocated to the U.S. reduction fishery and 2,100 mtons (30%) will be allocated to the Mexican reduction fishery.

Mexican harvests have been significant in recent years and have exceeded U.S. catches in every year since 1977 (Table 2.3-1). In the absence of an agreement with Mexico, it is possible that the total catch by Mexico and the U.S. during some years will exceed OY. This may have the effect of decreasing the stock level and total OY in subsequent years.

4.0 Management Alternatives

The Council developed three reduction quota options and two overfishing options that represent a range of possible actions.

4.1 Reduction Quota at Low Levels of Spawning Biomass

4.1.1 Specification of Options

The options pertaining to the reduction OY formula are as follows:

4.1.1.1 Status Quo (Option 1)

The Status Quo (Option 1) involves no modification to the current FMP and OY formulas. Under this option, the reduction OY is 1) zero when the spawning biomass is less than or equal to 300,000 mtons, and 2) the difference between the spawning biomass and 300,000 mtons, up to a limit of 200,000 mtons, when the spawning biomass is greater than 300,000 mtons.

4.1.1.2 Unconditional Option (Option 2)

Option 2 is the Unconditional Option. Under this option, the reduction OY is 1) 7,000 mtons when the spawning biomass is less than or equal to 307,000 mtons, and 2) the difference between the spawning biomass and 300,000 mtons when the spawning biomass is greater than 307,000 mtons.

4.1.1.3 Conditional Option (Option 3)

Under the Conditional Option (Option 3), the reduction OY depends on the level of total biomass as well as spawning biomass. Under this option, when the total biomass is greater than or equal to 375,000 mtons, the reduction OY is 1) 7,000 mtons if the spawning biomass is less than or equal to 307,000 mtons, and 2) the difference between the spawning biomass and 300,000 mtons, up to a maximum of 200,000 mtons, if the spawning biomass is greater than 307,000 mtons. When the total biomass is less than 375,000 mtons, the reduction OY is 1) zero if the spawning biomass is less than or equal to 300,000 mtons, and 2) the difference between the spawning biomass and 300,000 mtons, up to a maximum of 200,000 mtons, if the spawning biomass is greater than 300,000 mtons.

4.1.2 Clarification of Options

The Status Quo (Option 1) closes the reduction fishery when the spawning biomass is less than or equal to 300,000 mtons. However, use of a 300,000 mton cutoff level for the other options would have produced some anomalous results. For instance, specification of a 300,000 mton cutoff under the Unconditional Option (Option 2) would cause the reduction fishery to receive a 1,000 mton quota if the spawning biomass were 301,000 mtons, but a 7,000 mton OY if the spawning biomass were 299,000 mtons. By setting the cut-off at 307,000 mtons for this option, the reduction fishery is allowed to take 7,000 mtons at all spawning biomass levels less than or equal to 307,000 mtons.

The rationale for selecting a total biomass cutoff level of 375,000 mtons under the Conditional Option (Option 3) is that spawning biomass can be regarded as a poor measure of total biomass when the fraction spawning is less than 80% of the total (i.e., 375,000 mtons x 0.80 = 300,000 mtons, the original cutoff value). Note also that when total biomass is greater than or equal to 375,000 mtons, reduction quotas under the Conditional Option depend on whether the spawning biomass falls above or below 307,000 mtons. When total biomass is less than 375,000 mtons, however, reduction quotas under this option depend on whether the spawning biomass falls above or below 300,000 mtons. The reason for this asymmetry is that specification of a 307,000 mton spawning biomass threshold when total biomass falls below 375,000 mtons would cause the Conditional Option to close the reduction fishery when the spawning biomass falls between 300,000 mtons and 307,000 mtons. This would restrict the reduction fishery more than the Status Quo, which allows a small fishery within this range of spawning biomass. In other words, it would cause the Conditional Option to be inconsistent with a major purpose of the amendment, which is to reduce restrictions on the reduction fishery.

The Status Quo (Option 1) closes the reduction fishery when the spawning biomass is less than or equal to 300,000 mtons, while the Unconditional Option (Option 2) provides a 7,000 mton reduction OY when the spawning biomass is less than or equal to 307,000 mtons. The Conditional Option (Option 3) specifies that when the total biomass is greater than or equal to 375,000 mtons, the reduction OY is determined in the manner of the Unconditional Option. When the total biomass is less than 375,000 mtons, the reduction OY is determined in the manner of the Status Quo. Thus, the Conditional Option is a hybrid version of the other two options. It is less restrictive than the Status Quo but more restrictive than the Unconditional Option.

4.2 Definition of Overfishing

4.2.1 Specification of Options

During the preparation of Amendment 5 to the anchovy FMP, the Council considered and rejected the possibility of disallowing all harvests at low levels of spawning biomass (see Section 3.2.2). This amendment reconsiders the pros and cons of setting such a lower limit in view of the revised guidelines for National Standard 1. To this end, the Council has developed two options pertaining to the definition of overfishing.

4.2.1.1 No-Lower-Cutoff Option

The No-Lower-Cutoff Option defines overfishing as any harvest in excess of OY, where OY is determined according to the harvest formula in the FMP. This definition is consistent with the view that the OY formula provides adequate protection against overfishing.

The effect of the No-Lower-Cutoff Option on the reduction fishery at low levels of abundance will depend on which reduction OY option is chosen. If the Status Quo is chosen, the No-Lower-Cutoff Option will disallow all reduction fishing when the spawning biomass is less than or equal to 300,000 mtons. If the Unconditional Option is chosen, it will allow a 7,000 mton reduction harvest when the spawning biomass is less than or equal to 307,000 mtons. If the Conditional Option is chosen, it will 1) disallow all reduction fishing when the spawning biomass is less than or equal to 300,000 mtons and total biomass is less than 375,000 mtons, and 2) allow a 7,000 mton reduction harvest when the spawning biomass is less than or equal to 307,000 mtons and total biomass is greater than or equal to 375,000 mtons.

Regardless of which reduction OY option is chosen, the No-Lower-Cutoff Option allows unlimited live bait harvest and a 7,000 mton quota for other non-reduction uses, independent of the level of spawning biomass. It should be noted that U.S. live bait and other non-reduction harvests are typically modest, averaging 4,078 mtons and 1,188 mtons respectively over the nine seasons beginning with 1979/80 (Table 3.2-1).

4.2.1.2 Lower-Cutoff Option

The Lower-Cutoff Option defines overfishing 1) in the same manner as the No-Lower-Cutoff Option when the spawning biomass is greater than or equal to 50,000 mtons, and 2) as harvests of any kind when the spawning biomass falls below 50,000 mtons. This option disallows all fishing (for reduction, live bait and other non-reduction uses) at levels of spawning biomass less than 50,000 mtons.

4.2.2 Consistency with Revised National Standard 1

Both of the overfishing options are consistent with the revised guidelines for National Standard 1 in the following respects:

1) Both options provide an objective and measurable standard for defining overfishing. For the No-Lower-Cutoff Option, the standard takes the form of an objective and measurable threshold level of spawning biomass (300,000 mtons under the current reduction OY

formula, or 307,000 mtons if the reduction OY formula is amended), at and below which only modest harvests are allowed. For the Lower-Cutoff Option, this standard takes the form of an objective and measurable interval of spawning biomass (50,000-300,000 mtons) within which modest harvests are allowed and a level of spawning biomass (50,000 mtons) below which all harvests are disallowed. Both options allow for the monitoring and evaluation of the stock relative to the threshold level on an annual basis.

2) The analysis of both options is based on modelling of long-term reproductive capability.

3) Both options allow for a program to rebuild the stock when it becomes depleted. For the No-Lower-Cutoff Option, the program involves restriction of U.S. harvests to modest levels when the spawning biomass is less than or equal to 300,000 mtons. For the Lower-Cutoff Option, the program involves restriction of U.S. harvests to modest specified levels when the spawning biomass falls in the interval 50,000-300,000 mtons and disallowance of all U.S. harvests when the spawning biomass falls below 50,000 mtons.

4.3 Combining Reduction Quota Options with Overfishing Options

4.3.1 Specification of Options

The three reduction quota options presented in Section 4.1.1 and the two overfishing options presented in Section 4.2.1 were combined to yield six total options for consideration by the Council.

Combinations of the reduction quota options with the Lower-Cutoff option for overfishing were accomplished by eliminating all harvests when the spawning biomass falls below 50,000 mtons. These combined options are referred to as Options 1L-3L in Table 4.3-1, and are illustrated in Figure 2.

Combinations of the reduction quota options with the No-Lower-Cutoff option were accomplished by allowing harvests when the spawning biomass falls below 50,000 mtons according to the appropriate OY formula. These combined options are referred to as Options 1-3 in Table 4.3-1, and are illustrated in Figure 3.

4.3.2 Consideration of Mexican Harvest

The Council has no influence on Mexican harvests in the absence of a bilateral agreement. Therefore, 70% of the reduction and non-reduction OY's specified under each of the options in Table 4.3-1 is allocated to U.S. fishermen. This is the same approach to unilateral management used in the current FMP.

5.0 Environmental Assessment (EA)/Regulatory Impact Review (RIR)/Initial Regulatory Flexibility Analysis (IRFA)

This section consists of an Environmental Assessment (EA), Regulatory Impact Review (RIR) and Initial Regulatory Flexibility Analysis (IRFA). It was prepared in accordance with the requirements of Executive Order 12291, the National Environmental Policy Act, the Regulatory Flexibility Act, and the Paperwork Reduction Act. This analysis compares the management options summarized in Table 4.3-1 on the basis of the following criteria:

1) The biological impact on the northern anchovy population and brown pelican reproductive success.

2) Economic impacts on harvesters, processors and consumers of northern anchovy.

3) The costs incurred by the government in order to implement each option.

4) Monitoring and enforcement costs incurred by State governmental units that oversee compliance.

5) Compliance costs and recordkeeping requirements imposed on small businesses (i.e., vessel operators and fish processors).

5.0.1 The Simulation Model

The effects of each of the six options on the anchovy stock and the reduction fishery were evaluated using a simulation model which is described in Jacobson and Thomson (1989). The model assumes that profits to fishermen depend on anchovy abundance (measured as catch-per-unit-effort in units of mtons/hour), reduction and non-reduction harvests (mtons), operating costs ($/hour), and ex-vessel prices for anchovy ($/mton). It was assumed that fishermen take the entire reduction quota if fishing is profitable and that no fishing takes place when fishing is not profitable. The reduction, live bait and other non-reduction fisheries were considered separately in the model.

Operating costs for the reduction, nonreduction and live bait fisheries were estimated to be $288.29/hour. This figure was obtained by converting the figure for reduction fishery costs used in the current FMP (PFMC, 1983, Section 6.4) to 1988 dollars by correcting for inflation. No data concerning operating costs in the live bait and non-reduction fisheries were available.

Ex-vessel prices for the live bait, nonreduction and reduction fisheries were estimated to be $681/mton, $287/mton and $79/mton, respectively. The ex-vessel price for live bait was obtained by converting the figure used in the current FMP (PFMC, 1983, Section 3.5.1.1) to 1988 dollars by correcting for inflation. The non-reduction ex-vessel price used in the model is the mean of ex-vessel prices (converted to 1988 dollars) paid during 1980-1988 (Table 5.0-1). The reduction fishery ex-vessel price used in the model is the price paid during 1981 (the most recent season in which U.S. reduction landings exceeded 50,000 mtons), converted to 1988 dollars (Table 5.0-2). The value used ($79/mton) is about 2.5 times greater than the price actually paid during 1988 ($32/mton). This relatively high price was used in order to exaggerate the potential effects of the various options on harvest of the anchovy stock.

Live bait catches in the model were 4,078 mtons per season and nonreduction landings were 1,188 mtons per season. These values are the average of live bait and non-reduction harvests for the nine seasons beginning in 1979/80 (Table 3.2-1).

Table 5.0-3 describes the simulation results for each of the six options in terms of total biomass, reduction catch and profit, fishery closures, and reproductive success of the endangered California brown pelican (Pelecanus occidentalis californicus). The relationship between brown pelican breeding success and anchovy abundance used in the simulation model is documented in Jacobson and Thomson (1989).

5.1 Biological Impacts

According to Table 5.0-3, the biological impacts, measured in terms of total biomass and brown pelican breeding success, are the same for all of the six options considered. Mean total biomass is 840,000 mtons and mean pelican breeding success is 0.99 fledglings per breeding pair per season for each option.

The apparently small biological impact of modest reduction and non-reduction harvests at low levels of abundance can be attributed to several factors:

1) Even if reduction harvests are allowed when the spawning biomass is less than or equal to 300,000 mtons (as they are under Options 2 and 3 and, to a lesser

extent, Options 2L and 3L), such harvests are not likely to occur. A simple economic analysis based on the model used in the simulations suggests that reduction fishing becomes unprofitable at low levels of biomass, i.e., that economic constraints tend to protect the stock from overfishing by the reduction fleet. This result is discussed in greater detail in Section 5.2.

2) Unlike the reduction fishery, the non-reduction fishery is likely to be active even at very low levels of abundance. However, because spawning biomass levels below 50,000 mtons occurred very infrequently in the course of the simulations (Table 5.0-3), the effect of non-reduction harvests at low levels of biomass is not well represented in the overall results.

An alternative way to analyze the biological impact of non-reduction harvests is to compare the time required for the stock to recover from a low level of spawning biomass (e.g., 25,000 mtons) to a higher level (e.g., 300,000 mtons) when non-reduction harvests are and are not allowed. To accomplish this, a modified version of the simulation model was rerun for Options 1 and 1L. The spawning biomass at the beginning of each simulation was set at 25,000 mtons. The number of years required for the stock to reach a spawning biomass of 300,000 mtons (the "recovery time") was recorded. Five hundred thousand individual simulation runs were done for each of the two options. Mean time to recovery was 7.9 years with the lower-level cutoff and 8.6 years without it, a difference of 0.7 years. In other words, the mean recovery time with the cutoff was 0.7 years less, on average, than the mean recovery time without the cutoff.

The simulation model suggests that the benefits of a cutoff for all fishing may be small and that the population may be quite resilient to the effects of modest fishing pressure at low levels of abundance. This result is supported by historical data, which indicate that the stock was able to rebound from low levels of abundance in the mid-1950's (Table 3.1-1), despite annual harvests of 25,000 to 30,000 mtons (Table 2.4-1).

It should be noted, however, that the parameters in the simulation model were estimated from data for 1964-1985, which were medium to high biomass years (Jacobson and Thomson 1989). Thus, the estimates of mean recovery times from low levels of spawning biomass are extrapolations and possibly unreliable. The true difference in mean recovery times with and without a 50,000 mton cutoff may be larger.

5.2 Socioeconomic Impacts

5.2.1 U.S. Reduction Fishery

A very small fraction of the fishmeal supply in the U.S. is derived from northern anchovy (Table 5.2-1). Even in 1975, when anchovy meal production peaked at 25.1 mtons, anchovy comprised only 10% of total U.S. production and 7% of total U.S. supply. Given the modest market position of anchovy meal relative to other fishmeals and the very small changes in reduction harvest proposed in this amendment, none of the options considered in this amendment is expected to have a significant effect on domestic fishmeal prices and availability. All further discussion of reduction fishery impacts will focus on California harvesters and processors.

The simulation results in Table 5.0-3 indicate that there are no differences among options in terms of catch or profit for local harvesters. Mean annual catch is 150,000 mtons and mean annual profit is 3.7 million dollars for all options. It should be noted that these catch and profit estimates are much higher than the values historically experienced in the reduction fishery. The reason for this disparity is that the simulation model incorporates two unrealistic assumptions, in order to exaggerate the effect of the fishery on the stock: 1) that the fishermen take the entire OY when fishing is profitable, and 2) that the ex-vessel reduction price is $79 per mton.

In actuality, anchovy is only one of several species targetted by the U.S. reduction fleet (see Section 2.4.2.1). Because anchovy commands a lower ex-vessel price than any of these other species, the fleet is more likely to target on it when other species are not available, and is unlikely to exhaust the reduction quota in most years (Thomson et.al. 1989). Also, the ex-vessel reduction price used in the model is considerably higher than the prices actually experienced since 1981 (Table 5.0-2), so the model exaggerates the number of years in which fishing is profitable.

Table 5.0-3 also describes the frequency and duration of no-fishing intervals under each of the options. According to the simulation model, reduction fishing would cease completely in 15% of all years under Options 1/1L and 11% of all years under Options 2/2L and 3/3L. Reduction fishing closures of one or more years in duration would occur about nine times every hundred years under Options 1/1L and about six times every hundred years under Options 2/2L and 3/3L. The mean length of closures would be about two years for all options.

An important distinction is whether cessation of fishing occurs as a result of FMP-mandated closures at low levels of spawning biomass or because prevailing ex-vessel prices and costs make fishing unprofitable. According to the simulation model, FMP-mandated closures would occur in 13% of all years under Options 1/1L, 0% of all years under Options 2/2L, and 9% of all years under Options 3/3L (Table 5.0-3). However, fishing would be unprofitable in 11% of all years under each of the options. These results suggest that the reduction fleet generally would not find it profitable to fish at low levels of spawning biomass even if fishing were allowed by the FMP. Lack of profit appears to be a more binding constraint on reduction fishing than FMP-mandated closures.

Figure 4 illustrates this point by describing the "breakeven" price associated with different levels of total biomass. The breakeven price is the ex-vessel price that reduction fishermen would have to receive in order to cover their operating costs at a specified level of total biomass. At the $79 ex-vessel price assumed in the simulation model, fishing is profitable at total biomass levels of 350,000 mtons and higher. In recent years ex-vessel prices have been much lower than $79 per mton and landings have also been low (Table 5.0-2). The relationship depicted in Figure 4 reinforces the common perception that the low reduction landings in recent years have been due to low ex-vessel prices rather than availability of anchovy.

The general picture that emerges from this analysis is that economic factors tend to protect the stock from overfishing by the reduction fleet. It should be remembered, however, that the results obtained here depend on the biological and economic structure of the model. In particular, the results depend heavily on assumptions about reduction ex-vessel prices, the relationship between fishing costs and anchovy abundance, and the behavior of the Mexican fleet. The probability that Options 2 and 3 could contribute to stock depletion would increase if ex-vessel prices should exceed historical levels, if fishing costs do not increase as anchovy abundance decreases, and/or if the combined U.S.-Mexican harvest should exceed OY.

5.2.2 U.S. Non-Reduction Fishery

The non-reduction fishing fleet described in Section 2.4.2.2 supplies live and dead bait to an economically significant recreational fishery in California. According to results from the Marine Recreational Fishery Statistics Survey, about eight million marine recreational fishing trips are made in California each year (Table 5.2-2). This figure underestimates the true level of fishing activity, since it does not include 1) trips targetted at salmon or striped bass, and 2) partyboat and private boat trips that originate in the U.S. but fish in Mexican waters. About 93% of all trips in the recreational fishery are undertaken by California residents. For this reason, all further discussion concerning impacts on the non-reduction fishery will be limited to impacts within California.

Unlike Options 1-3, Options 1L-3L disallow all non-reduction harvests when the spawning biomass falls below 50,000 mtons. Spawning biomass levels this low have occurred rarely (only twice since 1954, according to Table 3.1-1). However, the impact on the non-reduction fleet and on the recreational fishery of closing the non-reduction fishery at low levels of spawning biomass is potentially significant.

Juvenile anchovies tend to concentrate in shallow shelf areas and bays. Because they are likely to be accessible to the bait boats and because demand and ex-vessel prices for bait are likely to be strong, the non-reduction fleet (unlike the reduction fleet) may find it profitable to harvest anchovies even when abundance is low.

Most of the major species targetted by recreational anglers (kelp/sand bass, rockfishes, bonito, barracuda, yellowtail, and tunas) feed on a variety of species, such as squid, jack mackerel and sardines, as well as anchovies. Because of the presence of these other sources of food, it is likely that species targetted by the recreational fishery will continue to be available when anchovy biomass is low. Therefore, the demand for bait cannot be expected to diminish significantly in years of low anchovy abundance.

Live anchovies are generally the bait of choice for anglers targetting on kelp/sand bass, white seabass, bonito, barracuda, yellowtail, and tunas. Live/dead anchovies are the principal bait for rockfish anglers. These target species comprise approximately 75%-90% of total partyboat landings (Table 5.2-3) and probably an equally large proportion of private boat landings. Given this heavy reliance on anchovy for bait, closure of the anchovy non-reduction fishery could have a very significant impact on bait fleet revenues and on the recreational fishery. Some of this impact may be mitigated, depending on the availability and acceptability of bait substitutes.

For partyboat and private anglers who target on rockfish and for shore-based anglers in general, baits such as live/dead squid and frozen herring could be substituted for anchovy. Substitution of other baits could result in a decline in participation by rockfish anglers, however, because rockfish catch rates tend to be higher with live anchovy than with other baits. Substitution possibilities are more limited for anglers targetting on the pelagic species. Live squid is a viable bait substitute for some target species; squid, however, are available during December-April but not during the peak summer fishing season. Live sardines are a good substitute, but their availability is very limited at this time.

On the basis of information indicating that the spawning biomass of Pacific sardines had exceeded 20,000 short tons, the State of California lifted its eighteen-year moratorium on Pacific sardine catches in 1986. During each of the years 1986-1990, the State has allowed an annual sardine quota for directed fishing of 1,000 short tons. The State also allows an annual live bait quota of 318 mtons (350 short tons) and a dead bait quota of 227 mtons (250 short tons). By comparison, anchovy live bait catch has averaged 4,078 mtons and dead bait catch has averaged 1,188 mtons over the nine seasons beginning in 1979/80 (Table 3.2-1). Whether the sardine live and dead bait quotas would be sufficiently high to meet the demand for bait in years of low anchovy abundance is unknown, since the extent and timetable for sardine recovery is highly uncertain at this time.

Implementation of any of the Lower-Cutoff options (Options 1L, 2L or 3L) will require specification of an allowable incidental take of anchovy with other bait species when the spawning biomass falls below 50,000 mtons. Given that some co-mingling of anchovies with sardines can be expected, a 0% allowable incidental take of anchovies would likely preclude substitution of sardines for anchovies as live bait. Substitution possibilities are likely to increase at higher allowable levels of incidental take.

To summarize, the economic impacts of Options 1-3 and Options 1L-3L are expected to be similar, except in those (occasional) years when the spawning biomass falls below 50,000 mtons. In low biomass years, Options 1L-3L are expected to have an adverse economic impact on the bait fleet and on the recreational fishery that it supports. This impact may be lessened, depending on 1) the allowable incidental take of anchovies with other species, and 2) the availability of sardines and other species as bait substitutes. However, the timetable for recovery of the sardine population is highly uncertain at this time.

5.3 Implementation Costs

In order to be implemented, each of the six options being considered requires that spawning biomass (and total biomass, in the case of Options 3 and 3L) be estimated on an annual basis. Currently, biomass is estimated by the egg production method (EPM)(Lasker 1985) or an equivalent technique, such as the Stock Synthesis Model (Methot 1989). The last EPM survey was done in 1985. Since that time, estimates of abundance have been obtained using the Stock Synthesis Model calibrated to the 1985 EPM estimate, as well as egg production data from annual surveys and age composition data from the Mexican reduction fishery.

The choice between an EPM estimate and a Stock Synthesis estimate involves a trade-off between cost and precision. The cost of obtaining an EPM estimate is approximately $600,000. This includes vessel operation and equipment aboard ship and in laboratories, and computer time and labor for data collection, data management and analysis. A Stock Synthesis estimate provides lower precision than an EPM estimate but can be obtained for less than $10,000. A Stock Synthesis estimate does not require dedicated vessel time, since the samples can be obtained at an insignificant marginal cost during regularly scheduled ocean surveys sponsored by California Cooperative Oceanic Fisheries Investigations (CalCOFI). It also requires much less laboratory time, data management and analysis than an EPM estimate.

No EPM estimate has been conducted since 1985 because of: 1) the near absence of a reduction fishery in the U.S. in recent years, due to lack of profitability, and 2) the need to divert limited funds to assessment of other managed species.

Implementation costs, as reflected in the frequency of EPM estimation relative to Stock Synthesis estimation, are not expected to vary significantly among the options, for the following reasons:

> 1) As indicated by the simulation results in Table 5.0-3, lack of profitability is expected to close the reduction fishery in about 11% of all years for each of the six options being considered. Thus, to the extent that lack of profitability impacts the frequency of EPM estimates, no difference among options should be expected.
>
> 2) Fishery managers and the fishing industry will likely be especially aware of the need to monitor the stock when abundance is low. The conservation rationale for frequent EPM estimates at low levels of abundance may be particularly compelling under Options 1-3, which allow some harvests even at very low levels of abundance. On the other hand, there may be a compelling economic

rationale for frequent EPM estimates at low levels of abundance under Options 1L-3L, since even a small change in spawning biomass from below to above 50,000 mtons could have a major economic impact on the non-reduction fishery and on the recreational fishery that it supports. Thus the frequency and cost of EPM spawning biomass estimates would probably be similar under any of the proposed options.

5.4 Monitoring and Enforcement Costs

5.4.1 Reduction and Non-Reduction Fisheries (Other Than Live Bait)

Monitoring of reduction landings under the current FMP involves two activities: 1) tracking the amount of anchovy landed when the fishery is open, and 2) ensuring that no fishing takes place during periods of fishery closure. The State of California requires that processors report landings of all commercially harvested species to the California Department of Fish and Game (CDFG). The State imposes a "use tax" on all landings on the basis of receipts provided by the canneries. These same landings receipts are used to monitor anchovy reduction landings. CDFG also conducts dockside surveillance to ensure that no fishing occurs when the reduction fishery is closed. This surveillance is conducted as an adjunct to other CDFG activities (e.g., sampling of other species) which take place at the cannery docks.

The current FMP also requires monitoring of landings for non-reduction uses (other than live bait). Compliance with the non-reduction quota is monitored in the same manner as compliance with the reduction quota, i.e., via landings receipts.

All of the other options being considered impose limits on reduction and non-reduction landings similar to the Status Quo. Therefore, monitoring and enforcement costs for the reduction and non-reduction fisheries (other than live bait) are likely to be the same, regardless of which option is chosen.

5.4.2 Live Bait Fishery

Because the Status Quo (Option 1) imposes no restrictions on live bait catch, no monitoring of the live bait fishery is required. The same would be true for Options 2 and 3. However, Options 1L-3L impose additional responsibilities with regard to monitoring live bait catch when the spawning biomass falls below 50,000 mtons.

Unlike catches that are intended for other uses, live bait catches cannot be monitored via landings receipts because they are not landed. Live bait boats typically contract with partyboats to supply bait for a fraction of passenger fee revenues. Direct at-sea transactions between bait boats and partyboats sometimes occur as the partyboats are enroute to the fishing grounds. Live bait that is not sold in this manner is transferred to receivers that are tied up at dock. Bait contained in the receivers is sold to partyboats and also to anglers on privately owned boats.

Monitoring of live bait catches at low levels of spawning biomass could theoretically be accomplished by:

1) expanding the scope of current patrol boat activity by state wardens to monitor the contents of bait receivers and at-sea transactions between bait boats and partyboats; or

2) placing observers aboard live bait boats to monitor catches.

The operational feasibility of monitoring live bait catches is questionable, regardless of which approach is taken. As indicated in Section 5.2.2, there is likely to be considerable co-mingling of anchovies with other species in the nearshore areas fished by the bait fleet. If one of Options 1L-3L is adopted, it may be necessary to specify incidental catch allowances for anchovy taken during fishing for other species. Monitoring and enforcing incidental take allowances for the live bait fishery would be difficult, since it would require sampling of catches that are alive and highly motile. Accurate estimation of incidental take may not be possible without causing some mortality to the fish in baitwells and receivers (C. Cooney, California Department of Fish and Game, pers. comm.).

5.5 Compliance Costs and Record-Keeping Requirements

California state law requires processors and fishing vessels to obtain permits (free of charge) in order to engage in reduction fishing activities. Vessels that fish for reduction and non-reduction (other than live bait) purposes are required to provide processors with landings-related information, which is recorded on landings receipts for submission to the California Department of Fish and Game. This recordkeeping requirement would continue, even in the absence of the FMP, in order to satisfy ongoing state requirements for information about commercial landings.

The live bait fleet currently provides records on catch to the California Department of Fish and Game on a voluntary basis. None of the options considered in this amendment relies on these logbooks for any purpose, nor do they impose any other compliance or recordkeeping requirements on the live bait fishery.

6.0 Recommended Options

6.0.1 Reduction Harvest Formula

Of the three reduction OY formulas considered, the Council recommends adoption of the Unconditional Option (i.e., a reduction OY of 7000 mtons when the spawning biomass is less than or equal to 307,000 mtons). This option is the least restrictive on the reduction fishery, but is not expected to adversely affect the anchovy stock.

The simulation model that was used to analyze the effects of the three reduction OY options was designed to exaggerate the effect of the reduction fishery on the stock. In particular, it was assumed that 1) the fishermen take the entire OY when fishing is profitable, and 2) the ex-vessel reduction price is $79 per mton, which is considerably higher than the prices actually experienced since 1981 (Table 5.0-2). Despite these assumptions, no differences were detected in the effects of the three reduction

OY options on total biomass, brown pelican breeding success, and reduction catch and profit (Sections 5.1 and 5.2.1). The major reason for this result is that economic factors tend to protect the stock from overfishing by the reduction fleet at low levels of spawning biomass. Lack of profit appears to be a more binding constraint on reduction fishing than FMP-mandated closures.

6.0.2 Definition of Overfishing

The Council recommends that the No-Lower-Cutoff Option for the definition of overfishing be adopted. The basis for this recommendation is that: 1) low levels of spawning biomass are unlikely to occur, 2) harvests by the reduction and non-reduction fisheries (including live bait) are expected to be modest when spawning biomass levels are low, 3) modest levels of harvest at low levels of spawning biomass are not expected to significantly affect the stock's ability to recover from low levels of biomass, and 4) potential economic and logistic problems are associated with implementation of a lower cutoff.

Under the least restrictive option for amending the reduction OY formula (the Unconditional Option), only a modest reduction harvest (7,000 mtons) would be allowed at low levels of spawning biomass. Morever, even this level of harvest may not occur since reduction fishing is not expected to be profitable at low levels of abundance (Section 5.2.1). Records on live bait catch (going back to 1939) and on other non-reduction harvests (going back to 1965) indicate that non-reduction harvests have historically been modest, even in the absence of regulation (Table 2.3-1).

The modest reduction and non-reduction harvests that occur at low levels of spawning biomass are not expected to significantly affect the stock's ability to rebound from low levels of abundance. The simulation results indicate that time to recovery will not be significantly affected, regardless of whether or not a lower cutoff is imposed (Section 5.1). This conclusion is supported by historical data, which indicate that the stock was able to rebound from low levels of abundance in the mid-1950's (Table 3.1-1), despite annual harvests of 25,000 mtons to 30,000 mtons (Table 2.4-1).

Imposition of a lower cutoff on the live bait fishery would impose significant economic hardship on the recreational fishery in low biomass years (Section 5.2.2). It would also require that the incidental take of anchovy with other bait species be monitored. Accurate estimation of incidental take may not be possible without causing some mortality to the live catch contained in baitwells and receivers (Section 5.4.2).

7.0 Recommendations for Future Amendments

The Council recommends that the Anchovy FMP be reviewed when any of the following situations occurs:

1) A bilateral management agreement is reached with Mexico.

2) Fisheries develop or management plans are adopted for other California pelagic species which significantly affect the operation of, or value of, the anchovy fishery.

3) A substantial anchovy fishery develops for human consumption.

4) Scientifically documented information becomes available regarding:

a) adverse impact of the anchovy fishery on other species of animal or plant life, especially those listed as endangered or threatenened;

b) adverse impact of the commercial fishery on the abundance and/or availability of live bait and predator fish;

c) change in the anchovy population response to exploitation.

8.0 TABLES AND FIGURES

Table 2.3-1. Northern anchovy landings in California and Mexico during 1916-1988 (mtons). California landings constitute virtually all of the landings in the United States.*

	California Landings						
Year	Reductn	Non Red**	Total	Calif. Live Bait	Total Calif.	Total Mexico	Grand Total
1916	---	---	241	0	241	0	241
1917	---	---	239	0	239	0	239
1918	---	---	394	0	394	0	394
1919	---	---	730	0	730	0	730
1920	---	---	259	0	259	0	259
1921	---	---	883	0	883	0	883
1922	---	---	296	0	296	0	296
1923	---	---	140	0	140	0	140
1924	---	---	158	0	158	0	158
1925	---	---	42	0	42	0	42
1926	---	---	27	0	27	0	27
1927	---	---	167	0	167	0	167
1928	---	---	162	0	162	0	162
1929	---	---	173	0	173	0	173
1930	---	---	145	0	145	0	145
1931	---	---	140	0	140	0	140
1932	---	---	136	0	136	0	136
1933	---	---	144	0	144	0	144
1934	---	---	117	0	117	0	117
1935	---	---	82	0	82	0	82
1936	---	---	89	0	89	0	89
1937	---	---	103	0	103	0	103
1938	---	---	334	0	334	0	334
1939	---	---	974	1,364	2,338	0	2,338
1940	---	---	2,866	1,820	4,686	0	4,686
1941	---	---	1,862	1,435	3,297	0	3,297
1942	---	---	768	234	1,002	0	1,002
1943	---	---	712	0	712	0	712
1944	---	---	1,765	0	1,765	0	1,765
1945	---	---	733	0	733	0	733
1946	---	---	872	2,493	3,365	0	3,365
1947	---	---	8,591	2,589	11,180	0	11,180
1948	---	---	4,915	3,379	8,294	0	8,294
1949	---	---	1,510	2,542	4,052	0	4,052
1950	---	---	2,213	3,469	5,682	0	5,682
1951	---	---	3,154	4,665	7,819	0	7,819
1952	---	---	25,303	6,178	31,481	0	31,481
1953	---	---	38,935	5,798	44,733	0	44,733
1954	---	---	19,237	6,066	25,303	0	25,303
1955	---	---	20,272	5,557	25,829	0	25,829
1956	---	---	25,819	5,744	31,563	0	31,563
1957	---	---	18,392	3,729	22,121	0	22,121

1958	---	---	5,263	3,843	9,106	0	9,106
1959	---	---	3,254	4,297	7,551	0	7,551
1960	---	---	2,294	4,225	6,519	0	6,519
1961	---	---	3,498	5,364	8,862	0	8,862
1962	---	---	1,254	5,595	6,849	669	7,518
1963	---	---	2,073	4,030	6,103	944	7,047
1964	---	---	2,257	4,709	6,966	4,599	11,565
1965	155	2,446	2,601	5,645	8,246	9,171	17,417
1966	24,810	3,440	28,250	6,144	34,394	13,243	47,637
1967	29,346	2,229	31,575	4,898	36,473	20,104	56,577
1968	12,515	1,581	14,096	6,644	20,740	14,267	35,007
1969	59,153	2,209	61,362	4,891	66,253	3,871	70,124
1970	84,328	2,982	87,310	5,543	92,853	27,977	120,830
1971	39,601	1,089	40,690	5,794	46,484	20,079	66,563
1972	60,435	2,252	62,687	5,307	67,994	30,047	98,041
1973	118,432	1,895	120,327	5,639	125,966	15,424	141,390
1974	73,400	1,640	75,040	5,126	80,166	44,987	125,153
1975	141,586	2,214	143,800	5,577	149,377	56,877	206,254
1976	112,270	1,059	113,327	6,202	119,529	75,746	195,275
1977	99,674	1,457	101,131	6,410	107,541	142,575	250,116
1978	10,339	1,118	11,457	6,013	17,470	140,001	157,471
1979	47,408	5,836	53,244	5,364	58,608	204,585	263,193
1980	43,699	5,338	49,037	4,921	56,234	245,797	302,031
1981	51,290	246	51,536	4,698	56,234	258,700	314,934
1982	43,742	1,117	44,859	6,978	51,837	177,587	229,424
1983	2,854	1,446	4,300	4,187	8,487	79,389	87,876
1984	1,722	1,183	2,905	4,397	7,302	101,118	108,420
1985	825	1,184	2,009	3,775	5,784	121,081	126,865
1986	546	1,002	1,548	3,956	5,504	96,417	101,921
1987	149	1,154	1,303	3,572	4,875	124,475	129,350
1988	234	1,234	1,468	4,188	5,656	79,230	84,886

* Separate statistics on reduction and non-reduction landings in California are available beginning in 1965, when a separate reduction quota was first established.

** Includes anchovy used for canning, consumption as fresh fish, freezing and dead bait.

Sources:

1. Data for 1962-1974 Mexican landings from Chavez, H. et.al. 1977. The fishery for northern anchovy, *Engraulis mordax*, off California and Baja California in 1975. CalCOFI Rept. 19: 147-165.
2. Data for 1975-1988 Mexican landings from Larry Jacobson, pers. comm.
3. Data for 1916-1964 California reduction landings and 1939-1964 live bait catches from PFMC. 1983. Northern Anchovy Fishery Management, Tables 3.2-1 and 3.2-2.
4. Data for 1965-1988 California reduction, non-reduction and live bait harvests from Thomson, C. et.al. 1989. Status of the California Coastal Pelagic Fisheries in 1988. NMFS, SWFC Admin. Rep. LJ-89-14. Also previous issues of the same report.

Table 3.1-1. Total and spawning biomass of northern anchovy estimated with the stock synthesis model during 1954-1989 (mtons).

Year	Biomass on Feb. 15	
	Total	Spawning
1954	63,570	54,760
1955	53,610	37,920
1956	45,990	25,420
1957	153,920	141,160
1958	213,410	213,150
1959	182,370	182,160
1960	118,580	118,470
1961	170,820	160,900
1962	357,500	214,170
1963	563,040	520,210
1964	645,000	639,000
1965	723,000	528,000
1966	556,000	541,000
1967	385,000	368,000
1968	358,000	340,000
1969	357,000	335,000
1970	350,000	273,000
1971	628,000	264,000
1972	932,000	523,000
1973	1,362,000	1,335,000
1974	1,648,000	1,094,000
1975	1,400,000	1,204,000
1976	983,000	947,000
1977	787,000	786,000
1978	429,000	429,000
1979	828,000	544,000
1980	764,000	757,000
1981	772,000	736,000
1982	464,000	419,000
1983	550,000	533,000
1984	377,000	371,000
1985	681,000	532,000
1986	607,000	601,000
1987	594,000	583,000
1988	369,000	336,000
1989	1,008,000	237,000

Source: Data for 1954-1963 from Methot, R.D. 1989. Synthetic estimates of historical abundance and mortality for northern anchovy. In E. Vetter and B. Megrey, eds. Mathematical analysis of fish stock dynamics: reviews, evaluations and current applications. Am. Fish. Soc. Symp. Ser. No. 6. American Fisheries Society, Bethesda, MD.

Data for 1964-1988 from L. Jacobson, pers. comm. See also Jacobson, L.D. and N.C.H. Lo. 1989. Spawning biomass of the northern anchovy in 1989. NMFS, SWFC Admin. Rep. LJ-89-17, Figure 2.

Table 3.2-1. Northern anchovy nonreduction catch in California, by season and disposition of catch (mtons).*

Season	Live Bait	Other	Total
1979/80	4,036	1,241	5,277
1980/81	4,364	892	5,256
1981/82	4,629	866	5,495
1982/83	3,711	1,363	5,074
1983/84	4,487	1,493	5,980
1984/85	3,838	839	4,677
1985/86	4,180	1,521	5,701
1986/87	3,175	967	4,142
1987/88	4,283	1,511	5,794
1988/89	2,967**	647**	3,614

* Catches are reported to the California Department of Fish and Game via mandatory fish logs. Figures do not reflect actual catches to date because of some delinquent logs.

** Preliminary estimates reflecting catches through April 1989.

Source: Thomson, C. et.al. 1989. Status of the California Coastal Pelagic Fisheries in 1988. NMFS, SWFC Admin. Rep. LJ-89-14. Also previous issues of the same report.

Table 4.3-1. Summary of options. The maximum reduction OY for all options is 200,000 mtons. All figures expressed in mtons. Abbrevations "SB" used for spawning biomass and "TB" for total biomass.*

		Optimum Yield		
Option	Conditions	Reduction	Live Bait	Other Non-Red
Reduction quota options combined with Lower-Cutoff Option for overfishing:				
1L. Status Quo	SB<50K	0	0	0
	50K≤SB≤300K	0	Unlim	7K
	SB>300K	SB-300K	Unlim	7K
2L. Unconditional	SB<50K	0	0	0
	50K≤SB≤307K	7K	Unlim	7K
	SB>307K	SB-300K	Unlim	7K
3L. Conditional	TB≥375K and			
	SB<50K	0	0	0
	50K≤SB≤307K	7K	Unlim	7K
	SB>307K	SB-300K	Unlim	7K
	TB<375K and			
	SB<50K	0	0	0
	50K≤SB≤300K	0	Unlim	7K
	SB>300K	SB-300K	Unlim	7K
Reduction quota options combined with No-Lower-Cutoff Option for overfishing:				
1. Status Quo	SB≤300K	0	Unlim	7K
	SB>300K	SB-300K	Unlim	7K
2. Unconditional	SB≤307K	7K	Unlim	7K
	SB>307K	SB-300K	Unlim	7K
3. Conditional	TB≥375K and			
	SB≤307K	7K	Unlim	7K
	SB>307K	SB-300K	Unlim	7K
	TB<375K and			
	SB≤300K	0	Unlim	7K
	SB>300K	SB-300K	Unlim	7K

* Reduction and non-reduction quotas for U.S. fishermen are 70% of the figures shown for "Reduction" and "Other Non-Red" fishing.

Table 5.0-1. Ex-vessel prices (1988 $'s/mton) for anchovy taken by the U.S. nonreduction (excluding live bait) fishery during 1980-1988.

Year	Price
1980	$ 296
1981	97
1982	313
1983	246
1984	450
1985	518
1986	187
1987	184
1988	292

Source: Thomson, C. et.al. 1989. Status of the California Coastal Pelagic Fisheries in 1988. NMFS, SWFC Admin. Rep. LJ-89-14. Also previous issues of the same report.

Table 5.0-2. U.S. reduction landings (mtons) and ex-vessel prices (1988 $'s/mton) for northern anchovy during 1974-1988

Year	U.S. Reduction Landings	Price
1974	73,401	$99
1975	141,586	68
1976	112,270	76
1977	99,674	92
1978	10,339	87
1979	47,408	77
1980	43,699	79
1981	51,290	79
1982	43,742	51
1983	2,854	46
1984	1,722	37
1985	825	33
1986	546	29
1987	149	28
1988	234	32

Source: Thomson, C. et.al. 1989. Status of the California Coastal Pelagic Fisheries in 1988. NMFS, SWFC Admin. Rep. LJ-89-14. Also previous issues of the same report.

Table 5.0-3. Results of simulation analyses.

	Options		
	1,1L StatQuo	2,2L Uncond	3,3L Cond
Total biomass (million mt)			
Mean	0.84	0.84	0.84
Standard deviation	0.46	0.46	0.46
Coefficient of variation	54%	54%	54%
Reduction catch (million mt)			
Mean	0.15	0.15	0.15
Standard deviation	0.077	0.077	0.077
Coefficient of variation	51%	51%	51%
Reduction profit (million $)			
Mean	3.7	3.7	3.7
Standard deviation	2.6	2.6	2.6
Coefficient of variation	70%	70%	70%
Brown pelican breeding success (fledglings/pair)			
Mean	0.99	0.99	0.99
Standard deviation	0.14	0.14	0.14
Coefficient of variation	15%	15%	15%
Intervals with no reduction landings			
% of years	15%	11%	11%
Mean number per 100 years	9.2	5.9	6.1
Mean length of intervals	1.7	1.9	1.9
Intervals with no reduction landings due to no quota			
% of years	13%	0%	9%
Mean number per 100 years	8.3	0.0	5.0
Mean length of intervals	1.6	0.0	1.8
Intervals with no reduction landings due to no potential profit			
% of years	11%	11%	11%
Mean number per 100 years	5.9	5.9	5.9
Mean length of intervals	1.9	1.9	1.9
Percent of years when spawning biomass ≤ criteria levels			
Criteria level			
300K mtons	13.0%	13.0%	13.0%
200K mtons	4.3%	4.3%	4.3%
100K mtons	0.5%	0.5%	0.5%
90K mtons	0.4%	0.4%	0.4%
80K mtons	0.2%	0.2%	0.2%
70K mtons	0.1%	0.1%	0.1%
60K mtons	0.0%	0.0%	0.0%

Table 5.2-1. Production, imports, exports and total supply of fishmeal in the U.S. during 1960-1988 (thousands of mtons).

	Domestic Production					
Year	Anchovy	Other*	Total	Imports	Exports	Supply
1960	0.0	263.2	263.2	119.7	---	382.9
1961	0.0	282.4	282.4	197.6	---	480.0
1962	0.0	283.3	283.3	228.9	---	512.2
1963	0.0	232.2	232.2	341.4	---	573.5
1964	0.0	213.5	213.5	398.3	---	611.8
1965	0.0	230.5	230.5	245.6	---	476.1
1966	4.1	199.3	203.4	406.2	---	609.6
1967	5.1	186.5	191.6	591.0	---	782.6
1968	2.5	210.8	213.3	233.1	---	446.3
1969	10.3	218.9	229.2	143.3	---	372.6
1970	14.7	229.5	244.2	105.1	4.3	345.1
1971	7.0	258.6	265.6	256.9	9.2	513.4
1972	10.1	248.9	259.0	355.6	9.4	605.2
1973	20.0	233.2	253.2	62.1	33.3	282.0
1974	12.8	251.8	264.6	62.0	50.3	276.2
1975	25.1	228.3	253.4	107.4	10.7	350.1
1976	20.1	251.2	271.3	127.4	30.0	368.6
1977	17.3	231.1	248.4	73.9	32.7	289.6
1978	1.9	319.0	320.9	39.8	46.0	314.7
1979	9.0	320.2	329.2	81.3	14.2	396.3
1980	7.1	315.2	322.3	44.9	77.4	289.8
1981	9.3	272.0	281.3	53.9	42.6	292.6
1982	7.3	323.1	330.4	76.5	16.2	390.6
1983	0.5	338.5	339.0	61.6	70.2	330.4
1984	0.0	334.7	334.7	75.7	18.3	392.0
1985	0.0	319.6	319.6	231.6	31.4	519.8
1986	0.0	308.1	308.1	168.1	34.9	441.3
1987	0.0	349.6	349.6	178.6	46.9	481.4
1988	0.0	283.5	283.5	120.4	111.8	292.1

* Consists largely of menhaden meal produced on the Atlantic and Gulf coasts and modest amounts of tuna-mackerel meal.

Source: Bureau of Commercial Fisheries. 1960-1970. Fishery statistics of the United States.

National Marine Fisheries Service. 1971-1988. Fisheries of the United States.

Table 5.2-2. Estimated number of recreational fishing trips in California by fishing mode (thousands of trips) and percentage by out-of-state residents during 1981-1987.*

Year	Shore	Party/ Charter	Private/ Rental	Total	% by Out-of-State Residents
1981	3,748	1,429	2,775	7,952	6.8%
1982	3,483	2,274	2,546	8,302	8.1%
1983	3,613	1,629	2,893	8,135	7.4%
1984	3,742	1,349	3,199	8,292	6.9%
1985	3,438	1,378	2,989	7,804	7.2%
1986	3,539	1,538	3,801	8,876	7.0%
1987**	2,835	1,073	3,695	7,604	6.0%

* Excludes trips targetted on salmon and striped bass and all boat trips that originated in the U.S. but fished in Mexican waters.

** Preliminary estimates.

Source: National Marine Fisheries Service. 1981-1986. Marine Recreational Fishery Statistics Survey, Pacific coast. Current Fishery Statistics 8323, 8325, 8328, 8393.

J. Witzig, National Marine Fisheries Service, Washington, D.C., pers. comm. for 1987 estimates.

Table 5.2-3. Reported catch by California commercial passenger fishing vessels by species group during 1970-1988 (thousands of fish)*

Year	Bass	Bonito & Barracuda	Tuna	Rockfish	Other	Total
1970	927	1,026	99	2,726	853	5,631
1971	953	203	45	2,286	1,117	4,604
1972	847	457	147	3,159	852	5,462
1973	663	565	236	3,651	808	5,923
1974	622	197	140	4,125	607	5,691
1975	503	107	105	4,005	634	5,354
1976	658	305	116	3,678	392	5,149
1977	400	211	106	3,263	869	4,849
1978	477	389	149	3,021	1,220	5,256
1979	463	606	87	3,789	1,705	6,647
1980	586	588	81	3,412	1,741	6,408
1981	740	724	121	3,381	1,348	6,315
1982	587	292	77	3,139	1,275	5,371
1983	463	430	417	2,377	938	4,625
1984	360	465	349	2,040	959	4,172
1985	572	196	227	2,064	1,090	4,150
1986	702	429	78	1,828	1,038	4,075
1987	735	675	90	1,742	861	4,103
1988	773	399	91	1,959	1,104	4,326

* "Bass" includes kelp/sand bass and white sea bass.
"Tuna" includes albacore/bluefin/skipjack/yellowfin tuna and yellowtail.
"Rockfish" includes rockfish and lingcod.

Source: California Department of Fish and Game. 1970-1988. Report of fish caught by the California commercial passenger fishing vessel fleet.

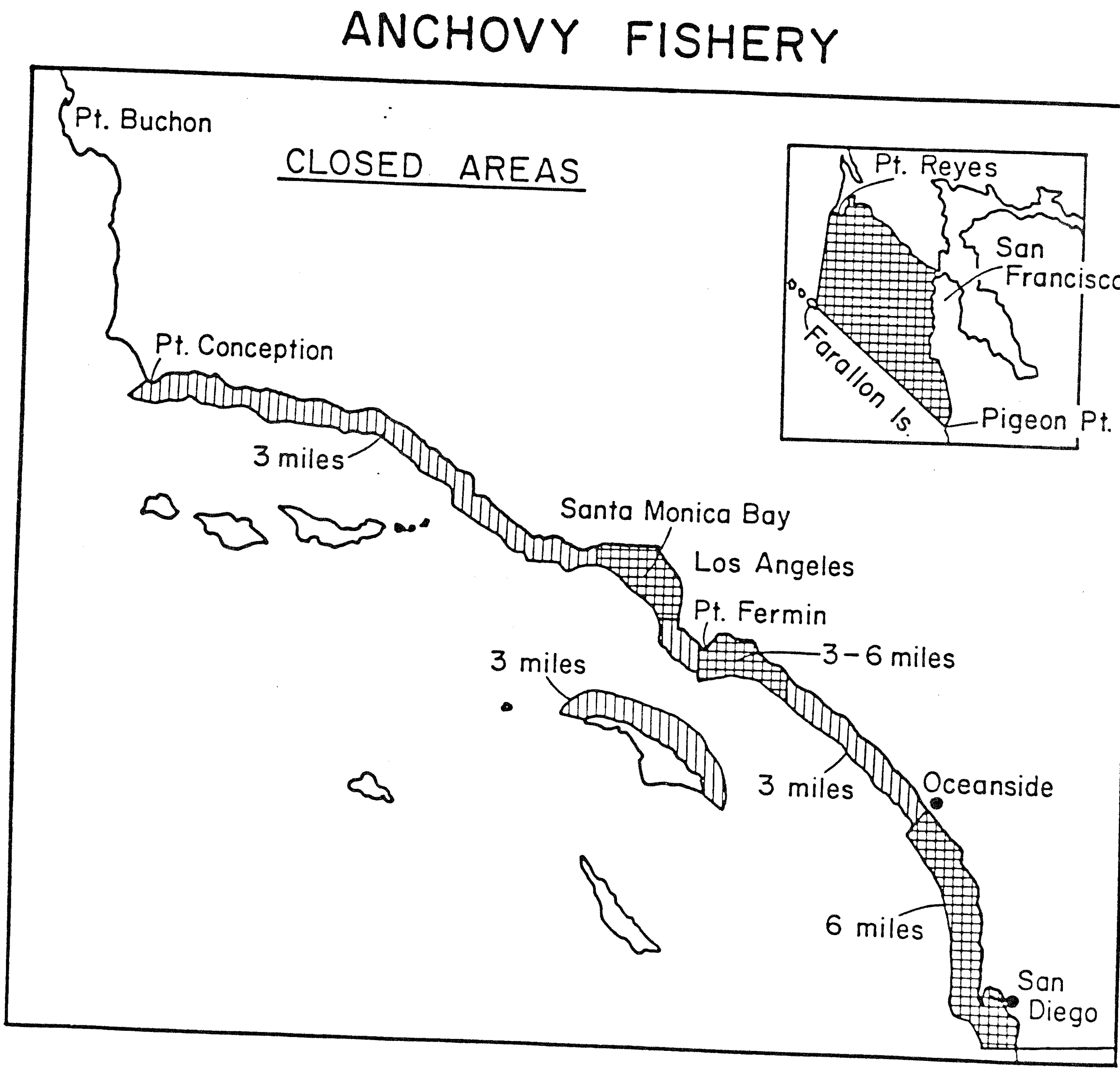

FIGURE 1. AREAS CLOSED TO ANCHOVY REDUCTION FISHING

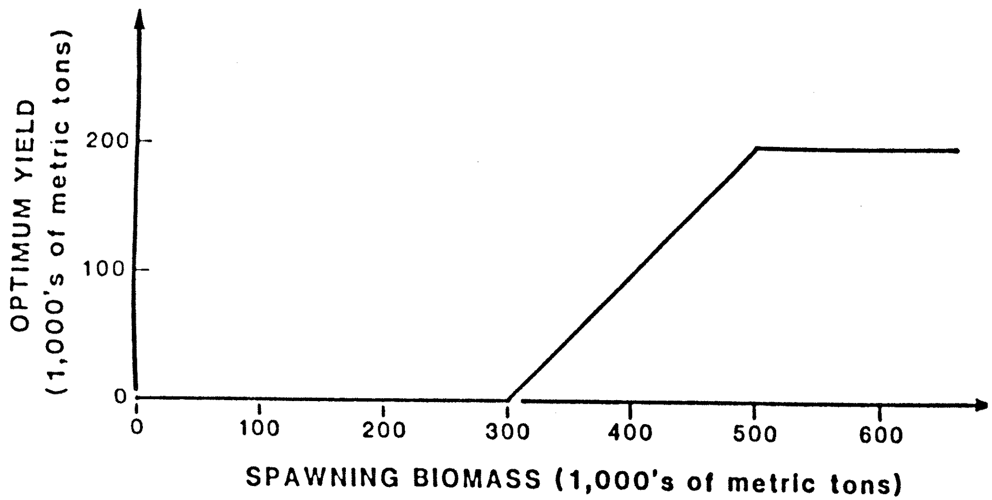

Figure 2a. Status Quo Option with Lower-Cutoff (Option 1L)

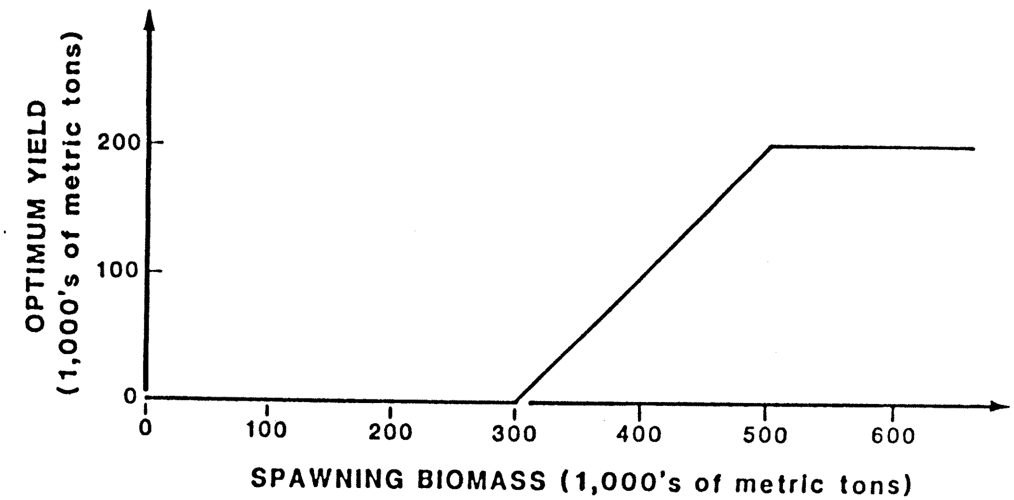

Figure 2c. Conditional Option with Lower-Cutoff when Total Biomass<375,000 MT (Option 3L)

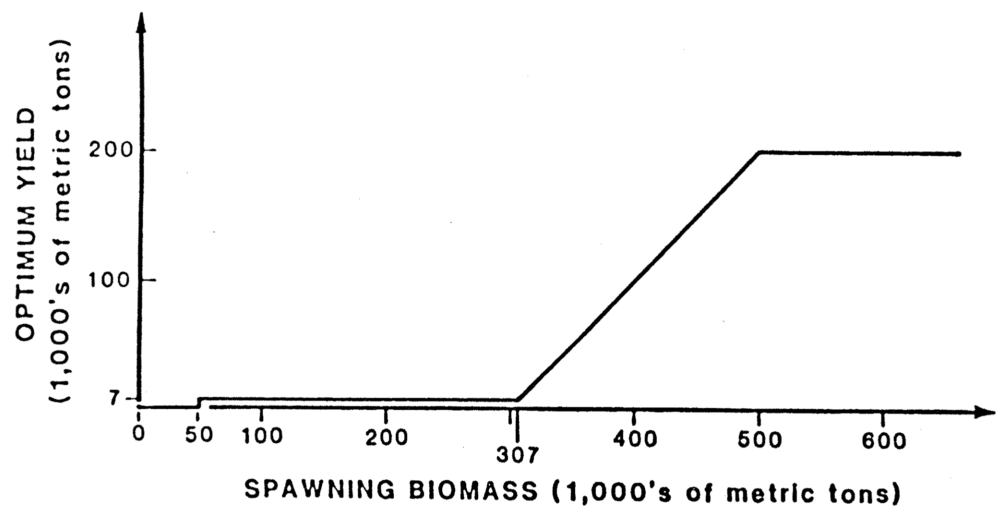

Figure 2b. Unconditional Option with Lower-Cutoff (Option 2L)

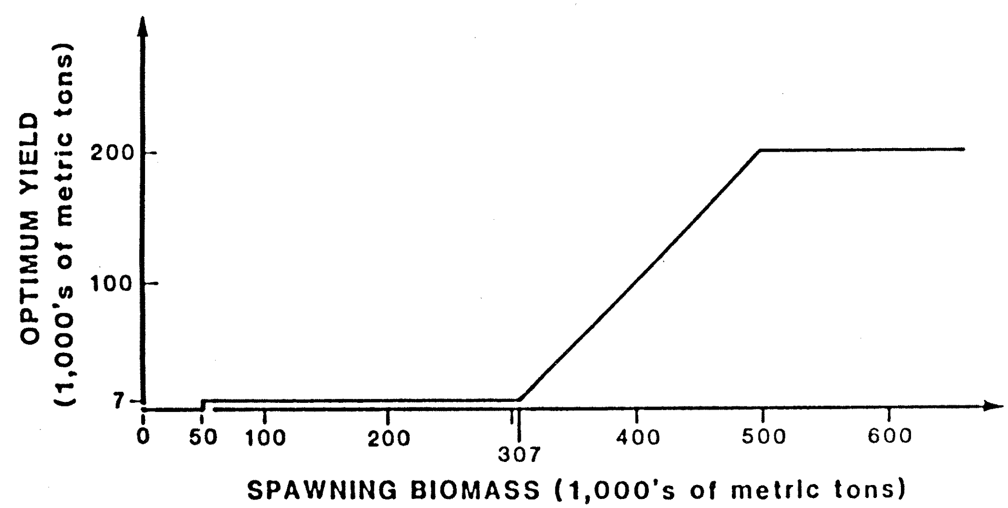

Figure 2c'. Conditional Option with Lower-Cutoff when Total Biomass≥375,000 MT (Option 3L)

FIGURE 2. REDUCTION OPTIMUM YIELD FORMULAE ASSOCIATED WITH OPTIONS 1L-3L.

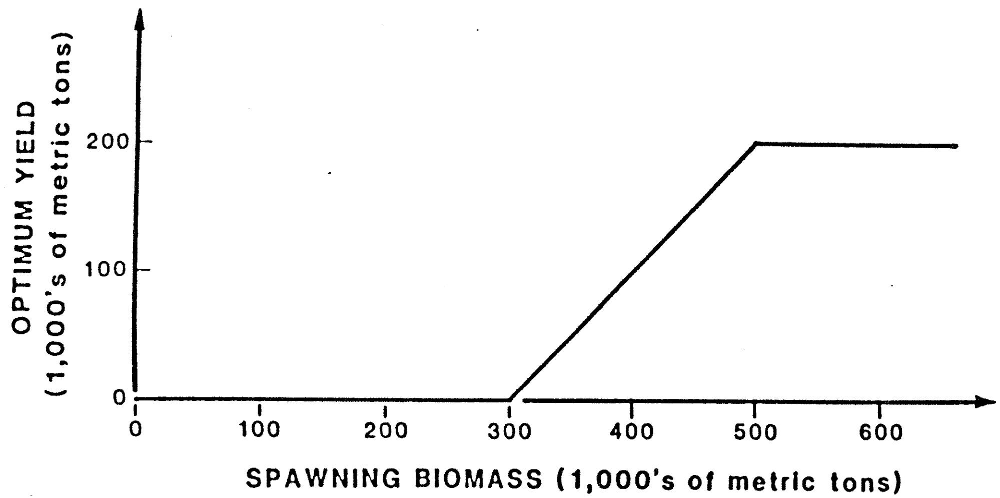

Figure 3a. Status Quo Option with No-Lower-Cutoff (Option 1)

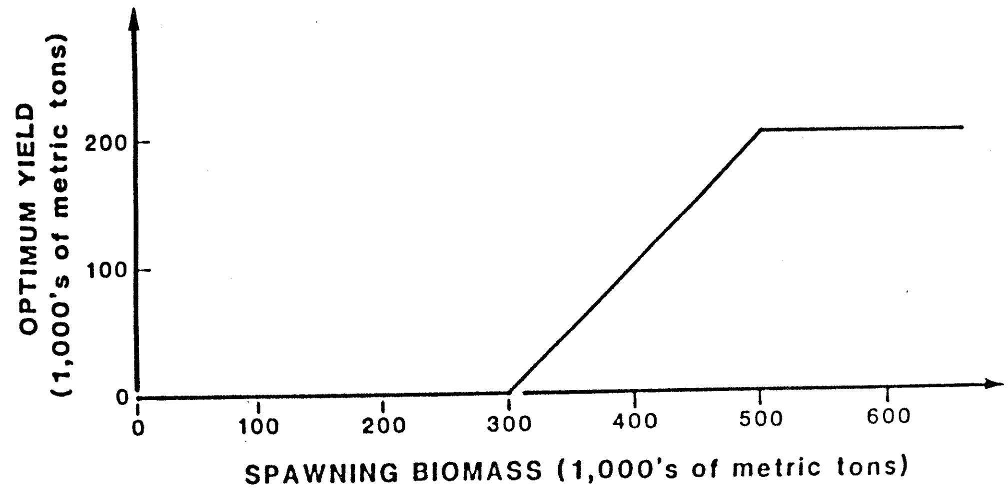

Figure 3c. Conditional Option with No-Lower-Cutoff when Total Biomass<375,000 MT (Option 3)

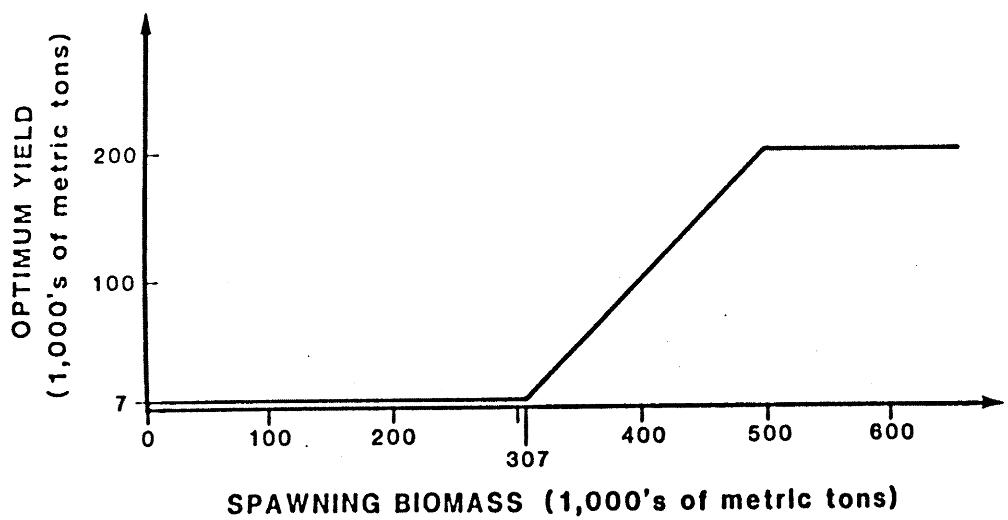

Figure 3b. Unconditional Option with No-Lower-Cutoff (Option 2)

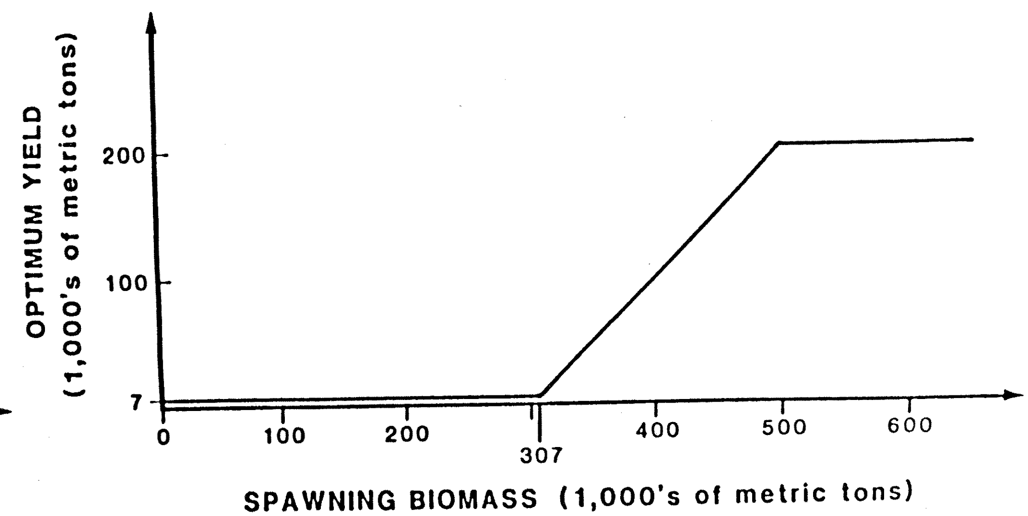

Figure 3c'. Conditional Option with No-Lower-Cutoff when Total Biomass≥375,000 MT (Option 3)

FIGURE 3. REDUCTION OPTIMUM YIELD FORMULAE ASSOCIATED WITH OPTIONS 1-3.

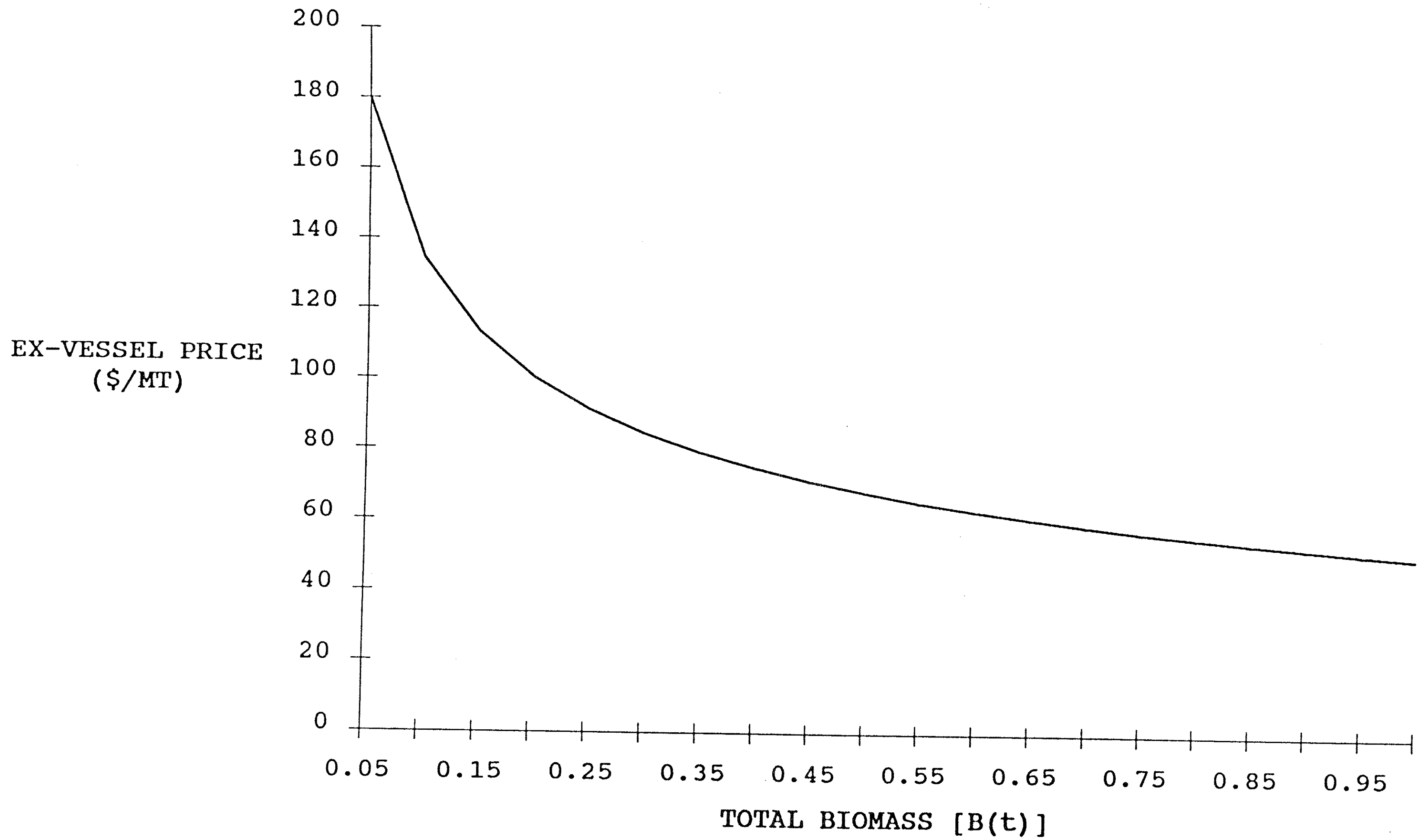

FIGURE 4. RELATIONSHIP BETWEEN BREAKEVEN EX-VESSEL PRICE AND TOTAL BIOMASS

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PACIFIC FISHERY MANAGEMENT COUNCIL

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August 28, 1990

Dear Reviewer:

At their July 1990 meeting, the Pacific Fishery Management Council (Council) approved a revised draft of Amendment 6 to the Northern Anchovy Fishery Management Plan (FMP) for public review and comment. This amendment would revise the optimum yield (OY) formula to allow a small reduction fishery when the spawning biomass falls below 300,000 metric tons (mt) and would define overfishing as (a) any harvest in excess of OY, where OY is determined according to the harvest formula in the FMP, when spawning biomass during either the current or preceding season was greater than or equal to 50,000 mt, and (b) as harvest of any kind when the spawning biomass during the current and preceding season was less than 50,000 mt. All fisheries (reduction, live bait and other non-reduction) will be closed in the second season when spawning biomass falls below 50,000 mt for two consecutive seasons, and the closure continues until the spawning biomass equals or exceeds 50,000 mt. The earlier draft stated that the Council preferred the overfishing definition with no lower cutoff. In July, the Council reconsidered this issue and adopted the 50,000 mt/2 year threshold option.

The Council intends to take final action on the proposed amendment at its September 19–21, 1990 meeting in Carmel, California. In preparation for the proposed action, the Council has prepared a draft Environmental Assessment, Regulatory Impact Review, and Initial Regulatory Flexibility Analysis. This document is provided for your review, and written comments on the document will be accepted until **September 14, 1990**. There will be an opportunity to present oral comments directly to the Council at the September 19–21 meeting at the Carmel Mission Inn in Carmel, California.

Please send written comments to the Pacific Fishery Management Council, 2000 SW First Avenue, Suite 420, Portland, Oregon 97201. Additional copies are also available at this address.

Sincerely,

Lawrence D. Six

Lawrence D. Six
Executive Director

JWG