Section 8

GULF OF ALASKA NORTHERN ROCKFISH

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8.0 Executive Summary

The northern rockfish assessment is now reported separately from other members of the slope rockfish complex. For northern rockfish, the age-structured model from last year's SAFE is recommended for this year. There are no changes in the model from last year's SAFE. The model was updated to include the 2003 survey biomass estimate, catch from 2002, preliminary catch for 2003, survey age composition from 2001, fishery age composition from 2003, and fishery length composition from 2003. Based on this model the recommended ABC is 4,874 mt. The corresponding reference values for northern rockfish recommended for this year are summarized in the following:

$B_{40\%}$ (mt)	23,929
B_{2004} (mt)	36,482
$F_{40\%}$	0.057
F_{ABC} (maximum allowable)	0.057
ABC (mt, maximum allowable)	4,874

This ABC is the maximum allowable ABC under tier 3. There is considerable uncertainty in the survey biomass estimates for Gulf of Alaska northern rockfish and consequently precaution is warranted for the management of this stock.

Response to SSC Comments

There were no comments from the SSC specifically directed towards the GOA northern rockfish assessment in last year's SAFE.

8.1 INTRODUCTION

8.1.1 General Distribution

The northern rockfish, *Sebastes polyspinis*, is a locally abundant and commercially valuable member of its genus in Alaskan waters. As implied by its common name, northern rockfish has one of the most northerly distributions among the 60+ species of *Sebastes* in the north Pacific Ocean. It ranges from extreme northern British Columbia around the northern Pacific Rim to eastern Kamchatka and the northern Kurile Islands and also north into the eastern Bering Sea (Allen and Smith 1988). Within this range, northern rockfish are most abundant in Alaska waters, from the western end of the Aleutian Islands to Portlock Bank in the central Gulf of Alaska to (Clausen and Heifetz 2004). Northern rockfish are managed separately in the Gulf of Alaska and Aleutian Islands.

8.1.2 GOA Management Units

Since 1988 the North Pacific Fishery Management Council (NPFMC) has managed northern rockfish in the Gulf of Alaska as part of the slope rockfish assemblage. In 1991, the NPFMC divided the slope rockfish assemblage in the Gulf of Alaska into three management subgroups: Pacific ocean perch, shortraker/rougheye rockfish, and all other species of slope rockfish. In 1993, a fourth management subgroup, northern rockfish, was also created. These subgroups were established to protect Pacific ocean perch, shortraker/rougheye, and northern rockfish (the four most sought-after commercial species in the assemblage) from possible overfishing. Each subgroup is now assigned an individual ABC (acceptable biological catch) and TAC (total allowable catch), whereas prior to 1991, an ABC and TAC was assigned to the entire assemblage. ABC and TAC for each subgroup, including northern rockfish, is apportioned to the three management areas of the Gulf of Alaska (Western, Central, and Eastern) based on the average distribution of exploitable biomass from the three most recent Gulf of Alaska trawl surveys. Exploitable biomass for slope rockfish apportionment is calculated as the average of the three most recent trawl survey biomass estimates for depths greater than 100m.

Amendment 58, which took effect in 1998, prohibited trawling in the Eastern Gulf of Alaska management area east of 140 degrees W. longitude. Since most slope rockfish are caught exclusively with trawl gear, this amendment could have concentrated fishing effort for slope rockfish in the Eastern Gulf area into the relatively small area between 140 degrees and 147 degrees W. longitude that remained open to trawling. To ensure that such a geographic over-concentration of harvest would not occur, since 1999 the NPFMC has divided the Eastern Gulf area into two smaller management areas: West Yakutat (area between 147 and 140 degrees W. longitude) and East Yakutat/Southeast Outside (area east of 140 degrees W. longitude). Separate ABC's and TAC's are now assigned to each of these smaller areas for Pacific ocean perch and the "other slope rockfish" management subgroup.

Since northern rockfish are relatively scarce in the Eastern Gulf of Alaska, the ABC apportioned to the Eastern Gulf of Alaska management area is small. This small ABC is generally too difficult to be managed effectively as a directed fishery. Since 1999 the ABC for northern rockfish apportioned to the Eastern Gulf of Alaska management area is included in the West Yakutat ABC for "other slope rockfish."

8.1.3 Evidence of Stock Structure

Gulf of Alaska northern rockfish grow significantly faster and reach a larger maximum length than Aleutian Islands northern rockfish (Clausen and Heifetz 2004). Aleutian Islands northern rockfish can also be older (max age 72) than Gulf of Alaska northern rockfish (max age 67). However, a genetic study of northern rockfish collected at three locations near the western Aleutian Islands, the western Gulf of Alaska, and Kodiak Island provided no evidence for genetically distinct stock structure within the sampled population (Gharrett et al., 2003). The genetic analysis was considered preliminary and sample sizes were small.

Consequently, the lack of evidence for stock structure does not necessarily confirm stock homogeneity. Additional genetic study is needed to verify these results.

8.1.4 Life History, Habitat Utilization, and Diet

Little is known about the life history of northern rockfish. Northern rockfish are presumed to be viviparous with internal fertilization and internal incubation of eggs. There have been no studies on fecundity of northern rockfish. Observations during research surveys in the Gulf of Alaska indicate that parturition (larval release) occurs in the spring and is completed by summer. Larval northern rockfish cannot be unequivocally identified to species at this time, even using genetic techniques, so information on larval distribution and length of the larval stage is unknown. The larvae metamorphose to a pelagic juvenile stage, but there is no information on when these juveniles become demersal.

Little information is available on the habitat of juvenile northern rockfish. Studies using submersibles have indicated that several species of rockfish are associated with rocky, shallower habitats during their juvenile stage (Carlson and Straty 1981, Kreiger 1993). Although these studies did not specifically observe northern rockfish, it is likely that juvenile northern rockfish also utilize these shallower habitats. Length frequencies of northern rockfish captured in NMFS bottom trawl surveys and observed in commercial fishery bottom trawl catches indicate that older juveniles are found on the continental shelf, generally at locations inshore of the adult habitat (Pers. comm. Dave Clausen).

Trawl surveys and commercial fishing data indicate that the preferred habitat of adult northern rockfish in the Gulf of Alaska is on relatively shallow rises or banks on the outer continental shelf at depths of ~75-150 m and that northern rockfish have patchy, localized distributions, within these habitats (Clausen and Heifetz 2004). Northern rockfish also appear to be associated with relatively rough bottoms on these banks, and they are mostly demersal in their distribution (Pers. comm. Dave Clausen). Observations from a submersible in the Aleutian Islands have also identified adult northern rockfish associated with boulders and sponges in mixed sand/gravel on the shallow (<200m) slope (Pers. obs. Dean Courtney).

Northern rockfish are generally planktivorous (feed on plankton) with euphausiids being the predominant prey item in both the GOA and the Aleutian Islands (Yang 1993, 1996, Yang and Nelson 2000). Offshore euphausiids are not directly associated with the bottom but rather are thought to be advected onshore near bottom at the upstream ends of underwater canyons where they become easy prey for planktivorous fishes (Brodeur 2001). This may help to explain the patchy, localized distributions of northern rockfish. Copepods, hermit crabs, and shrimp have also been noted as prey items in much smaller quantities (Yang 1993, 1996). Predators of northern rockfish are not well documented, but likely include larger fish such as Pacific halibut that are known to prey on other rockfish species. It is not known how predator prey relationships might influence the population dynamics of northern rockfish.

8.2 FISHERY

8.2.1 Catch History

A Pacific ocean perch trawl fishery by the U.S.S.R. and Japan began in the Gulf of Alaska in the early 1960's. This fishery developed rapidly, with massive efforts by the Soviet and Japanese fleets. Catches peaked in 1965, when a total of nearly 350,000 metric tons (mt) was caught, but this declined to 45.5 mt by 1976 (Ito 1982). It is very likely that some northern rockfish were taken in this fishery, but there are no available summaries of northern rockfish catches for this period. Foreign catches of all rockfish were often reported simply as “Pacific ocean perch”, with no attempt to differentiate species.

Available commercial catch information for slope rockfish in the years since 1977 is listed in Table 8-1. The reader is cautioned that slope rockfish catch data for 1977 - 1987 are for the Pacific ocean perch complex (a former management grouping consisting of Pacific ocean perch and 4 other rockfish species), Pacific ocean perch alone, or all *Sebastes* rockfish, depending upon the year (see Footnote in Table 8-1). Actual catches of the slope rockfish in the commercial fishery are only shown for 1988-present. The acceptable biological catches and quotas in Tables 8-1 and 8-2 are the Gulfwide values.

Foreign fishing dominated the fishery from 1977 to 1984, and catches generally declined during this period. Most of the catch was taken by Japan (Carlson et al. 1986). Catches reached a minimum in 1985, after foreign trawling in the Gulf of Alaska was prohibited.

The domestic fishery first became important in 1985, and expanded each year until 1991. Much of the expansion of the domestic fishery was apparently related to increasing annual quotas; quotas increased from 3,702 mt in 1986 to 20,000 mt in 1989. In the years 1991-95, overall catches of slope rockfish diminished as a result of the more restrictive management policies enacted during this period. The restrictions included: (1) establishment of the management subgroups, which limited harvest of the more desired species; (2) reducing levels of total allowable catch (TAC) to promote rebuilding of Pacific ocean perch stocks; and (3) conservative in-season management practices in which fisheries were sometimes closed even though substantial unharvested TAC remained. These closures were necessary because, given the large fishing power of the rockfish trawl fleet, there was substantial risk of exceeding the TAC if the fishery were to remain open.

Directly reported catch has been available for northern rockfish since 1993 (Table 8-1). Most of the catch has been taken in the Central area, where the majority of the northern rockfish exploitable biomass is located. Gulfwide catches for the years 1993-2003 have ranged from 2,947 mt to 5,760 mt, depending on the year. Annual ABC’s and TAC’s have been relatively consistent during this period, and have varied between 4,880 mt and 5,760 mt. Catches of northern rockfish were below their TAC during the years 2000 - 2002: in 2000 and 2002, as a conservative measure to ensure the TAC was not exceeded, and in 2001 because the maximum allowable bycatch of Pacific halibut was reached in the central Gulf of Alaska for “deep water trawl species”, one of which is northern rockfish.

With the advent of a NMFS observer program aboard foreign fishing vessels in 1977, enough information on species composition of rockfish catches was collected so that estimates of the northern rockfish catch can be made for 1977-88 for the foreign and the subsequent joint venture fisheries in the Gulf of Alaska (Table 8-2). The relatively large catch estimates for the foreign fishery in 1982-83 are an indication that at least some directed fishing probably occurred in those years. Joint venture catches of northern rockfish, however, appear to have been relatively modest.

A completely domestic trawl fishery for rockfish in the Gulf of Alaska began in 1984 and a domestic observer program was implemented in 1990, so that catches of northern rockfish can also be estimated for the years 1990-92 (Table 8-2). Catch estimates of northern rockfish increased greatly over these years, from ~1,700 mt in 1990 to nearly 7,800 mt in 1992. The increases for 1991 and 1992 can be explained by the removal of Pacific ocean perch and shortraker/rougheye rockfish from the slope rockfish management group. As a result of this removal, relatively low TAC’s were adopted for these three species, and the rockfish fleet redirected more of its effort to northern rockfish in 1991 and 1992.

Research catches of northern rockfish have been relatively small and are listed in Table 8-3.

8.2.2 Description of the Fishery

Historically, bottom trawls have accounted for nearly all the commercial harvest of northern rockfish in the Gulf of Alaska; for example, in the years 1990-98, bottom trawls took over 99% of the catch (Clausen and Heifetz 2004). Before 1996, most of the slope rockfish trawl catch (>90%) was taken by large factory-trawlers that processed the fish at sea. A significant change occurred in 1996, however, when smaller shore-based trawlers began taking a sizeable portion of the catch in the Central area for delivery to processing plants in Kodiak. The following table shows the percent of the total catch of northern rockfish in the Central area that shore-based trawlers have taken since 1996[1]

	Percent of catch taken by shore-based trawlers in the Central area						
	1996	1997	1998	1999	2000	2001	2002
Northern rockfish	32	32	53	44	73	57	73

Factory trawlers continued to take nearly all the northern rockfish catch in the Western area.

in the Gulf of Alaska, northern rockfish are generally caught with bottom trawls identical to those used in the Pacific ocean perch fishery. Many of these nets are equipped with so-called “tire gear”, in which automobile tires are attached to the footrope to facilitate towing over rough substrates. Most of the catch has been taken during July, as the directed rockfish trawl fishery in the Gulf of Alaska has traditionally opened around July 1. Rockfish trawlers usually direct their efforts first toward Pacific ocean perch because of its higher value relative to other rockfish species; after the TAC for Pacific ocean perch has been reached and NMFS closes directed fishing for this species, trawlers then switch and target northern rockfish.

A study of the northern rockfish fishery for the period 1990-98 showed that most (an estimated 89%) of the catch was taken from just five relatively small fishing grounds: Portlock Bank, Albatross Bank, an unnamed bank south of Kodiak Island that fishermen commonly refer to as the “Snakehead”, Shumagin Bank, and Davidson Bank (Clausen and Heifetz 2004). In particular, the Snakehead was the most important fishing ground, as it accounted for 46% of the northern rockfish catch during these years. All of these grounds can be characterized as relatively shallow offshore banks on the outer continental shelf.

8.2.3 Bycatch

Data from the observer program for 1990-98 indicated that 82% of the northern rockfish catch during that period came from directed fishing for northern rockfish, and 18% was taken as bycatch in fisheries for other species (Clausen and Heifetz 2004).

The only detailed analysis of bycatch in slope rockfish fisheries of the Gulf of Alaska is that of Ackley and Heifetz (2001), who examined data from the observer program for the years 1993-95. For hauls targeting on northern rockfish, the predominant bycatch species was dusky rockfish, distantly followed by “other slope rockfish”, Pacific ocean perch, and arrowtooth flounder.

8.2.4 Discards

Gulfwide discard rates[2] (% discarded) for northern rockfish in the commercial fishery for 1993-2002 are as follows:

Year	Northern rockfish
1993	26.5
1994	17.7
1995	12.7

[1]National Marine Fisheries Service, Alaska Region, Fishery Management Section, P.O. Box 21668, Juneau, AK 99802-1688. Data are from weekly production and observer reports through October 5, 2002.

[2]Source: National Marine Fisheries Service, Alaska Region, Fishery Management Section, P.O. Box 21688, Juneau, AK 99802-1688. Data are from weekly production and observer reports through October 5, 2002.

1996	16.5
1997	27.8
1998	18.3
1999	11.1
2000	8.7
2001	17.5
2002	9.8

These discard rates are generally similar to those in the Gulf of Alaska for Pacific ocean perch and slightly higher than those for dusky rockfish.

8.3 DATA

New data added for this assessment includes 2003 survey biomass estimate, catch from 2002, preliminary catch for 2003, survey age composition from 2001, fishery age composition from 2003, and fishery length composition from 2003.

8.3.1 Fishery Data

8.3.1.1 Catch

Detailed catch information for northern rockfish is listed in Tables 8-1 and 8-2.

8.3.1. Age and Size composition

Observers aboard fishing vessels and at onshore processing facilities have provided data on size and age compositions of the commercial catch of northern rockfish. Table 8-4 and Figure 8-1 summarize the length compositions, and Table 8-5 and Figure 8-2 summarize the age compositions. The fishery length compositions indicate the recent recruitment of smaller fish to the population during the years 2002 and 2003 (Figure 8-1). The fishery age compositions indicate that strong year classes occurred around the years 1976, and 1984 (Figure 8-2). The fishery age compositions from 2002 may also indicate that 1994 is emerging as a strong year class, however the sample size (195) for the at sea fishery age composition data in 2002 appears to be too small to adequately resolve recent year classes (Figure 8-2). The clustering of several large year classes in each period is most likely due to ageing error.

8.3.2 Survey Data

8.3.2.1 Biomass Estimates from Trawl Surveys

Bottom trawl surveys were conducted on a triennial basis in the Gulf of Alaska in 1984, 1987, 1990, 1993, 1996, and 1999, and these surveys became biennial in 2001 and 2003. The surveys provide an index of absolute abundance (biomass), size and age composition data, and growth characteristics. The trawl surveys have used a stratified random design to sample fishing stations that cover all areas of the Gulf of Alaska out to a depth of 500 m (in some surveys to 1,000 m). Generally, attempts have been made through the years to standardize the survey design and the fishing nets used, but there have been some exceptions to this standardization. In particular, much of the survey effort in 1984 and 1987 was by Japanese vessels that used a very different net design than what has been the standard used by U.S. vessels throughout the surveys. To deal with this problem, fishing power comparisons of rockfish catches have been done for the various vessels used in the surveys (for a discussion see Heifetz et al. 1994). Results of these comparisons have been incorporated into the biomass estimates listed in this report, and the estimates are believed to be the best available. Even so, the reader should be aware that use of Japanese vessels in 1984 and 1987 does introduce an element of uncertainty as to the standardization of these two surveys. Also, a different survey design was used in the eastern Gulf of Alaska in 1984, and the eastern Gulf of Alaska was not covered by the 2001 survey. These data inconsistencies for the eastern Gulf of Alaska have little effect on the survey results for northern rockfish, as relative abundance of northern rockfish is very low in the eastern Gulf of Alaska.

The biomass estimates for northern rockfish have been highly variable from survey to survey (Table 8-6; Figure 8-3.). In particular, the Gulfwide biomass increased from about 100,000 mt to nearly 344,000 mt from 1996 to 2001, and then decreased to 66,000 mt in 2003. Such large fluctuations in biomass do not seem reasonable given the long life, slow growth, low natural mortality and the relatively modest level of commercial catch of northern rockfish.

The variance of individual biomass estimates has also been high and is reflected in the large 95% confidence intervals associated with recent survey biomass estimates of northern rockfish (Table 8-6; Figure 8-3). In both 1999 and 2001, a single very large survey haul of northern rockfish greatly increased the biomass estimates and resulting estimate of biomass variance; the haul in 2001 was the largest individual catch (14 mt) of northern rockfish ever taken during a Gulf of Alaska survey.

The highly variable biomass estimates for northern rockfish suggest that the stratified random design of the surveys does a relatively poor job of assessing stock condition of northern rockfish and that a different survey approach may be needed to reduce the variability in biomass estimates.

8.3.2.2 <u>Survey Size Compositions</u>

The Gulf of Alaska trawl surveys provide size composition data for northern rockfish population. Generally, the northern rockfish size compositions have been unimodal, and provide no indication of recruitment of smaller fish. Estimated mean length of the population increased from 34.7 cm in 1990 to 37.8 cm in 1999, and then decreased slightly to ~37 cm in 2001 and 2003. Survey size composition estimates are not used directly in the current age structured assessment model but are used to expand the length stratified survey age compositions to random samples of survey age composition for use in the model.

8.3.2.3 <u>Survey Age Compositions</u>

The Gulf of Alaska trawl surveys provide age composition data for northern rockfish by extrapolating the length stratified survey age frequencies obtained from break and burn otolith readings through the randomly collected survey length composition data collected for northern rockfish. Survey age compositions for the Gulfwide northern rockfish population are available for 1984, 1987, 1990, 1993, 1996, 1999 and 2001(Table 8-7, and Figure 8-4). The age compositions from each survey indicate that recruitment of northern rockfish is highly variable. Several surveys (1984, 1987, 1990, and 1996) show especially strong year classes from the period around 1975-77, although they differ as to which specific years were greatest, perhaps due to aging errors. The 1993, 1996, and 1999 age compositions also indicate the 1983-85 year classes may be stronger than average which is in agreement with recent age compositions obtained from the commercial fishery described above. Mean age of northern rockfish in the surveys has increased from 13.1 years in 1984 to 18.6 years in 1999 and come down slightly to 18.15 years in 2001.

8.4 ANALYTIC APPROACH

Gulf of Alaska northern rockfish are currently assessed using an age structured modeling approach. Courtney et al. (1999) presented a stock assessment model for northern rockfish using AD Model Builder software. This is the fourth year that this model will be used for the assessment of northern rockfish.

8.4.1 <u>Model Structure</u>

The base model (Model 1) for this year's stock assessment is the same age-structured model used the last two years. The model was constructed using AD Model Builder software and was described in detail in an earlier SAFE appendix (Courtney et al. 1999). The model is fit to available fishery catch, age, and size compositions and to trawl survey age compositions. Catch is interpolated for missing years (Courtney et al. 1999). Trawl survey biomass estimates are incorporated as indices of abundance by estimating survey catchability (*q*). Natural mortality is fixed at an independently estimated value of 0.06 and a single selectivity is assumed for the fishery and the survey. Penalty functions are incorporated into the model objective function to constrain recruitment variability, fishing mortality variability, and selectivity at age. Ageing errors are incorporated with the use of age-error and age-length transition matrices. The log parameters are estimated rather than parameters on the original scale for reliability in the estimation process (Kimura 1989, 1990). Additional structure is added to the model by incorporating a stock recruit relationship (Courtney et al. 1999).

Prior distributions are incorporated as penalties in the overall model objective function for recruitment variability, survey catchability, and steepness of the stock recruitment relationship (Courtney et al. 1999). The initial values and their prior distributions for recruitment variability, survey catchability, and steepness of the stock recruitment relationship area assumed to be similar for northern rockfish and Pacific ocean perch in the Gulf of Alaska.

8.5 ASSESSMENT PARAMETERS

8.5.1 Parameters Estimated Independently

The natural mortality rate (M) for northern rockfish in the Gulf of Alaska is estimated to be 0.06. This estimate was determined by Heifetz and Clausen (1991) using the method of Alverson and Carney (1975). Maximum reported age for northern rockfish in the Gulf of Alaska is 67 years (2002 fishery age composition) and 72 in the Aleutian Islands (Malecha and Heifetz 2000). Age at first recruitment to the commercial fishery is 4 and to the survey is 2 (Tables 8-5 and 8-7).

Area	Mortality rate	Maximum age	Age of first recruitment
Gulf of Alaska	0.06*	67	2 - 4
Aleutians	-	72	-
* Used in this assessment.			

Age at 50% maturity (13 years) and size at 50% maturity (36.1 cm fork length) for northern rockfish in the Gulf of Alaska was estimated from a sample of 77 females in the central Gulf of Alaska[3]

Area	Size at 50% maturity	Age at 50% maturity	Sample size
Central Gulf of Alaska	36.1	12.8*	77
* Used in this assessment.			

Length-weight coefficients for the formula $W=aL^b$, where W = weight in grams and L = length in mm, are from Heifetz and Clausen (1989) and Martin (1997), and Courtney et al. (1999).

Area	Sex	a	b	Year
GOA	combined	1.63×10^{-5}	2.98	1989
GOA	combined	1.37×10^{-5}	3.04	1997
GOA	males	1.55×10^{-5}	2.99	1997
GOA	females	1.53×10^{-5}	3.01	1997
GOA	combined	1.75×10^{-5}	2.98	1999*
* Used in this assessment.				

[3]C. Lunsford, National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801. Pers. Commun. July 1997.

The von Bertalanffy growth parameters for northern rockfish in the Gulf of Alaska are in Heifetz and Clausen (1991) Courtney et al. (1999) and Malecha and Heifetz (2000).

Area	Sex	t_0	k	L_{inf} (cm)	Year
GOA	combined	-1.51	0.190	35.60	1991
GOA	combined	-0.76	0.170	38.30	1999*
GOA	combined	-0.64	0.165	39.16	2001
GOA	male	-0.26	0.187	37.83	2001
GOA	female	-0.87	0.152	40.22	2001
AL	combined	-7.16	0.103	34.27	2001

* Used in current assessment.

8.5.2 Parameters Estimated Conditionally

Parameters estimated conditionally include but are not limited to: catchability, selectivity (up to full selectivity) for survey and fishery, recruitment deviations, mean recruitment, fishing mortality, and spawners per recruit levels (Courtney et al. 1999).

8.6 MODEL ALTERNATIVES

8.6.1 Base Model (Model 1)

The base model (Model 1) for this year's stock assessment for northern rockfish is the same age-structured model used in last two year's stock assessments.

Courtney et al. (1999) found that the base model fit the age composition and biomass index poorly and did not satisfactorily describe the population structure. An examination of several alternative model likelihood weights revealed that the most likely cause of the poor fit was an apparent inconsistency in the data between the survey age compositions and the fishery length compositions. In particular, the length compositions were composed of a single mode that progressed in size through time (Table 8-1). The model interpreted this mode as a single very large year class, 1976, which dominated the population dynamics of the model. Alternatively, the age composition was composed of several less clearly defined modes which progressed in age through time.

An alternative case was obtained by forcing the model to fit the age composition data. The model was forced to fit to survey age composition was by increasing the survey age composition likelihood weight from one to ten. The value chosen for the weighting term was based upon a sensitivity analysis (Figure 10 in Courtney et al. 1999). The sensitivity test suggested that a weighting value of ten was just as effective at fitting the age data as the higher weight of fifty used in the 1999 alternative case model, but that the lower weight had less of an impact on the model's fit to the other data. In this case, the model estimated several strong year classes and the fishery/survey selectivity curve appeared to be more reasonably defined. The alternative case from 1999 was the preferred model (Courtney et al. 1999) and was implemented for this years assessment with the modifications described below. Similarly, the model was forced fit to fishery age composition by setting the fishery age composition likelihood weight to ten.

The maximum age for which selectivity at age is estimated was reduced from age 23+ to age 11. Selectivity at age from ages 12 through 23+ were set equal to that of age 11. The choice of age 11 as the maximum selected age was based upon results of the alternate case model from 1999 (Figure 12 in Courtney et al. 1999). The model showed a local peak in selectivity at age 11 and values ranging above and below the peak after age 11. This behavior suggested an asymptote in selectivity at age 11. A test of model sensitivity to the choice of maximum selected age (ranging from 8 to 14) showed little effect on the population (projected catch in 2001 varied only 6% over the range of values). The resulting values estimated for selectivity at age followed a logistic growth pattern with a maximum selectivity at age 11 without assuming a functional relationship between selectivity and age (Courtney et al. 1999).

In the 1999 model, the number of hauls used to collect fishery length and survey age data were used as weighting terms in the multinomial likelihoods due to fishery size and survey age respectively. The purpose of these weighting terms was to reduce the influence of data collected from a relatively low number of hauls in any given year. However, there were generally more hauls observed for fishery length data than for survey age data, and consequently more weight was given to length compositions than to age compositions using this weighting scheme (Tables 8-4 and 8-7). As done last year, the problem was addressed by scaling the number of hauls for fishery length and age data and for survey age data to a maximum of one hundred. The number one hundred was chosen in order to keep the scale of the sample sizes on the same order of magnitude as the sample sizes which ranged from 6 to 176 hauls.

8.6.2 Model 2

We explored the use of an alternative model (Model 2). This alternative model uses the Gulf of Alaska northern rockfish data from the base model (Model 1) but runs the data through the age structured model recommended this year for Gulf of Alaska Pacific ocean perch assessment. Gulf of Alaska Pacific ocean perch age structured model (Model 2) is described in detail in section 7 of this SAFE (Hanselman et al 2003). The only change we made to the Gulf of Alaska Pacific ocean perch model (Model 2) was to change the prior on the CV of recruitment deviations from 0.2 to 0.02.

The other differences between Model 2 and Model 1 are that Model 2 relaxed the selectivity penalties and set all likelihood weights, except that for catch, to one. Model 2 also reformulated the fishing mortality regularity/deviation penalty, relaxed the weight on the fishing mortality regularity/deviation penalty, and removed the spawner recruit relationship from the estimation of beginning biomass (B0). However, reformulation of the fishing mortality regularity /deviation penalty (northern rockfish alternative Model 5, Heifetz et al. 2001) and the removal of the spawner recruit relationship from the estimation of beginning biomass (B0, northern rockfish alternative Model 3, Heifetz et al. 2001) had little effect on parameter estimation in the current northern rockfish model (Model 1). Consequently, the main difference in the fishing mortality regularity/deviation penalties between Model 2 and Model 1 seems to be the relaxed weight on the fishing mortality regularity/deviation penalty in Model 2.

8.7 MODEL EVALUATION

The unweighted likelihood components and penalties, and selected measures of stock status are similar for the two model runs except that the likelihood in Model 2 indicates a better fit to fishery size compositions. A comparison of selected likelihood components and results from the two model runs follow:

	Model	
Selected likelihood components (unweighted)	1*	2
Catch	0.01	0.00
Survey biomass index	6.22	7.16
Fishery age comp	29.03	32.10
Survey age comp	30.76	38.46
Fishery size comp	107.60	75.44
Recruitment deviations	17.76	0.07
Total (unweighted)	191.39	153.23
Objective Function (Total weighted)	501.43	172.36
Selected model results		
Survey q	0.46	0.64
(Spawning biomass 2002)/ (Spawning biomass 2001)	0.97	0.96
(Spawning biomass 2002)/ (Spawning biomass 1977)	1.51	0.91
Average Recruitment (1977, 2002)	17.86	16.12
Total biomass 2002	112,712	90,783
(CV)	(34%)	(43%)

*Recommended model for ABC determination

Recruitment estimates are similar for the two models but Model 2 places proportionally more biomass in the 1994 year class (Figure 8-5). Ending biomass is roughly 20% smaller for Model 2 and there is proportionally more biomass from 1977 - 1992 in Model 2 (Figure 8-6). Fits to survey biomass are the similar (Figure 8-7). Estimated selectivity is steeper in Model 2 (Figure 8-8). The trend in fishing mortality over time is the same in both models (tracks catch) but Model 2 fishing mortality rates are higher (e.g., F40% of 0.067). The higher fishing mortality allowed by Model 2 is a result of the proportionally larger 1994 recruitment in Model 2 (Figure 8-5).

The overall objective function (weighted) is substantially smaller for Model 2 than for Model 1. Model 2 was able to achieve a comparable fit to the data as Model 1 with smaller weighting terms on several likelihood components. Model 1 is forced to fit the age composition by increasing the weighting terms for age data. However, the weights of several penalty terms also had to be increased to keep the model behavior reasonable (Heifetz et al. 2001, 2000, Courtney et al. 1999). Model 2 fits the age data by assuming a higher recruitment variability (CV of recruitment variability is 0.2 in Model 1 and 0.02 in Model 2) and assuming less regularity in fishing mortality and selectivity. Both models end up with a similar estimate of recruitment variability (near 1.0) and fishing mortality (tracks catch) but parameter estimation in Model 2 is less restricted by weighting terms than Model 1. A new Gulf of Alaska northern rockfish model will be examined for next year's assessment which incorporates the refinements made this year to the Gulf of Alaska Pacific ocean perch model (Model 2) discussed above.

8.8 MODEL RESULTS (Model 1 unless otherwise noted)

Fits of Model 1 to fishery and survey age compositions are shown in Figures 8-9 and 8-10. Model 1 estimates of the time series of female spawning biomass, total biomass (age 6 and greater), catch/(6+ total biomass), and number of age-two recruits from Model 1 are shown in Table 8-8. Model 1 estimates of total biomass (mt), mature female spawning biomass (mt), and recruitment (millions of fish) along with 95 percent confidence intervals obtained from the AD model builder covariance matrix are shown in Figure 8-11. A summary of the current Model 1 estimates of age composition, fishery and survey selectivity, maturity at age (estimated independently), and weight at age is in Table 8-9.

The number of age-2 recruits in 2004 was estimated as the average recruitment from the 1977 - 1995 year classes (17,990, Table 8-8). Estimated female spawning biomass in 2004 is 36,482 mt, exploitable biomass is 90,058 mt, and age 6+ total biomass is 95,149 mt (Table 8-8).

For the first time, the 1994 year class has emerged as a larger than average year class (Figures 8-5 and 8-11). Otherwise, recruitment since the 1988 year class has been below average, and the current population is dominated by older fish from three strong year classes (1968-1970, 1975-1977, and 1982-1984, Figures 8-5 and 8-9 through 8-11). The spread in these strong year classes is likely due to ageing error. According to the age structured model, the spawning biomass of these large year classes has already peaked (between 1991 and 1992), and spawning biomass is projected to decrease as these large year classes die off (Figure 8-6). Unless another strong year class appears, spawning biomass is projected to fall below $B_{40\%}$ (23,929 mt) in 2012 and yield is projected to fall below equilibrium yield at $F_{40\%}$ (3,985 mt) by 2010 (Model 1, Figure 8-6).

The use of an age-structured model has improved our understanding of northern rockfish population dynamics, however there is still considerable uncertainty in the estimates of population abundance. Biomass projections from the age structured model are highly uncertain. The 2003 ending biomass estimated from Model 1had a coefficient of variation of 34% (based upon the covariance matrix from the AD Model output). This is a minimum estimate of variation that does not take into account the uncertainty of independently estimated parameters such as natural mortality and maturity. In particular, the estimates of maturity at age are based on a small sample of fish (n=77) collected in one year and the calculation of $F_{40\%}$ and $B_{40\%}$ depend on these estimates of maturity.

The 2003 survey biomass estimate (66,368 mt) came in at 18% of the 2001 biomass estimate (355,275 mt, Figure 8-3). Such high inter-annual variability in biomass seems unlikely for a long lived slow growing species like northern rockfish and is generally not fit by the model (Figure 8-7). Improving the fit changes the resulting biomass estimate. Courtney et al. (1999) tested the model sensitivity to the likelihood weights on the abundance index. Increasing the likelihood weight on the abundance index improved the fit of the abundance index and all the other data except the age data. However, the population representation implied by the age data was chosen as the most reasonable representation of the population structure for this assessment (i.e., the alternative case from Courtney et al. 1999). The uncertainty inherent in this choice was examined in a previous assessment (Heifetz et al. 2000). By increasing the likelihood weight of the survey abundance index from 1(the value used in the current assessment) to 5 (the population representation implied by a stronger fit to survey abundance and the maximum weight from Courtney et al. 1999), the resultant 2000 ending biomass estimate was increased by approximately 50%. This sensitivity to changes in survey biomass weights underscores the uncertainty in the current biomass estimate.

8.9 PROJECTIONS AND HARVEST ALTERNATIVES

8.9.1 Harvest Alternatives

Except for the addition of new data (2003 survey biomass estimate, catch from 2002, preliminary catch for 2003, survey age composition from 2001, fishery age composition from 2003, and fishery length composition from 2003), the model used to recommend northern rockfish ABC this year is the same as the northern rockfish age-structured model from last two year's SAFE documents. A detailed report describing the northern rockfish model configuration was presented in an earlier SAFE appendix (Courtney et al. 1999). Based on this year's recommended assessment model (Model 1), the projected spawning biomass in 2004 B_{2004} is 36,482 mt. $B_{40\%}$, determined from average recruitment of the 1977-95 year-classes is 23,929 mt. Since B_{2004} is greater than $B_{40\%}$, the computation in tier 3a [i.e., $F_{ABC} \le F_{40\%}$] is used to determine the maximum value of F_{ABC}. As in last year's assessment, we recommend that $F_{40\%}$ be used as the basis for ABC calculations. We recommend that the ABC for northern rockfish for the 2004 fishery in the Gulf of Alaska be set 4,874 mt (Model 1).

Projected spawning biomass (B_{2004}, 36,482 mt), equilibrium spawning biomass ($B_{40\%}$, 23,929), and ABC for 2004 (4,874 mt) recommended from year's assessment are slightly lower than projected spawning biomass (B_{2003}, 42,743 mt), equilibrium spawning biomass ($B_{40\%(2003)}$, 25,268), and ABC for 2003 (5,537 mt) recommended from last years assessment. Given the uncertainty in the recent biomass estimates, the age structured model, the catch history, and the life history parameters, a model which results in a more conservative ABC, which is similar to that obtained last year, appears to be reasonable. The declining stock trend and the uncertainty in biomass estimates suggests that caution is warranted for management of this stock.

8.9.2 Projections

For northern rockfish, projected B_{2004} (36,482 mt) is greater than $B_{35\%}$ (20,938 mt) and by the definitions below, the stock is not over fished (Table 8-10). In addition, B_{2006} (32,523 mt) is greater than $B_{35\%}$ and by the definitions below the stock is not approaching an over fished condition (Table 8-10). Note that projected spawning biomass (36,433 mt) and catch (4,868 mt) in 2004 from the projection model are slightly lower than projected spawning biomass (36,482 mt) and catch (recommenced ABC of 4,874 mt) in 2004 from the Model 1. This is because the projection model calculates catch at the middle of the year and Model 1 calculates catch at the beginning of the year for 2004.

A standard set of projections is required for each stock managed under Tiers 1, 2, or 3. This set of projections that encompasses seven harvest scenarios is designed to satisfy the requirements of Amendment 56, the National Environmental Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). Figure 8-6 (Model 1) shows the recent trend and projection of yield and spawning biomass based on average recruitment and a $F_{40\%}$ harvest rate for Model 1.

For each scenario, the projections begin with the vector of 2003 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2004 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2003. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios will be used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2004, are as follow ("*max* F_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

Scenario 1: In all future years, F is set equal to *max* F_{ABC}. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TAC's.)

Scenario 2: In all future years, F is set equal to a constant fraction of *max* F_{ABC}, where this fraction is equal to the ratio of the F_{ABC} value for 2004 recommended in the assessment to the *max* F_{ABC} for 2004. (Rationale: When F_{ABC} is set at a value below *max* F_{ABC}, it is often set at the value recommended in the stock assessment.)

Scenario 3: In all future years, F is set equal to 50% of max F_{ABC}. (Rationale: This scenario provides a likely lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)

Scenario 4: In all future years, F is set equal to the most recent five year (1999 - 2003) average F. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of F_{TAC} than F_{ABC}.)

Scenario 5: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether a stock is currently in an over fished condition or is approaching an over fished condition. These two scenarios are as follows (for Tier 3 stocks, the MSY level is defined as $B_{35\%}$):

Scenario 6: In all future years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is over fished. If the stock is expected to be above its MSY in the first year (2004) or above ½ its MSY level in the first year (2004) and above its MSY level in 2014 under this scenario, then the stock is not over fished.)

Scenario 7: In the first two years (2004 and 2005), F is set equal to *max* F_{ABC}, and in all subsequent years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an over fished condition. If the stock is expected to be above its MSY level in 2016, under this scenario, then the stock is not approaching an over fished condition)

Projections and Status Determination

Harvest scenarios #6 and #7 are intended to permit determination of the status of a stock with respect to its minimum stock size threshold (MSST). Any stock that is below its MSST is defined to be over fished. Any stock that is expected to fall below its MSST in the next two years is defined to be approaching an over fished condition. Harvest scenarios #6 and #7 are used in these determinations as follows:

Is the stock over fished? This depends on the stock's estimated spawning biomass in 2004:
a) If spawning biomass for 2004 is estimated to be below ½ B35%, the stock is below its MSST.
b) If spawning biomass for 2004 is estimated to be above B35%, the stock is above its MSST.
c) If spawning biomass for 2004 is estimated to be above ½ B35% but below B35%, the stock's status relative to MSST is determined by referring to harvest scenario #6 (Table 8-10). If the mean spawning biomass for 2014 is below B35%, the stock is below its MSST. Otherwise, the stock is above its MSST.

Is the stock approaching an over fished condition? This is determined by referring to harvest scenario #7:

a) If the mean spawning biomass for 2006 is below ½ B35%, the stock is approaching an

over fished condition.
b) If the mean spawning biomass for 2006 is above B35%, the stock is not approaching an over fished condition.
c) If the mean spawning biomass for 2006 is above ½ B35% but below B35%, the determination depends on the mean spawning biomass for 2016. If the mean spawning biomass for 2016 is below B35%, the stock is approaching an over fished condition. Otherwise, the stock is not approaching an over fished condition.

A summary of the results of these scenarios for northern rockfish is in Table 8-10.

8.9.3 Apportionment of ABC

The 2004 area apportionments for Gulf of Alaska northern rockfish are 15.87% for the Western area, 84.10% for the Central area, and 0.03% for the Eastern area. Applying these apportionments to the recommended ABC for northern rockfish results in 773 mt for the Western area, 4,099 mt for the Central area, and 1mt for the Eastern area. For management purposes, the small ABC of northern rockfish in the Eastern area is combined with other slope rockfish.

Prior to the 1996 fishery, the apportionment of ABC among areas was determined from distribution of biomass based on the average proportion of exploitable biomass by area in the most recent three triennial trawl surveys. For the 1996 fishery, an alternative method of apportionment was recommended by the Plan Team and accepted by the Council. Recognizing the uncertainty in estimation of biomass yet wanting to adapt to current information, the Plan Team chose to employ a method of weighting prior surveys based on the relative proportion of variability attributed to survey error. Assuming that survey error contributes 2/3 of the total variability in predicting the distribution of biomass, the weight of a prior survey should be 2/3 the weight of the preceding survey. This results in weights of 4:6:9 for the 1999, 2001, and 2003 surveys, respectively. Exploitable survey biomass is calculated as survey biomass for depths greater than 100 m. The percentage of exploitable survey biomass by area is averaged rather than the raw values. The eastern Gulf was not covered by the 2001 trawl survey. The 2001 Eastern Gulf exploitable survey biomass estimate is the average of 1993, 1996, and 1999 Eastern Gulf exploitable survey biomass estimates.

Percentage of survey biomass by region and resulting area apportionments follow:

Percentage of exploitable survey biomass estimates by Gulf of Alaska region

Survey year	Western	Central	Eastern
1999	6.92%	93.04%	0.04%
2001	26.18%	73.79%	***0.03%***
2003	12.97%	87.01%	0.02%

Apportionment (4:6:9) weighted average of 1999, 2001,2003 percent exploitable biomass

	Western	Central	Eastern
Apportionment	15.87%	84.10%	0.03%

8.9.4 Overfishing Definition

Based on the definitions for overfishing in Amendment 44 in tier 3a (i.e., F_{OFL} = $F_{35\%}$=0.068), overfishing is set equal to 5,790 mt for Gulf of Alaska northern rockfish. The overfishing level is not apportioned by area for Gulf of Alaska northern rockfish.

8.9.5 Summary

A summary of biomass levels, exploitation rates and recommended ABCs and OFL's for northern rockfish is below. Exploitable biomass is for age 6 and greater biomass projected from the age structured models for 2004 (Table 8-8).

Model results table	**1***	2
Exploitable Biomass 2004 (mt)	95,149	81,677
B40% (mt)	23,929	18,858
Biomass 2004 (mt)	36,482	28,490
F50%	0.040	0.040
Projected Yield in 2004 at F50%	3,468	2,576
F40%	0.057	0.067
F ABC 2004 (maximum allowable = F40%)	**0.057**	0.067
ABC 2004 (mt, maximum allowable)	**4,874**	4,189
F OFL 2004 (=F35%)	**0.068**	0.080
OFL 2004	**5,790**	5,032

***Recommended model for ABC determination**

8.10 ECOSYSTEM CONSIDERATIONS

In general, a determination of ecosystem considerations for slope rockfish is hampered by the lack of biological and habitat information. A summary of the ecosystem considerations presented in this section is listed in Table 8-11.

8.10.1 Ecosystem Effects on the Stock

Prey availability/abundance trends: similar to many other rockfish species, stock condition of slope rockfish appears to be influenced by periodic abundant year classes. Availability of suitable zooplankton prey items in sufficient quantity for larval or post-larval northern rockfish may be an important determining factor of year class strength. Unfortunately, there is no information on the food habits of larval or post-larval rockfish to help determine possible relationships between prey availability and year class strength; moreover, identification to the species level for field collected larval slope rockfish is difficult. Visual identification is not possible though genetic techniques allow identification to species level for larval slope rockfish (Gharrett et. al 2001). Some juvenile rockfish found in inshore habitat feed on shrimp, amphipods, and other crustaceans, as well as some mollusk and fish (Byerly 2001). Adult slope rockfish such as Pacific ocean perch and northern rockfish feed on euphausiids. Adult rockfish such as shortraker and rougheye are probably opportunistic feeders with more mollusks and fish in their diet. Little if anything is known about abundance trends of likely rockfish prey items. Euphausiids are also a major item in the diet of walleye pollock. Changes in the abundance of walleye pollock could lead to a corollary change in the availability of euphausiids, which would then have an impact on Pacific ocean perch and northern rockfish.

Predator population trends: Rockfish are preyed on by a variety of other fish at all life stages, and to some extent marine mammals during late juvenile and adult stages. Whether the impact of any particular predator is significant or dominant is unknown. Predator effects would likely be more important on larval, post-larval, and small juvenile slope rockfish, but information on these life stages and their predators is nil.

Changes in physical environment: Strong year classes corresponding to the period around 1977 have been reported for many species of groundfish in the Gulf of Alaska, including Pacific ocean perch, northern rockfish, sablefish, and Pacific cod. Therefore, it appears that environmental conditions may have changed during this period in such a way that survival of young-of-the-year fish increased for many groundfish species, including slope rockfish. Pacific ocean perch appeared to have a strong 1986 or 1987 year class, and northern rockfish appeared to have a strong 1984 year class. These may be other years when environmental conditions were especially favorable for rockfish species. The environmental mechanism for this increased survival remains unknown. Changes in water temperature and currents could have effect on prey item abundance and success of transition of rockfish from pelagic to demersal stage. Rockfish in early juvenile stage have been found in floating kelp patches which would be subject to ocean currents. Changes in bottom habitat due to natural or anthropogenic causes could alter survival rates by altering available shelter, prey, or other functions.

8.10.2 Fishery Effects on the Ecosystem

Fishery-specific contribution to bycatch of HAPC biota: In the Gulf of Alaska, bottom trawl fisheries for pollock, deepwater flatfish, and Pacific ocean perch account for most of the observed bycatch of coral, while rockfish fisheries account for little of the bycatch of sea anemones or of sea whips and sea pens. The bottom trawl fisheries for Pacific ocean perch and Pacific cod and the pot fishery for Pacific cod accounts for most of the observed bycatch of sponges (Table 8-12).

Fishery-specific concentration of target catch in space and time relative to predator needs in space and time (if known) and relative to spawning components: The directed slope rockfish trawl fisheries begin in July concentrated in known areas of abundance and typically lasts only a few weeks. The annual exploitation rates on rockfish are thought to be quite low. Insemination is likely in the fall or winter, and parturition is likely mostly in the spring. Hence, reproductive activities are probably not directly affected by the commercial fishery.

Fishery-specific effects on amount of large size target fish: No evidence for targetting large fish

Fishery contribution to discards and offal production: Fishery discard rates of slope rockfish during 2000-2002 have been 7 - 11% for Pacific ocean perch, 9 - 18% for northern rockfish, 21 - 30 % for shortraker and rougheye rockfish, and 48 - 53% for other slope rockfish. The discard amount of species other than slope rockfish in the slope rockfish fishery has not been determined..

Fishery-specific effects on age-at-maturity and fecundity of the target fishery: unknown.

Fishery-specific effects on EFH non-living substrate: unknown, but the heavy-duty "rockhopper" trawl gear commonly used in the fishery can move around rocks and boulders on the bottom.

8.11 DATA GAPS AND RESEARCH PRIORITIES

8.11.1 Life History and Habitat Utilization

There is little information on larval, post-larval, or early life history stages of northern rockfish. Habitat requirements for larval, post-larval, and early stages mostly unknown. Habitat requirements for later stage juvenile and adult fish are anecdotal or conjectural. Research needs to be done on the bottom habitat of the major fishing grounds, on what HAPC biota are found on these grounds, and on what impact bottom trawling may have on these biota.

8.11.2 Assessment Data

The highly variable biomass estimates for northern rockfish suggest that the stratified random design of the surveys does a relatively poor job of assessing stock condition of northern rockfish and that a different survey approach may be needed to reduce the variability in biomass estimates.

Minimum sample sizes for rockfish age compositions should be established (e.g., using the methods of proportional allocation, p. 306-312 Quinn and Deriso, 1999) as sufficient sample size for age compositions are required to adequately resolve recent year classes. For example, fishery length compositions indicate the recruitment of smaller fish to the population during the years 2002 and 2003 (Figure 8-1). The fishery age compositions from 2002 may also indicate that 1994 is emerging as a strong year class. However the age composition sample size (195) appears to be too small to adequately resolve recent year classes (Figure 8-2).

8.11.3 Assessment Model Formulation

Examine a new Gulf of Alaska northern rockfish model which incorporates the refinements made this year to the Gulf of Alaska Pacific ocean perch model (Model 2) discussed above. Project catch from the Gulf of Alaska northern rockfish model at mid year rather than the beginning of the year. Estimate historical fishing mortality for Gulf of Alaska northern rockfish from the foreign Gulf of Alaska fishery from the early 1960's to 1977.

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Table 8-1.–Historical commercial catch[a] (mt) of fish in the slope rockfish assemblage in the Gulf of Alaska, with Gulfwide values of acceptable biological catch (ABC) and fishing quotas[b] (mt), 1977-1992. Commercial catch (mt) of northern rockfish in the Gulf of Alaska, with Gulfwide values of acceptable biological catch (ABC) and total allowable catch (TAC), 1993-2003. Catches in 2003 updated through October 31, 2003.

		Regulatory area				Gulfwide Management value	
Year	Fishery category	Western	Central	Eastern	Gulfwide Total	ABC	Quota
1977	Foreign	6,282	6,166	10,993	23,441		
	U.S.	0	0	12	12		
	JV	-	-	-	-		
	Total	6,282	6,166	11,005	23,453	50,000	30,000
1978	Foreign	3,643	2,024	2,504	8,171		
	U.S.	0	0	5	5		
	JV	-	-	-	-		
	Total	3,643	2,024	2,509	8,176	50,000	25,000
1979	Foreign	944	2,371	6,434	9,749		
	U.S.	0	99	6	105		
	JV	1	31	35	67		
	Total	945	2,501	6,475	9,921	50,000	25,000
1980	Foreign	841	3,990	7,616	12,447		
	U.S.	0	2	2	4		
	JV	0	20	0	20		
	Total	841	4,012	7,618	12,471	50,000	25,000
1981	Foreign	1,233	4,268	6,675	12,176		
	U.S.	0	7	0	7		
	JV	1	0	0	1		
	Total	1,234	4,275	6,675	12,184	50,000	25,000
1982	Foreign	1,746	6,223	17	7,986		
	U.S.	0	2	0	2		
	JV	0	3	0	3		
	Total	1,746	6,228	17	7,991	50,000	11,475
1983	Foreign	671	4,726	18	5,415		
	U.S.	7	8	0	15		
	JV	1,934	41	0	1,975		
	Total	2,612	4,775	18	7,405	50,000	11,475
1984	Foreign	214	2,385	0	2,599		
	U.S.	116	0	3	119		
	JV	1,441	293	0	1,734		
	Total	1,771	2,678	3	4,452	50,000	11,475
1985	Foreign	6	2	0	8		
	U.S.	631	13	181	825		
	JV	211	43	0	254		
	Total	848	58	181	1,087	11,474	6,083
1986	Foreign	Tr	Tr	0	Tr		
	U.S.	642	394	1,908	2,944		
	JV	35	2	0	37		
	Total	677	396	1,908	2,981	10,500	3,702
1987	Foreign	0	0	0	0		
	U.S.	1,347	1,434	2,088	4,869		
	JV	108	4	0	112		
	Total	1,455	1,438	2,088	4,981	10,500	5,000
1988	Foreign	0	0	0	0		
	U.S.	2,586	6,467	4,718	13,771		
	JV	4	5	0	8		
	Total	2,590	6,471	4,718	13,779	16,800	16,800
1989	U.S.	4,339	8,315	6,348	19,002	20,000	20,000
1990	U.S.	5,203	9,973	5,938	21,114	17,700	17,700

Table 8-1.--(Continued)

Gulfwide

Year	Management subgroup	Regulatory area Western	Central	Eastern	Gulfwide Total	Management value ABC	Quota
1991	POP	1,589	2,956	2,087	6,631	5,800	5,800
	SR/RE	123	408	171	702	2,000	2,000
	Other slope	634	4,011	162	4,806	10,100	10,100
1992	POP	1,266	2,658	2,234	6,159	5,730	5,200
	SR/RE	115	1,367	683	2,165	1,960	1,960
	Other slope	1,068	7,495	875	9,438	14,060	14,060
1993	Northern	902	3,778	145	4,825	5,760	5,760
1994	Northern	1,394	4,519	55	5,968	5,760	5,760
1995	Northern	113	5,476	45	5,634	5,270	5,270
1996	Northern	173	3,146	24	3,343	5,270	5,270
1997	Northern	62	2,870	15	2,947	5,000	5,000
1998	Northern	67	2,974	10	3,051	5,000	5,000
1999	Northern	574	4,825	c	5,399	4,990	4,990
2000	Northern	747	2,578	c	3,325	5,120	5,120
2001	Northern	539	2,588	c	3,127	4,880	4,880
2002	Northern	337	2,997	c	3,334	4,980	4,980
2003	Northern	429	4,720	c	5,149	5,530	5,530

Note: There were no foreign or joint venture catches after 1988. Catches prior to 1989 are landed catches only. Catches in 1989 and 1990 also include fish reported in weekly production reports as discarded by processors. Catches in 1991-2001 also include discarded fish, as determined through a "blend" of weekly production reports and information from the domestic observer program.

Definitions of terms: JV = Joint venture; Tr = Trace catches; POP = Pacific ocean perch management subgroup (1991-present); SR/RE = shortraker/rougheye management subgroup (1991-present); Other slope = other slope rockfish management subgroup (in 1991-92 consisted of all species in the slope rockfish assemblage except for Pacific ocean perch and shortraker and rougheye rockfish.

[a]Catch defined as follows: 1977, all *Sebastes* rockfish for Japanese catch, and Pacific ocean perch for catches of other nations; 1978, Pacific ocean perch only; 1979-87, the 5 species comprising the Pacific ocean perch complex; 1988-90, the 18 species comprising the slope rockfish assemblage; 1991-93, the 20 species comprising the slope rockfish assemblage; 1994-2002 the 21 species comprising the slope rockfish assemblage.

[b]Quota defined as follows: 1977-86, optimum yield; 1987, target quota; 1988-2001 total allowable catch.

[c]For the years after 1998, exact catches in the Eastern area are not available because northern rockfish in this area were transferred to the "other slope rockfish" management category.

Sources: Catch: 1977-84, Carlson et al. (1986); 1985-88, Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 S.W. 5th Avenue, Portland, OR 97201; 1989-2002, National Marine Fisheries Service, Alaska Region, P.O. Box 21668, Juneau, AK 99802. ABC and Quota: 1977-1986 Karinen and Wing (1987); 1987-2000, Heifetz et al. (2000); 2001 and 2002, North Pacific Fishery Management Council News and Notes, Vol. 5-02, Dec. 2002. 605 W. 4th Ave., Suite 306, Anchorage, Alaska 99501-2252.

Table 8-2.–Estimated commercial catch (mt) of northern rockfish in the Gulf of Alaska, 1977-92. Estimates are based on extrapolation of catch composition data from the foreign and domestic observer programs.

Year	Foreign	Joint venture	Domestic	Total
1977	622	0	0	622
1978	553	0	0	553
1979	666	3	0	669
1980	809	Tr.[3]	0	809
1981	1,469	0	0	1,469
1982	3,914	0	0	3,914
1983	2,705	911	0	3,616
1984	489	492	N.a.[4]	N.a.
1985	Tr.	108	N.a.	N.a.
1986	Tr.	11	N.a.	N.a.
1987	0	51	N.a.	N.a.
1988	0	Tr.	N.a.	N.a.
1989	0	0	N.a.	N.a.
1990	0	0	1,697	1,697
1991	0	0	4,528	4,528
1992	0	0	7,770	7,770

[3]Tr. = trace
[4]N.a. = not available

Sources:

1977-88: Wall et al. (1978, 1979, 1980, 1981, 1982), Nelson et al. (1983), Berger et al. (1984, 1985, 1987, 1988), Berger and Weikart (1988, 1989)

1989: Heifetz et al. (1999)

1990-91: Data on file at National Marine Fisheries Service, Alaska Region, P.O. Box 21668, Juneau, AK 99802 and Domestic Observer Program, National Marine Fisheries Service, Alaska Fisheries Science Center, REFM Division, 7600 Sand Point Way N. E., Seattle, WA 98115

1992: Heifetz et al. (1999)

Table 8-3.--Catch (mt) of northern rockfish taken during research cruises in the Gulf of Alaska, 1977-2003. (Tr.=trace)

Year	Catch
1977	Tr.
1978	0.5
1979	1.0
1980	0.5
1981	8.4
1982	6.4
1983	1.7
1984	11.3
1985	10.8
1986	0.7
1987	40.6
1988	0.0
1989	0.2
1990	19.2
1991	0.0
1992	0.0
1993	20.8
1994	0.0
1995	0.0
1996	12.5
1997	0.0
1998	2.5
1999	13.2
2000	0.0
2001	23.4
2002	0.0
2003	5.6

Table 8-4.-- Fishery length compositions for northern rockfish in the Gulf of Alaska.

Length							Year							
class (cm)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
15-24	8	4	0	2	1	42	1	8	18	7	91	8	9	2
25	8	9	1	4	0	47	2	34	2	5	11	1	1	6
26	4	21	3	10	1	74	0	72	6	13	20	10	4	8
27	18	33	4	11	5	97	3	106	5	15	21	16	9	14
28	36	64	17	23	14	88	5	109	9	7	44	24	19	18
29	73	110	38	57	29	110	9	109	14	7	43	57	29	55
30	80	288	78	112	57	134	30	90	24	15	62	79	76	81
31	96	529	173	248	135	164	26	57	23	20	81	88	115	159
32	151	967	385	484	246	222	66	62	60	37	132	110	198	245
33	207	1,733	670	830	568	453	162	108	109	80	148	129	204	379
34	333	2,550	1,247	1,132	946	864	351	206	211	122	189	143	168	378
35	547	2,741	1,912	1,631	1,421	1,364	706	426	475	173	218	174	158	400
36	800	2,008	2,162	1,754	1,623	1,652	1,026	618	891	361	302	226	184	340
37	738	1,222	2,128	1,359	1,391	1,714	1,041	681	1,160	534	363	304	238	339
38	550	610	1,824	1,073	811	1,371	785	616	1,069	685	467	312	283	398
39	360	288	1,286	729	431	863	544	371	771	567	442	280	281	395
40	168	131	810	514	203	400	346	207	445	449	311	223	204	375
41	79	87	443	359	96	211	191	95	207	271	192	133	144	287
42	37	27	165	189	55	162	95	43	82	134	97	102	96	219
43	18	47	59	49	38	117	48	19	46	77	46	66	56	154
44	8	32	55	9	28	97	22	9	19	31	31	38	29	61
45-52	8	86	64	3	39	222	68	2	6	57	29	64	29	56
Total (n)	4,327	13,587	13,524	10,582	8,138	10,468	5,527	4,048	5,652	3,667	3,340	2,587	2,534	4,369
(# hauls)	41	135	112	93	90	114	89	59	84	176	255	244	218	285
Mean length	36.0	34.7	36.6	36.0	35.9	36.3	37.0	35.7	37.3	38.0	36.4	36.9	36.4	36.8

Table 8-5.-- Fishery age compositions for northern rockfish in the Gulf of Alaska. All age compositions are based on "break and burn" reading of otoliths.

Age class	1988	1999	Year 2000	2001	2002
2	-	-	-	-	-
3	-	-	-	-	-
4	-	-	-	-	1.03
5	-	0.65	0.17	-	-
6	0.38	0.32	2.38	1.11	3.08
7	0.76	0.65	0.51	5.54	6.67
8	3.23	0.00	1.53	2.44	0.51
9	2.47	4.22	1.87	3.10	6.67
10	3.42	1.30	4.24	3.77	0.51
11	5.88	2.92	3.06	4.88	2.05
12	7.21	3.90	5.77	4.21	4.10
13	9.11	4.87	5.43	5.32	5.13
14	9.49	6.17	4.75	5.10	3.08
15	7.02	12.66	7.30	3.99	5.64
16	7.40	6.49	9.51	5.32	4.10
17	3.23	5.84	6.62	8.43	7.18
18	3.61	4.22	5.94	5.99	6.15
19	2.28	1.95	2.38	4.43	7.18
20	2.47	2.27	2.21	2.66	3.08
21	4.17	3.25	1.19	3.55	3.59
22	4.93	2.92	4.41	1.77	2.05
23	3.42	7.47	3.40	3.33	0.51
24	2.85	4.22	4.58	3.33	2.05
25	2.47	0.97	2.21	4.43	2.05
26	2.47	2.60	2.89	4.21	1.03
27	1.14	1.62	1.36	1.33	3.08
28	0.95	4.22	2.04	2.00	0.51
29	2.66	3.57	2.38	0.89	2.05
30	1.90	2.27	4.07	1.77	2.05
31	0.57	2.92	1.87	2.00	1.54
32	0.95	1.30	1.36	1.33	2.56
33	1.14	0.32	1.02	0.89	1.54
34	-	0.65	0.17	0.44	0.51
35	0.19	0.65	0.34	0.22	1.03
36	-	-	0.34	0.22	0.51
37	0.19	0.65	0.17	1.11	0.51
38	1.33	0.32	0.17	0.67	0.51
39	0.19	0.32	0.51	-	1.03
40-67	0.57	1.30	1.87	0.22	5.13
Total (n)	527	308	589	451	195
(# hauls)	56	160	188	156	60
Mean age	17.69	19.63	19.03	18.10	19.75

Table 8-6.--Biomass estimates (mt), by statistical area, for northern rockfish in the Gulf of Alaska based on triennial and biennial trawl surveys. Gulfwide 95% confidence bounds are also listed.

	Statistical areas						Gulfwide 95% confidence bounds	
Year	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern	Total	Lower	Upper
1984	27,716	5,165	6,448	5	0	39,334	16,719	61,949
1987	45,038	13,794	77,084	500	0	136,417	58,120	214,713
1990	32,898	5,792	68,044	343	0	107,076	12,973	201,179
1993	13,995	40,446	49,998	41	0	104,480	30,931	178,029
1996	28,114	40,447	30,212	192	0	98,965	46,306	151,625
1999	45,457	29,946	166,665	118	0	242,187	0	562,738
2001	93,291	24,490	225,833	117[a]	0[a]	343,731	0	746,461
2003	9,146	49,793	7,425	5	0	66,368	1,781	130,955

[a]Biomass estimates are not available for the Yakutat and Southeastern areas in 2001because these areas were not sampled that year. Substitute values are listed in this table and were obtained by averaging the biomass estimates for each of these areas in the 1993, 1996, and 1999 surveys.

Table 8-7.--Survey age compositions for northern rockfish in the Gulf of Alaska. All age compositions are based on "break and burn" reading of otoliths.

Age class	1984	1987	Year 1990	1993	1996	1999	2001
2	-	-	-	0.03	0.28	-	0.02
3	-	0.30	0.06	0.28	0.30	0.03	0.62
4	-	1.67	0.19	0.31	0.13	0.16	0.08
5	1.48	5.18	2.91	0.85	0.21	1.05	0.44
6	4.10	3.84	5.42	1.07	1.13	0.27	1.25
7	8.91	2.89	2.65	1.09	0.58	0.94	5.05
8	18.34	0.29	4.08	6.34	2.07	0.89	0.71
9	10.83	2.85	5.38	11.98	4.10	4.23	3.72
10	5.08	10.15	4.47	6.53	5.31	2.77	6.97
11	4.63	11.24	5.77	10.31	8.52	7.92	8.23
12	2.59	11.25	3.52	4.44	7.58	6.92	4.68
13	7.23	3.46	5.36	4.90	7.72	5.42	3.40
14	6.81	4.32	8.24	4.02	4.02	5.62	4.60
15	6.35	1.42	9.71	2.44	3.29	7.82	5.53
16	4.05	3.71	5.08	5.19	3.87	9.16	5.22
17	1.98	10.43	5.08	3.14	1.65	1.56	6.75
18	1.90	4.15	0.67	3.97	3.41	7.21	7.77
19	0.59	8.10	1.12	2.81	5.44	1.88	1.76
20	0.76	2.76	6.56	0.40	8.78	1.30	0.95
21	0.32	2.59	6.63	2.32	2.77	3.00	0.89
22	1.01	0.71	4.58	3.41	3.06	2.19	1.99
23	3.25	0.66	1.92	4.45	3.02	2.51	2.24
24	2.16	0.29	0.89	4.46	3.33	3.03	6.27
25	0.66	0.40	0.97	4.64	2.68	1.96	2.23
26	0.33	1.76	3.37	0.69	5.22	1.50	2.92
27	1.06	2.62	0.64	1.68	1.36	3.35	1.66
28	0.37	1.23	1.17	2.22	1.47	2.48	0.86
29	0.94	0.31	0.18	0.57	2.75	2.40	0.90
30	-	0.23	0.98	-	0.57	1.65	2.22
31	0.42	0.53	0.96	0.24	0.75	2.39	2.12
32	1.40	-	0.90	0.95	0.42	4.54	0.86
33-60	2.45	0.66	0.54	4.26	4.20	3.85	7.08
Total (n)	356	497	442	354	462	293	278
(# hauls)	6	17	14	20	19	29	47
Mean age	13.15	14.21	15.39	16.21	17.81	18.56	18.15

Table 8-8. Estimated time series of female spawning biomass, total exploitable biomass, 6+ biomass (age 6 and greater), catch/(6+ biomass), and the number of age two recruits for northern rockfish in the Gulf of Alaska based an age structured model.

Year	Spawning biomass (mt)		Total exploitable biomass (mt)		6+ Total Biomass (mt)		Catch / (6+ Total biomass)		Age two recruits (1000's)	
	Current	Previous	Current	Previous	Current	Previous	Current	Previous	Current	Previous
1977	25,489	26,000	71,536	78,831	92,351	99,101	0.007	0.006	29,523	36,814
1978	26,146	26,926	78,381	87,047	93,702	100,792	0.006	0.005	67,574	68,465
1979	27,230	28,343	85,551	95,277	98,119	106,701	0.007	0.006	17,352	25,403
1980	28,671	30,170	91,623	101,701	99,981	108,524	0.008	0.007	15,735	11,129
1981	30,387	32,315	96,217	106,703	105,176	115,441	0.014	0.013	7,213	10,545
1982	32,100	34,480	98,149	109,878	118,026	128,766	0.033	0.030	15,772	21,998
1983	33,074	35,928	99,101	111,987	119,166	131,792	0.030	0.027	19,735	25,126
1984	34,101	37,398	101,435	115,432	119,764	131,703	0.008	0.008	26,906	37,781
1985	35,954	39,628	106,935	121,695	120,610	133,230	0.001	0.001	22,884	17,799
1986	38,071	42,091	113,405	128,166	123,271	137,188	0.002	0.002	59,506	64,377
1987	40,130	44,477	117,836	132,639	126,240	141,378	0.004	0.003	16,043	21,298
1988	42,077	46,736	119,733	135,424	130,287	147,880	0.008	0.007	16,754	12,648
1989	43,700	48,670	121,045	138,006	132,845	149,700	0.011	0.010	19,441	21,919
1990	45,036	50,321	122,680	141,206	142,732	160,605	0.012	0.011	16,329	21,181
1991	46,155	51,754	125,239	144,984	144,331	163,303	0.031	0.028	4,472	3,338
1992	46,093	52,010	125,794	146,159	142,781	160,847	0.054	0.048	24,442	17,020
1993	44,817	51,050	123,696	144,089	138,309	156,553	0.035	0.031	12,511	2,549
1994	44,475	50,942	123,813	143,464	135,709	154,588	0.044	0.039	8,185	5,741
1995	43,732	50,374	121,374	140,199	129,218	147,523	0.044	0.038	2,312	3,940
1996	43,053	49,786	117,367	135,477	126,715	142,970	0.026	0.023	31,265	18,152
1997	43,055	49,789	115,224	132,220	124,098	137,430	0.024	0.021	4,959	18,997
1998	43,046	49,678	113,004	128,548	120,742	132,398	0.025	0.023	17,990	18,997
1999	42,776	49,187	110,274	123,940	115,714	126,541	0.047	0.043	17,990	18,997
2000	41,335	47,387	105,259	116,535	114,104	121,163	0.029	0.027	17,990	18,997
2001	40,501	46,076	102,174	111,020	109,672	115,141	0.029	0.027	17,990	18,997
2002	39,583	44,573	98,687	105,611	105,133	109,202	0.032	0.031	17,990	18,997
2003	38,445	42,743	95,098	105,263	100,110	108,834	0.051		17,990	18,997
2004*	36,482		90,058		95,149				17,990	

* Projected biomass based on average recruitment of 1977-1995 yearclasess.

Table 8-9. Estimated numbers (thousands) in 2004, fishery selectivity (assumed equal to survey selectivity) of northern rockfish in the Gulf of Alaska based on an age structured model. Also shown are schedules of age specific weight and female maturity.

Age	Numbers (1000's)	Percent mature	Weight (g)	Fishery/Survey selectivity
2	17,990	1	63	2
3	7,514	2	103	4
4	6,635	3	153	7
5	4,601	4	210	12
6	10,442	6	273	20
7	3,107	9	336	32
8	3,133	13	399	47
9	3,092	18	458	66
10	17,871	25	512	87
11	1,202	33	561	100
12	3,858	43	603	100
13	5,362	52	641	100
14	9,513	62	672	100
15	1,579	71	699	100
16	5,235	78	722	100
17	5,662	84	740	100
18	4,420	89	756	100
19	3,825	92	769	100
20	12,833	95	780	100
21	4,483	96	788	100
22	4,814	97	795	100
23+	42,295	98	801	100

Table 8-10. Northern rockfish spawning biomass, fishing mortality, and yield for seven harvest scenarios. B40% = 23,929 mt, B35% = 20,938 mt, F40% = 0.057, F35% = 0.068.

Year	Maximum permissible F	Author's F	Half maximum F	5-year average F	No fishing	Overfished	Approaching overfished?
Spawning biomass (mt)							
2003	38,445	38,445	38,445	38,445	38,445	38,445	38,445
2004	36,433	36,433	36,433	36,433	36,433	36,433	36,433
2005	34,454	34,454	35,438	35,407	36,450	34,079	34,454
2006	32,523	32,523	34,401	34,342	36,389	31,822	32,523
2007	30,676	30,676	33,352	33,267	36,266	29,696	30,343
2008	28,911	28,911	32,288	32,179	36,069	27,699	28,292
2009	27,290	27,290	31,276	31,145	35,864	25,887	26,427
2010	25,836	25,836	30,345	30,196	35,681	24,278	24,768
2011	24,577	24,577	29,533	29,366	35,554	22,898	23,340
2012	23,538	23,538	28,875	28,693	35,530	21,826	22,199
2013	22,763	22,763	28,407	28,211	35,658	21,063	21,376
2014	22,240	22,240	28,121	27,913	35,938	20,561	20,822
2015	21,947	21,947	28,026	27,806	36,397	20,290	20,507
2016	21,846	21,846	28,104	27,872	37,025	20,206	20,385
Fishing mortality							
2003	0.057	0.057	0.057	0.057	0.057	0.057	0.057
2004	0.057	0.057	0.029	0.030	0.000	0.068	0.057
2005	0.057	0.057	0.029	0.030	0.000	0.068	0.057
2006	0.057	0.057	0.029	0.030	0.000	0.068	0.068
2007	0.057	0.057	0.029	0.030	0.000	0.068	0.068
2008	0.057	0.057	0.029	0.030	0.000	0.068	0.068
2009	0.057	0.057	0.029	0.030	0.000	0.068	0.068
2010	0.057	0.057	0.029	0.030	0.000	0.068	0.068
2011	0.057	0.057	0.029	0.030	0.000	0.065	0.067
2012	0.056	0.056	0.029	0.030	0.000	0.062	0.063
2013	0.054	0.054	0.029	0.030	0.000	0.060	0.061
2014	0.053	0.053	0.029	0.030	0.000	0.058	0.059
2015	0.052	0.052	0.029	0.030	0.000	0.057	0.058
2016	0.052	0.052	0.029	0.030	0.000	0.057	0.058
Yield (mt)							
2003	5,149	5,149	5,149	5,149	5,149	5,149	5,149
2004	4,868	4,868	2,468	2,542	0	5,783	4,868
2005	4,586	4,586	2,389	2,460	0	5,390	4,586
2006	4,282	4,282	2,292	2,357	0	4,981	5,087
2007	4,021	4,021	2,208	2,269	0	4,631	4,727
2008	3,805	3,805	2,140	2,198	0	4,342	4,428
2009	3,629	3,629	2,087	2,141	0	4,107	4,183
2010	3,492	3,492	2,048	2,100	0	3,922	3,992
2011	3,413	3,413	2,034	2,085	0	3,646	3,771
2012	3,312	3,312	2,045	2,096	0	3,446	3,551
2013	3,225	3,225	2,072	2,122	0	3,341	3,427
2014	3,177	3,177	2,102	2,152	0	3,292	3,363
2015	3,165	3,165	2,134	2,184	0	3,289	3,346
2016	3,182	3,182	2,166	2,217	0	3,319	3,365

Table 8-11. Analysis of ecosystem considerations for slope rockfish.

Indicator	*Observation*	*Interpretation*	*Evaluation*
ECOSYSTEM EFFECTS ON STOCK			
Prey availability or abundance trends	important for larval and post-larval survival, but no information known	may help to determine year class strength	possible concern if some information available
Predator population trends	unknown		little concern for adults
Changes in habitat quality	variable	variable recruitment	possible concern
FISHERY EFFECTS ON ECOSYSTEM			
Fishery contribution to bycatch			
Prohibited species	unknown		
Forage (including herring, Atka mackerel, cod, and pollock)	unknown		
HAPC biota (seapens/whips, corals, sponges, anemones)	fishery disturbing hard-bottom biota, i.e., corals, sponges	could harm the ecosys- tem by reducing shelter for some species	concern
Marine mammals and birds	probably few taken		little concern
Sensitive non-target species	unknown		
Fishery concentration in space and time	little overlap be- tween fishery and reproductive activities	fishery does not hinder reproduction	little concern
Fishery effects on amount of large size target fish	no evidence for tar- geting large fish	large fish and small fish are both in population	little concern

Indicator	*Observation*	*Interpretation*	*Evaluation*
Fishery contribution to discards and offal production	discard rates moderate to high for some species of slope rockfish	little unnatural input of food into the ecosystem	some concern
Fishery effects on age-at-maturity and fecundity	**fishery is catching some immature fish**	**could reduce spawning potential and yield**	possible concern

Table 8-12. Average bycatch (kg) and bycatch rates during 1997 - 99 of living substrates in the Gulf of Alaska; POT - pot gear; BTR - bottom trawl; HAL - Hook and line (source - Draft Programmatic SEIS).

		Bycatch (kg)				Target	Bycatch rate (kg/mt target)			
Target fishery	Gear	Coral	Anemone	Sea whips	Sponge	catch (mt)	Coral	Anemone	Sea whips	Sponge
Arrowtooth flounder	POT	0	0	0	0	4	0.0000	0.0000	0.0000	0.0000
Arrowtooth flounder	BTR	58	99	13	24	2,097	0.0276	0.0474	0.0060	0.0112
Deep water flatfish	BTR	1,626	481	5	733	2,001	0.8124	0.2404	0.0024	0.3663
Rex sole	BTR	321	306	11	317	2,157	0.1488	0.1417	0.0053	0.1468
Shallow water flatfish	POT	0	0	0	0	5	0.0000	0.0000	0.0000	0.0000
Shallow water flatfish	BTR	53	4,741	115	403	2,024	0.0261	2.3420	0.0567	0.1993
Flathead sole	BTR	3	267	1	136	484	0.0071	0.5522	0.0019	0.2806
Pacific cod	HAL	28	4,419	961	33	10,765	0.0026	0.4105	0.0893	0.0030
Pacific cod	POT	0	14	0	1,724	12,863	0.0000	0.0011	0.0000	0.1340
Pacific cod	BTR	34	5,767	895	788	37,926	0.0009	0.1521	0.0236	0.0208
Pollock	BTR	1,153	55	0	23	2,465	0.4676	0.0222	0.0000	0.0092
Pollock	PTR	41	110	0	0	97,171	0.0004	0.0011	0.0000	0.0000
Demersal shelf rockfish	HAL	0	0	0	141	226	0.0000	0.0000	0.0000	0.6241
Northern rockfish	BTR	25	90	0	103	1,938	0.0127	0.0464	0.0000	0.0532
Other slope rockfish	HAL	0	0	0	0	14	0.0000	0.0000	0.0000	0.0000
Other slope rockfish	BTR	0	0	0	0	193	0.0000	0.0000	0.0000	0.0000
Pelagic shelf rockfish	HAL	0	0	0	0	203	0.0000	0.0000	0.0000	0.0000
Pelagic shelf rockfish	BTR	324	176	3	245	1,812	0.1788	0.0969	0.0017	0.1353
Pacific ocean perch	BTR	549	90	5	1,968	6,564	0.0837	0.0136	0.0007	0.2999
Pacific ocean perch	PTR	7	0	0	55	1,320	0.0052	0.0000	0.0000	0.0416
Shortraker/rougheye	HAL	6	0	0	0	19	0.3055	0.0000	0.0000	0.0000
Shortraker/rougheye	BTR	0	18	0	0	21	0.0000	0.8642	0.0000	0.0000
Sablefish	HAL	156	154	68	27	11,143	0.0140	0.0138	0.0061	0.0025
Sablefish	BTR	0	0	0	0	27	0.0000	0.0000	0.0000	0.0000
Shortspine thornyhead	HAL	0	0	0	0	2	0.0000	0.0000	0.0000	0.0000
Shortspine thornyhead	BTR	0	9	0	1	2	0.0000	4.8175	0.0000	0.4069

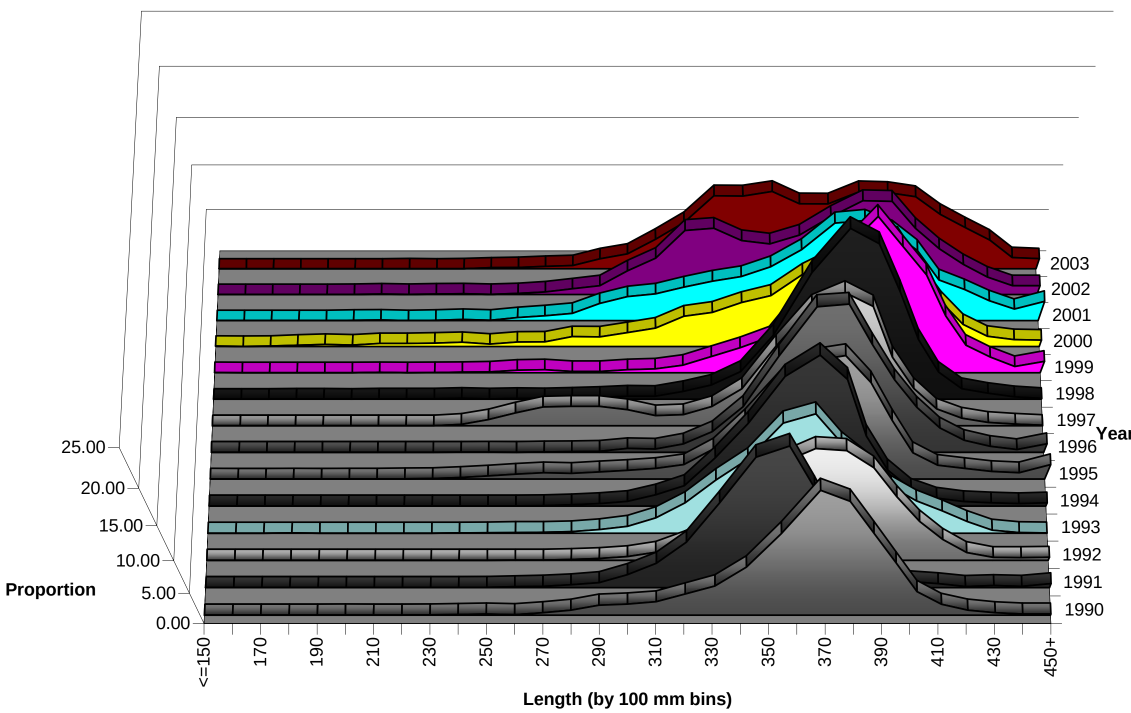

Figure 8-1.– Fishery length compositions for northern rockfish in the Gulf of Alaska.

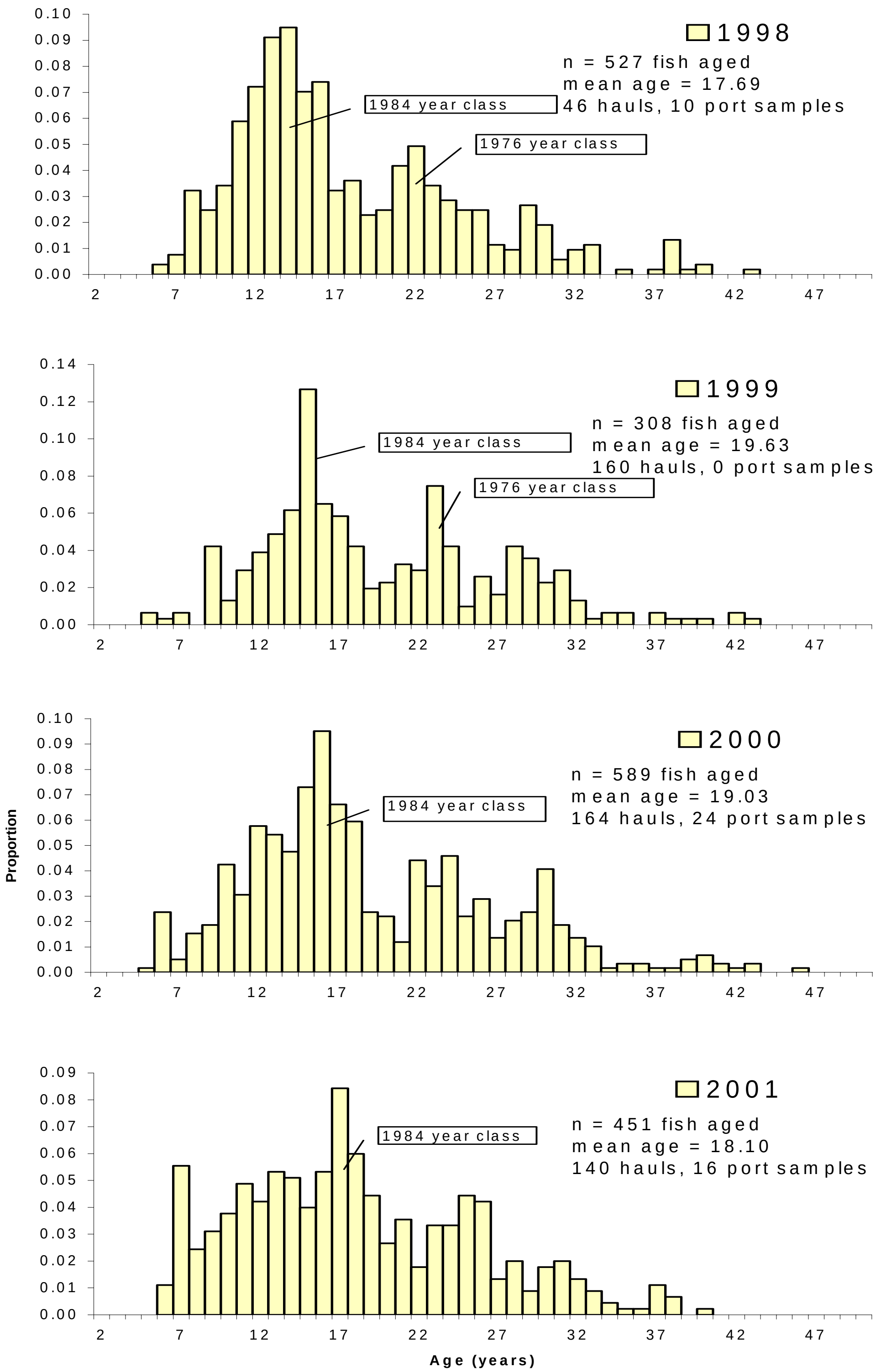

Figure 8-2.–Fishery age compositions for northern rockfish in the Gulf of Alaska.

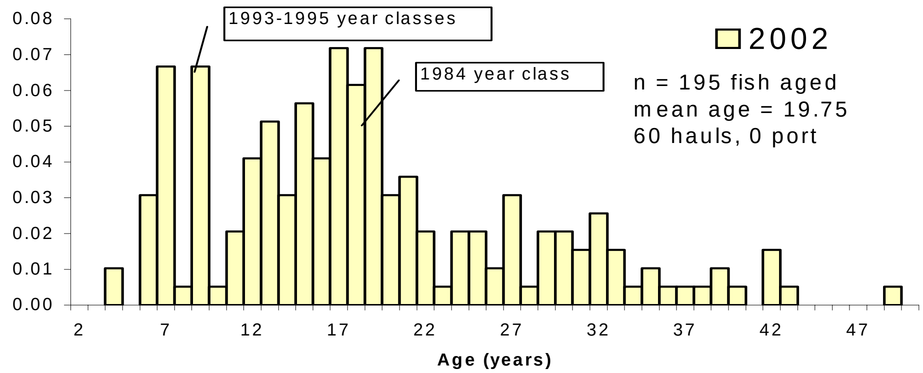

Figure 8-2.–Continued.

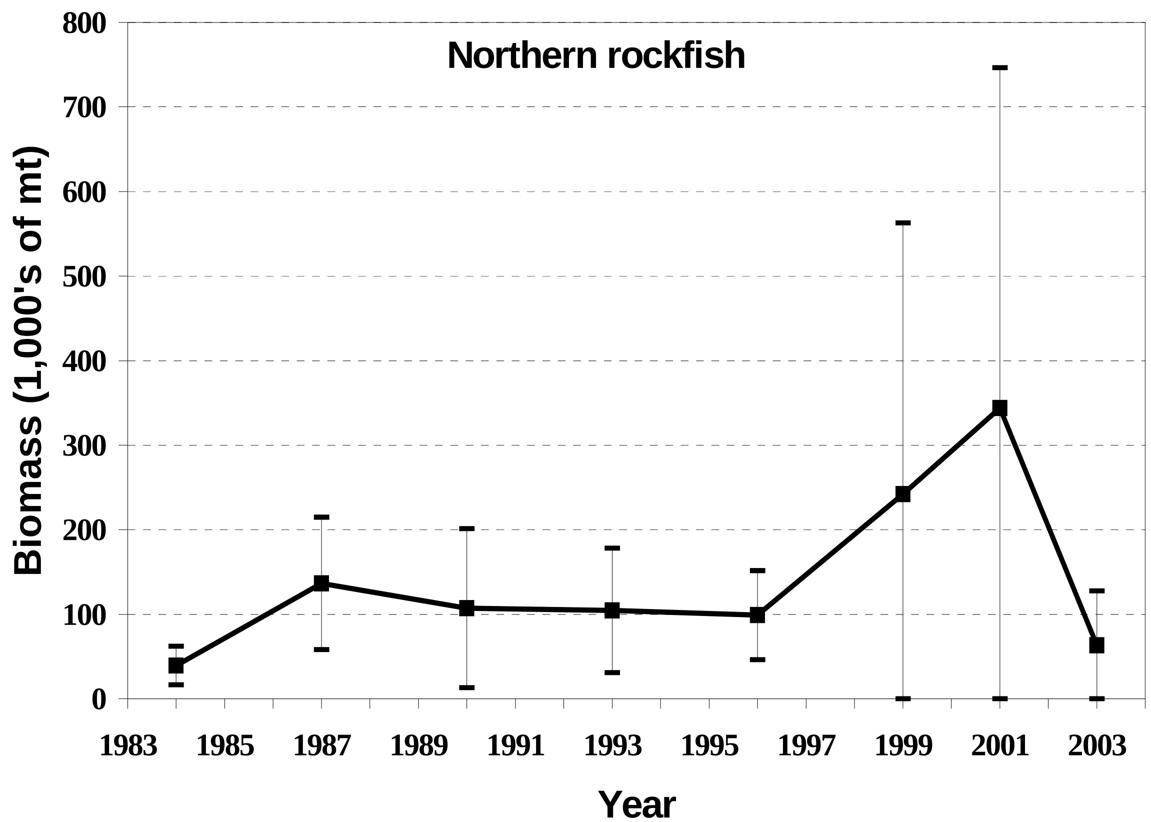

Figure 8-3.--Estimated biomass of northern rockfish in the Gulf of Alaska based on trawl surveys from 1984 to 2003. The vertical bars show the 95% confidence limits associated with each estimate.

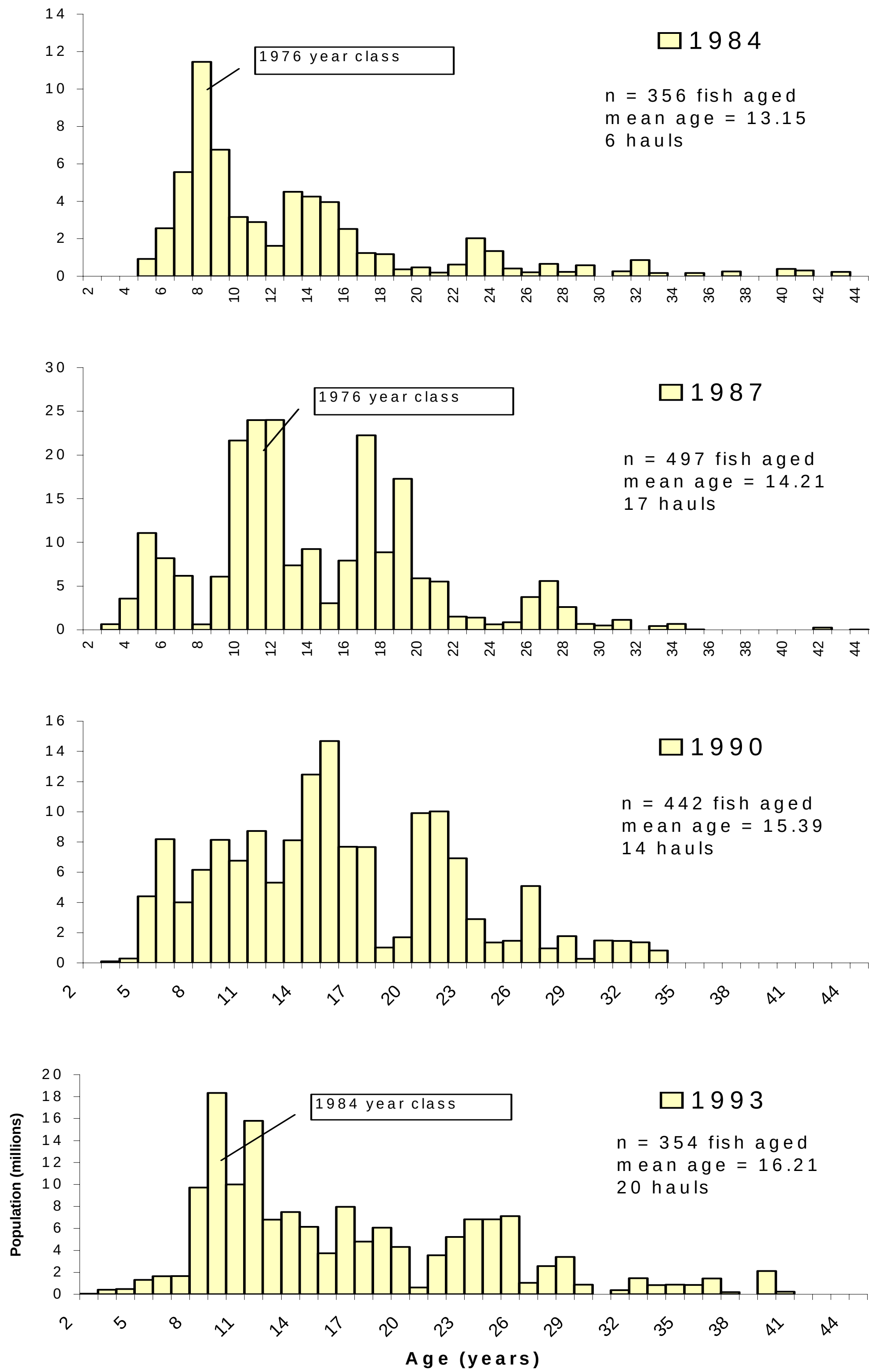

Figure 8-4.–Survey age compositions (estimated population in millions) for northern rockfish in the Gulf of Alaska.

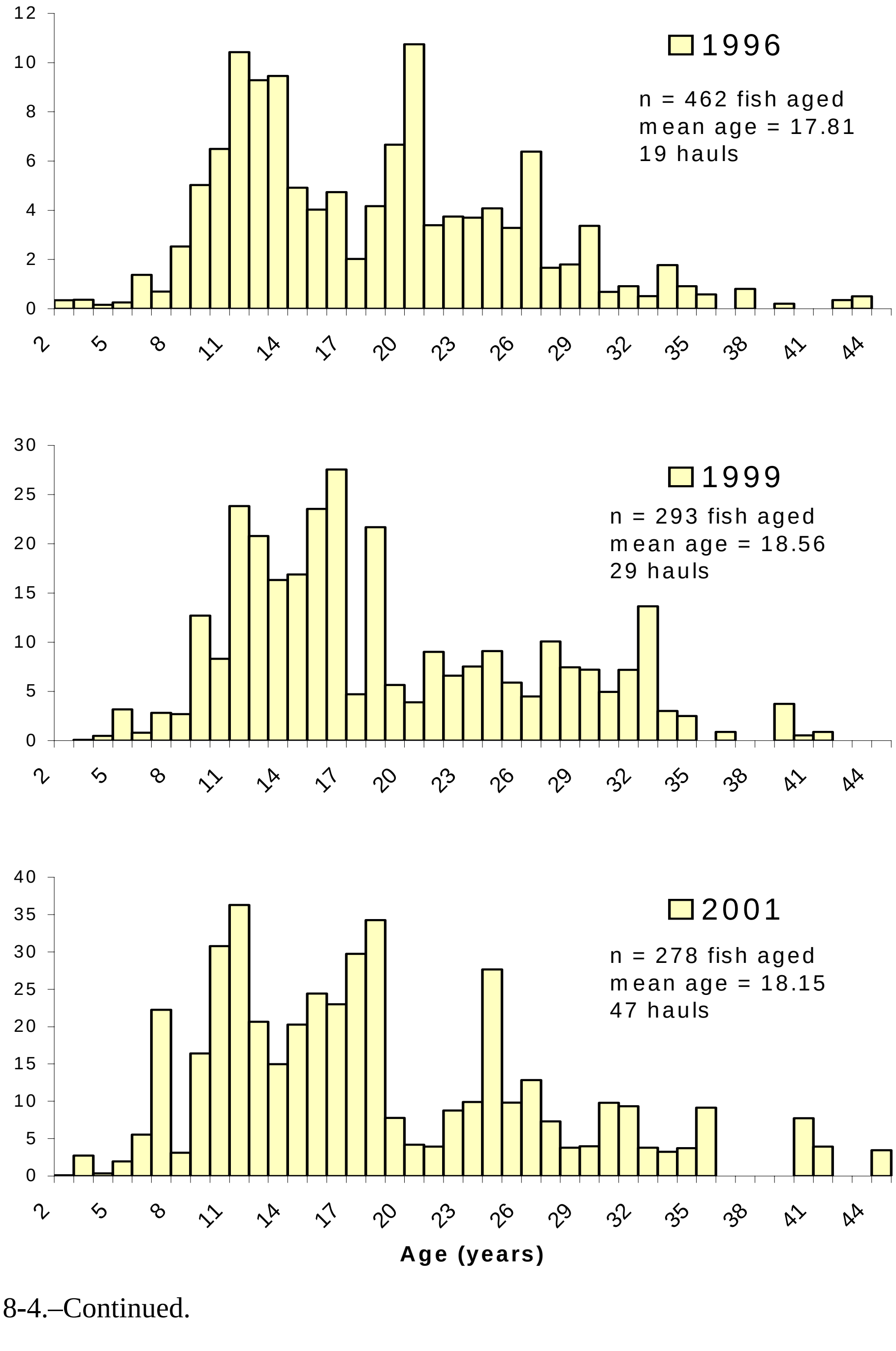

Figure 8-4.–Continued.

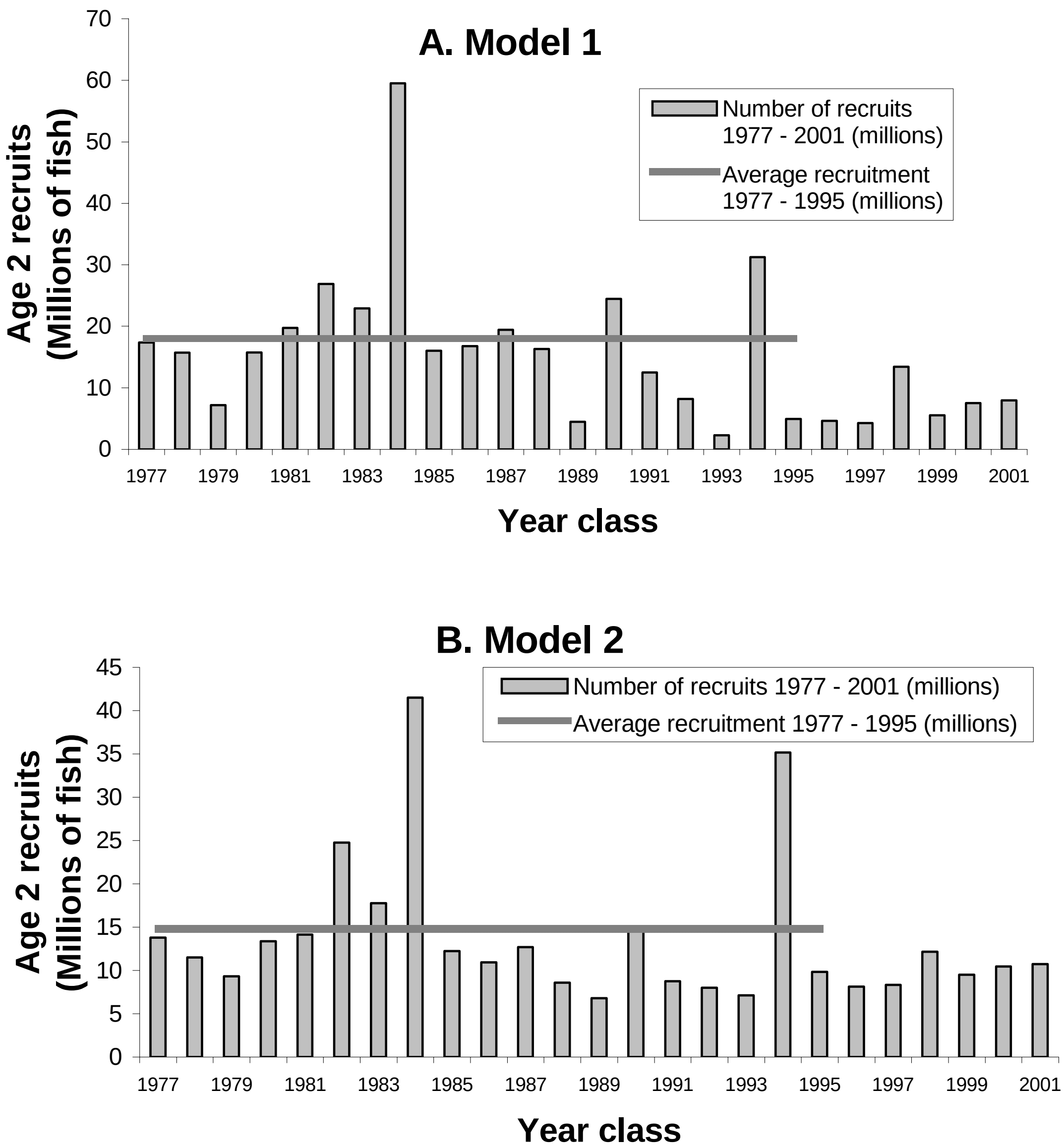

Figure 8-5. Number of recruits and average recruitment for year classes 1977 - 1995 from the age structured models for Gulf of Alaska northern rockfish.

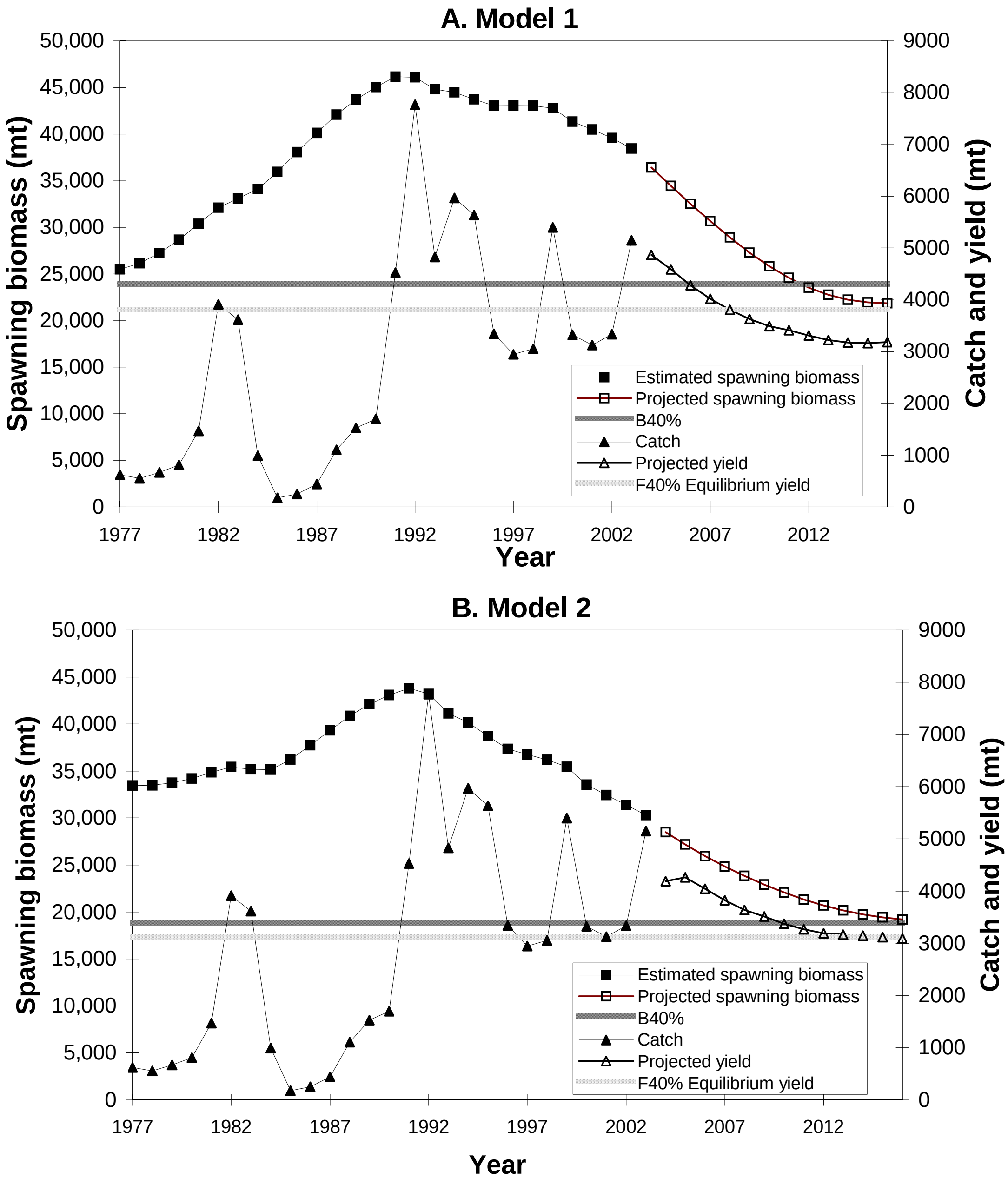

Figure 8-6. Recent trend and long term projection of spawning biomass and yield of northern rockfish in the Gulf of Alaska based on tier 3 computations. At average recruitment (based on 1977-1995 year classes) the spawning biomass is projected to fall below B40% in 2012 and the catch is projected to fall below F40% equilibrium in 2009 for Model 1.

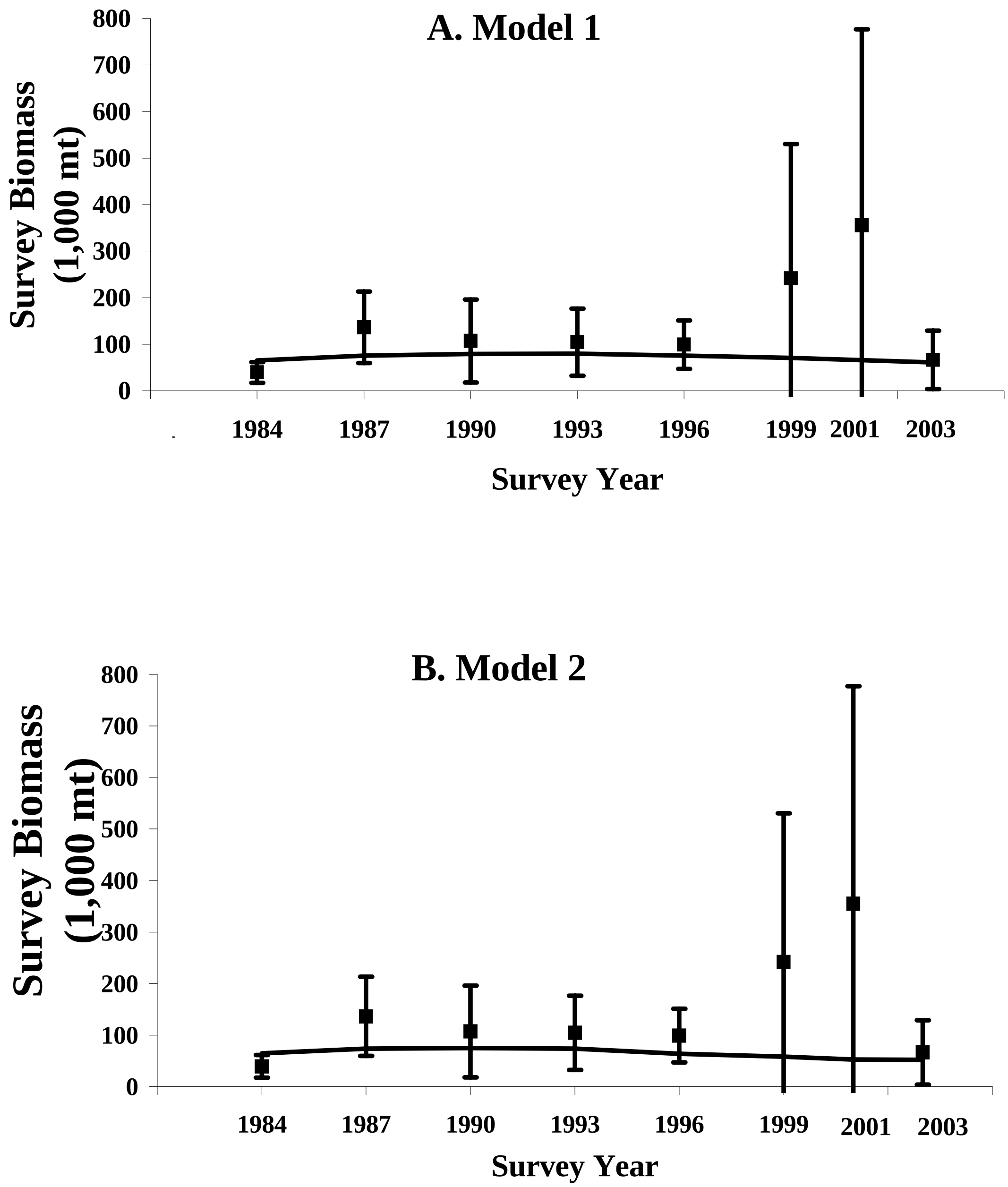

Figure 8-7. Observed and predicted survey biomass for northern rockfish in the Gulf of Alaska based on the age structured models. Ninety-five percent confidence limits sown for each biomass estimate.

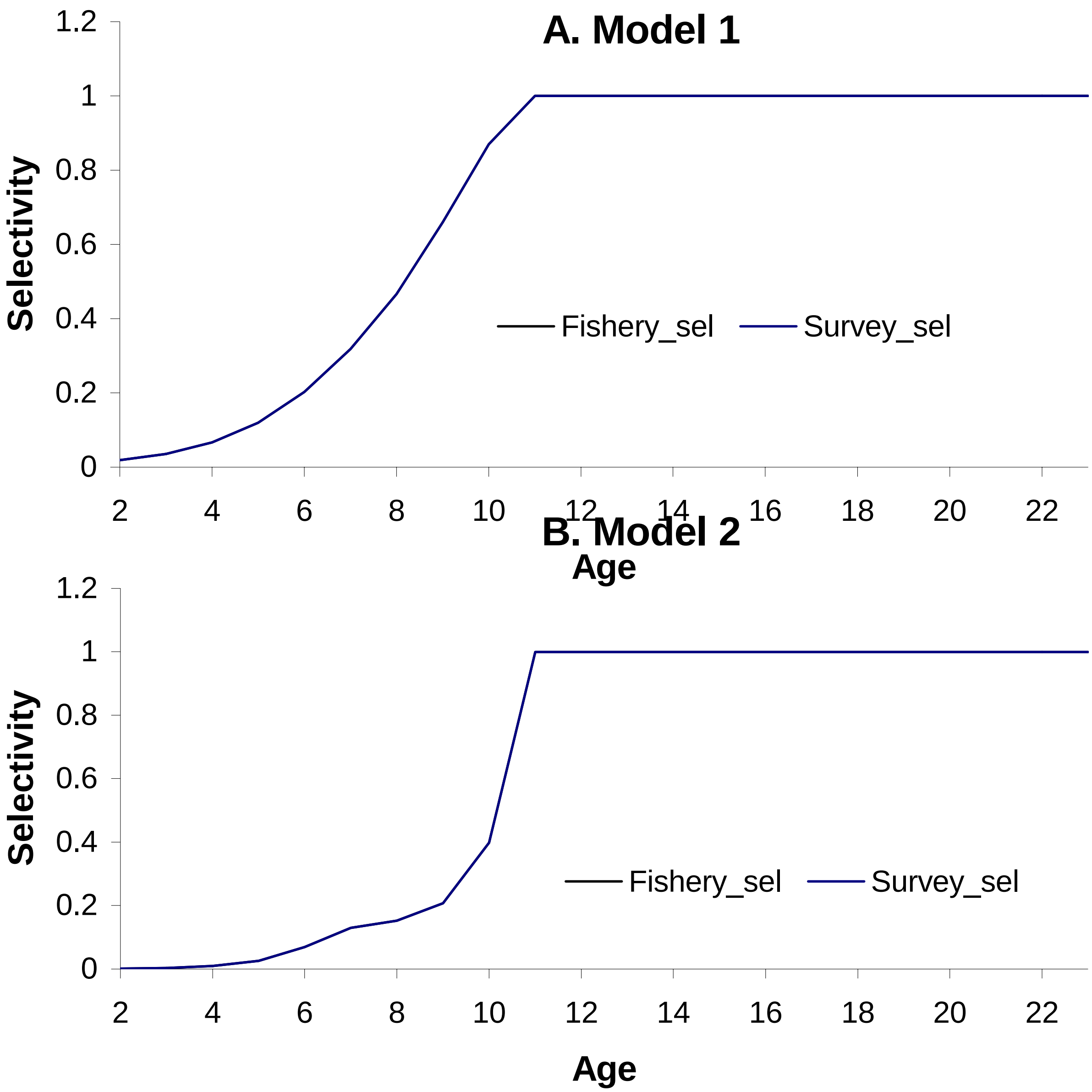

Figure 8-8. Estimated fishery and survey selectivity at age from the age structured models.

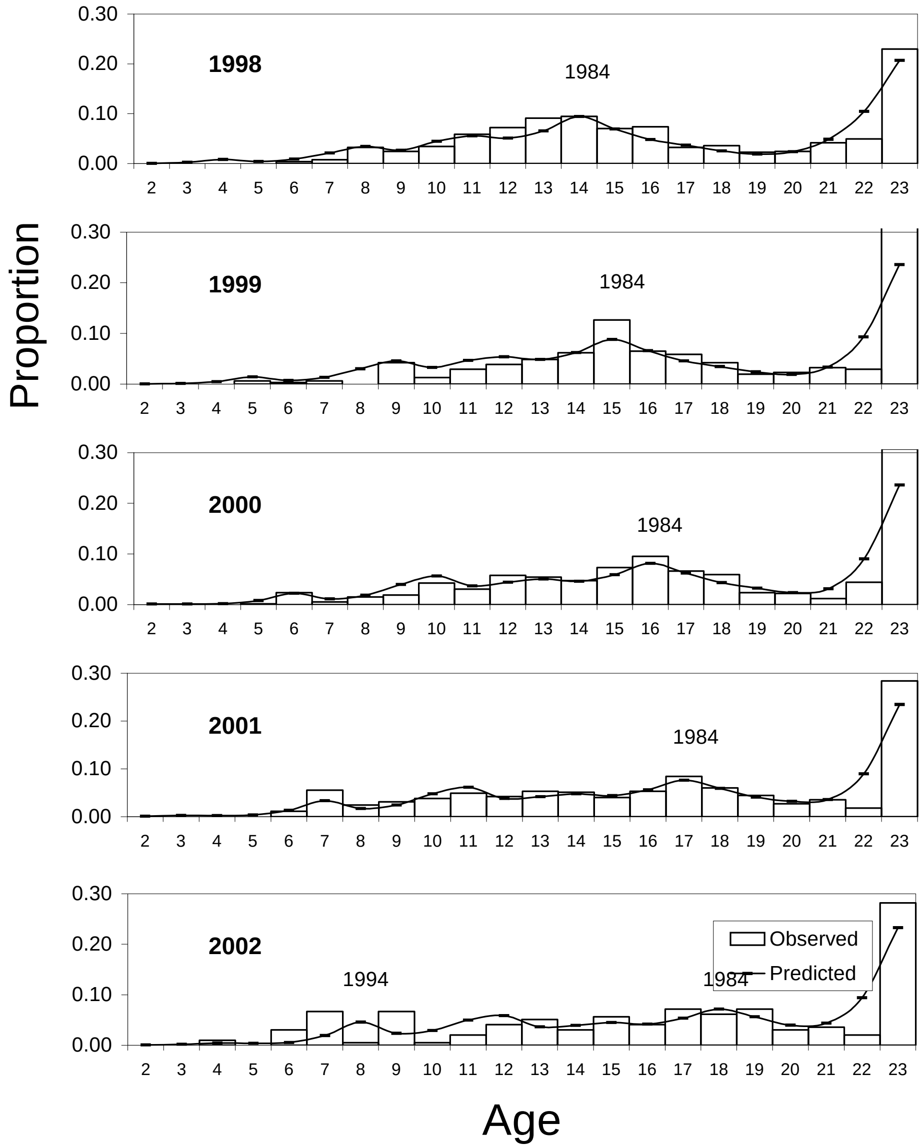

Figure 8-9. Model 1observed and predicted fishery age compositions for northern rockfish in the Gulf of Alaska.

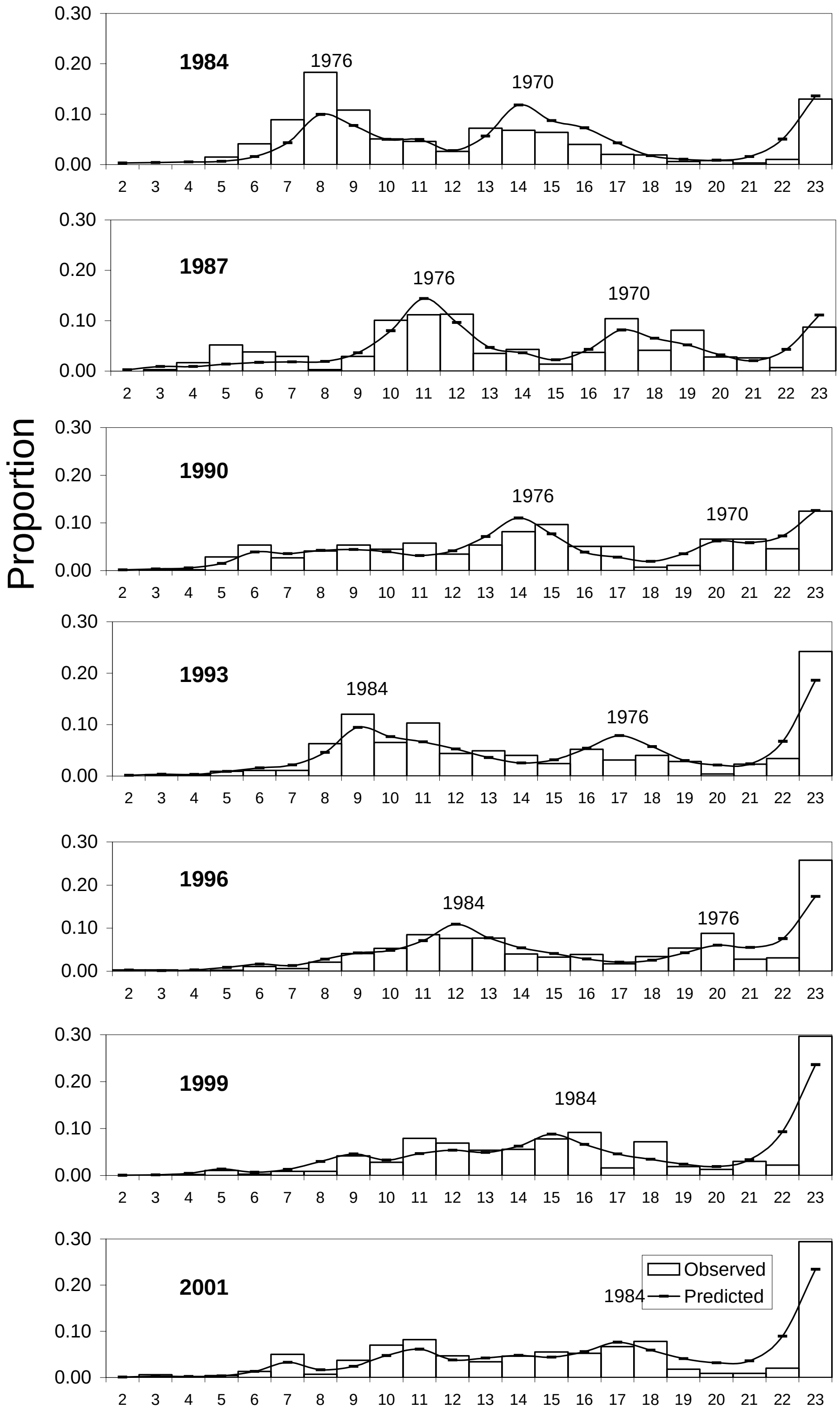

Figure 8-10. Model 1 observed and predicted survey age compositions for northern rockfish in the Gulf of Alaska.

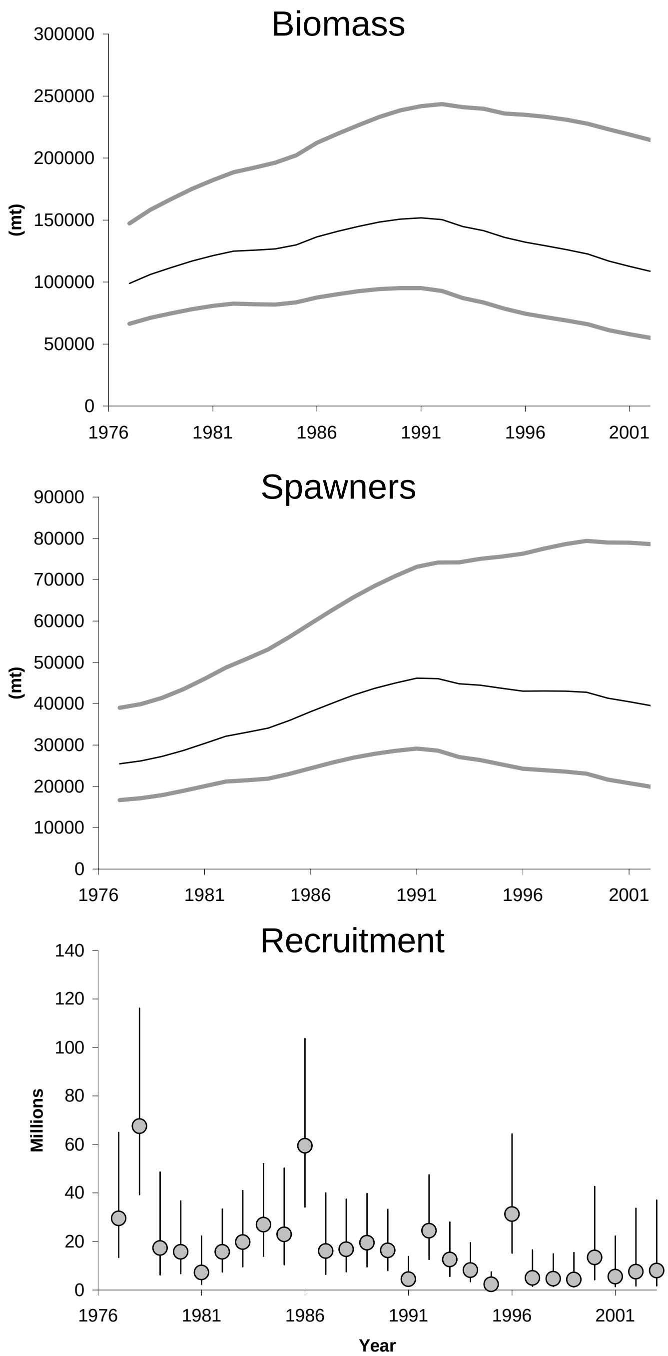

Figure 8-11. Model 1 biomass, spawners and recruitment estimates with 95% confidence interval from model covariance matrix.

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