Section 6

SLOPE ROCKFISH

by

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Executive Summary

Pacific ocean perch

For Pacific ocean perch, the model from last year's SAFE was used. ABC is based on a projection with updated catch data. Based on this projection the recommended ABC is 13,510 mt. The corresponding reference values for Pacific ocean perch are summarized in the following:

$B_{40\%}$ (mt)	110,120
B_{2001} (mt)	95,760
$F_{40\%}$	0.078
F_{ABC} (maximum allowable)	0.067
ABC (mt; maximum allowable)	13,510

We have constructed a stock assessment model for Pacific ocean perch using AD Model Builder software. We have configured the model similar to the stock synthesis model and using the same data. Initial exploratory runs of the model have been completed and we are resolving differences in model output between the stock synthesis and AD Model Builder versions. We anticipate that the AD Model Builder version will be used for next year's assessment.

Northern rockfish

For the first time the stock assessment for northern rockfish is based on an age-structured model constructed using AD Model Builder software. A detailed report describing the model configuration and preliminary results was presented in last year's SAFE report (Courtney et al. 1999). New data added for this assessment included the 1999 survey age compositions, updated catch from 1999 and 2000 fishery, and the 1999 fishery length data.

A few minor improvements were made to the model configuration which resulted in a satisfactory description of the population dynamics. The most important of these improvements resulted in an improved fit to the survey age composition. This was accomplished by removing the survey length composition data from the model and increasing the likelihood weight for survey age composition from 1 to 10. Last year the Gulf of Alaska Plan Team pointed out that the survey length composition data was already used in the model to expand the stratified survey age data. Consequently, survey length composition was removed from the model in this year's assessment. Increasing the likelihood weight enabled the model to fit the survey age data in a manner analogous to the method used for the alternate case from last year. The actual value chosen for the weighting term was based on a sensitivity analysis conducted last year. The sensitivity test indicated that a weighting value of ten was just as effective at fitting the age data as the higher weight of fifty used in lat year's alternative case model, but that the lower weight had less of an impact on the fits to the other data.

Based on this assessment the recommended ABC for northern rockfish is 4,880 mt. This ABC is the maximum allowable ABC under tier 3. Justification of this ABC is based on the nearness of the age structured model's assessment to that recommended last year, 5,120 mt. The declining stock trend, the weakness of recent recruitment estimates, and uncertainty suggest that precaution is warranted for management of this stock. The corresponding reference values for northern rockfish are summarized in the following:

$B_{40\%}$ (mt)	21,830
B_{2001} (mt)	39,090
$F_{40\%}$	0.055
F_{ABC} (maximum allowable)	0.055
ABC (mt, maximum allowable)	4,880

Shortraker, rougheye, and other slope rockfish

As in the past, exploitable biomass for shortraker and rougheye rockfish and other slope rockfish has been estimated by the unweighted average of the last three trawl survey results, excluding the biomass in the 1-100 m depth stratum. The 1-100 m depth stratum was removed from the estimate because most slope rockfish in this stratum are small juvenile fish younger than the age of recruitment, and thus are not considered exploitable. This results in an exploitable biomass of 70,885 mt for shortraker/ rougheye rockfish and 102,505 mt for other slope rockfish. Applying a combination of F=M and F=0.75M rates results in ABC's of 1,730 mt for shortraker/rougheye rockfish and 4,900 mt for other slope rockfish.

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6.1 INTRODUCTION

At least 30 rockfish species of the genus *Sebastes* inhabit waters of the Gulf of Alaska (Eschmeyer et al. 1983), and many are commercially valuable. Since 1988 in this region, the North Pacific Fishery Management Council (NPFMC) has divided these species into three management assemblages based on their habitat and distribution: demersal shelf rockfish, pelagic shelf rockfish, and slope rockfish.

Slope rockfish are defined as those species of *Sebastes* that, as adults, inhabit waters of the outer continental shelf and continental slope of the Gulf of Alaska, generally in depths greater than 150-200 m. In contrast, shelf rockfish inhabit shallower, more inshore waters of the shelf. Based on these criteria, 21 species of rockfish are classified into the slope rockfish assemblage (Table 6-1). The assemblage is dominated by one species, Pacific ocean perch (*Sebastes alutus*), which has historically been the most abundant rockfish in this region and has provided most of the past commercial catch.

Slope rockfish are viviparous, with internal fertilization and release of live young. For most species insemination appears to occur in the fall, and release of larvae occurs during spring and early summer. Identification of the larvae of many species of slope rockfish is not yet possible (Gharrett et al. 2000). Consequently there is considerable uncertainty about the early life history of many species. Slope rockfish are very slow growing and long lived with natural mortality rates usually less than 0.10. Maximum ages differ by species and may be as great as 140 yrs as is the case for rougheye rockfish (*S. aleutianus*).

Few studies have been conducted on the stock structure of slope rockfish. For some species, differences among areas in age composition, growth, fecundity, and prevalence of parasites suggest separate populations at the adult stage (Gunderson 1972; Leaman and Kabata 1987; Moles et al. 1998). Based on allozyme variation, Seeb and Gunderson (1988) concluded that Pacific ocean perch are genetically quite similar throughout their range, and genetic exchange may be the result of dispersion at early life stages. In contrast, preliminary analysis using mitochondrial DNA techniques suggest that genetically distinct populations of Pacific ocean perch exist (A. J. Gharrett pers. commun., University of Alaska Fairbanks, October 2000). Hawkins et al. (1997) and Gharrett and Gray (1998) concluded that that two genetically distinct populations of rougheye rockfish exist with partially overlapping geographic ranges. Currently, genetic studies are underway that should clarify the genetic stock structure of some species of slope rockfish.

In 1991, the NPFMC divided the slope 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 and shortraker, rougheye, and northern rockfish (the most sought-after commercial species in the assemblage) from possible overfishing. Each subgroup is now assigned an individual TAC (total allowable catch), whereas prior to 1991, a single TAC was assigned to the entire assemblage. Each subgroup TAC is apportioned to the three management areas of the Gulf of Alaska based on distribution of exploitable biomass.

Amendment 58, which took effect in 1998, prohibited trawling in the Eastern area east of 140 degrees W. longitude. Since most slope rockfish, especially Pacific ocean perch, are caught exclusively with trawl gear, it is possible that the entire Eastern area TAC for some species could be taken in the small area in the Eastern area that will remain open to trawling. Alternative apportionment strategies are currently being evaluated by the Gulf of Alaska Plan Team.

6.2 FISHERY

6.2.1 Historical Background

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 (Fig. 1). 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) were caught. This apparent overfishing resulted in a precipitous decline in catches in the late 1960's. Catches continued to decline in the 1970's, and by 1978 catches were only 8,000 mt.

Detailed catch information for slope rockfish in the years since 1977 is listed in Table 6-2a for the commercial fishery and in Table 6-2b for research cruises. The reader is cautioned that actual catches of slope rockfish in the commercial fishery are only shown for 1988-2000; for previous years, the catches listed 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 6-2). The acceptable biological catches and quotas in Table 6-2 are Gulfwide values, but in actual practice the NPFMC has divided these into separate, annual apportionments for each of the three regulatory areas of the Gulf of Alaska.

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. Since 1996, catches of Pacific ocean perch have increased again, as good recruitment and increasing biomass for this species have resulted in larger TAC's.

Historically, bottom trawls have accounted for nearly all the commercial harvest of slope rockfish. In recent years, however, a sizeable percentage of the shortraker/rougheye rockfish catch has been taken by longlines, and a sizable portion of the Pacific ocean perch catch has been taken by pelagic trawls. In the years 1993-2000, longline catches on an annual basis have ranged from 30% to 48% of the total Gulfwide harvest of shortraker/rougheye. Most of the shortraker/rougheye taken on longlines are caught incidentally in the sablefish and halibut longline fisheries. The percentage of the Pacific ocean perch catches taken in pelagic trawls has increased from 2-8% during 1990-95 to 14-20% during 1996-98.

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 Pacific ocean perch and 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
Pacific ocean perch	49	28	32	41	52
Northern rockfish	32	32	53	44	73

Factory trawlers continued to take most of the catch in the Western and Eastern areas.

6.2.2 Species composition

Detailed species composition data for the "other slope rockfish" and shortraker/rougheye subgroups in the 1992-99 commercial fishery are available from the domestic observer program (Table 6-3). One caveat is that these data are based only on trips that had observers on board. Consequently, they may be somewhat biased toward larger vessels, which had more complete observer coverage. For the shortraker/rougheye subgroup, Table 6-3 shows that shortraker rockfish have usually predominated in the commercial catch composition. For "other slope rockfish", the percentage data in Table 6-3 can be applied to the commercial catches in Table 6-2 to yield the following Gulfwide estimates of catch in mt for each species:

	1992	1993	1994	1995	1996	1997	1998	2000
Northern rockfish	7,770	-	-	-	-	-	-	-
Sharpchin rockfish	434	1,345	330	342	278	316	319	169
Redstripe rockfish	261	1,222	207	198	134	291	51	107
Harlequin rockfish	745	1,864	789	667	403	492	443	438
Silvergrey rockfish	130	487	219	123	8	34	8	19
Yellowmouth rockfish	102	498	40	15	6	63	1	2
Redbanded rockfish	-	-	23	22	30	15	20	21
Other species	2	16	4	31	23	6	21	32

These data indicate that for the current subgroup (i.e., excluding northern rockfish), harlequin, sharpchin, redstripe, silvergrey, and yellowmouth rockfish have been the predominant species caught in the commercial fishery. Also, it should be noted that there was a substantial increase in the catch of these five species in 1993, when northern rockfish were removed from the subgroup. Apparently, removing northern rockfish resulted in an expansion in the fishery for the other species. In 1994-1998, however, the estimated catches for all these species decreased considerably, due at least in part to the lower TAC's set for the subgroup in these years. Catches have remained low since 1998 because of the trawl closure that began that year in the eastern Gulf of Alaska. Most of the biomass of "other slope rockfish" species is located in this area, and fishermen have apparently been unsuccessful or not interested in catching these species with non-trawl gear.

6.2.3 Bycatch

The only analysis of bycatch in slope rockfish fisheries of the Gulf of Alaska is that of Heifetz and Ackley (1997). They examined data from the observer program for the years 1993-95. For hauls targeting Pacific ocean perch, the major bycatch species were arrowtooth flounder, shortraker/rougheye rockfish, sablefish,

[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 September 30, 2000.

and “other slope rockfish”. (This was based only on data for 1995, as there was no directed fishery for Pacific ocean perch in 1993-94.) For hauls targeting on northern rockfish, the principle bycatch species was dusky rockfish, followed by “other slope rockfish”. Although regulations called for no directed fishing for shortraker/rougheye rockfish during these years, Heifetz and Ackley identified some hauls in which these two species were apparently targeted; the major bycatch in these hauls was arrowtooth flounder, sablefish, and shortspine thornyhead.

The bycatch of slope rockfish species in non-rockfish fisheries has not been well documented. As previously mentioned, a substantial portion of the shortraker/rougheye annual catch comes as bycatch in the longline fisheries for Pacific halibut and sablefish. Presumably, some slope rockfish are also taken in flatfish trawl fisheries.

6.2.4 Discards

Gulfwide discard rates[2] (% discarded) for the four slope rockfish management subgroups in the commercial fishery for 1991-2000 are listed as follows:

Year	Pacific ocean perch	Shortraker/ rougheye	Northern rockfish	Other slope rockfish
1991	15.7	42.0	-	20.0
1992	21.5	10.4	-	29.7
1993	79.2	26.8	26.5	48.9
1994	60.3	44.8	17.7	65.6
1995	19.8	30.7	12.7	72.5
1996	17.2	22.2	16.5	75.6
1997	14.3	22.0	27.8	52.1
1998	14.0	27.9	18.3	66.3
1999	13.8	30.6	11.1	68.7
2000	10.7	21.2	8.7	52.8

The high discard rates for Pacific ocean perch in 1993 and 1994 can be attributed to its "bycatch only" status for most of this time period. Relatively high discard rates are also seen for "other slope rockfish" in 1993-2000, after northern rockfish were no longer in the group. Many of the remaining species in this group, such as harlequin and sharpchin rockfish, are small in size and of lower economic value, and there may be less incentive for fishermen to retain these fish. The above table also indicates that discards of shortraker/rougheye have been moderately high and northern rockfish have generally been relatively low over the years.

[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 September 30, 2000.

6.3 DATA

6.3.1 Fishery Data

6.3.1.1 Catch

Detailed catch information for slope rockfish is listed in Table 6-2.

6.3.1.2 Catch Per Unit Effort (CPUE) in the Japanese Trawl Fishery

The Japanese trawl fishery in the Gulf of Alaska provided detailed catch and effort information on Pacific ocean perch for the years 1964-84. These data indicated a steep decline in stock abundance of Pacific ocean perch from 1965 to 1976, and that stocks remained severely depressed in the years 1977-84 (Carlson et al. 1986). This time series of CPUE data ended in 1984 when Japanese trawl fisheries in the Gulf of Alaska were terminated.

6.3.1.3 Age and Size composition

Observers aboard fishing vessels and at onshore processing facilities have provided data on size composition of the commercial catch of slope rockfish. Tables 6-4 and 6-5 summarize the length compositions for Pacific ocean perch and northern rockfish. In the past, age data have not been routinely collected from the fishery. However for the 1998 fishery, otoliths were collected from 903 Pacific ocean perch and 421 northern rockfish. Thus age composition from the fishery will become available in the future.

6.3.2 Survey Data

6.3.2.1 Longline Surveys in the Gulf of Alaska

Two longline surveys of the continental slope of the Gulf of Alaska provide data on the relative abundance of slope rockfish in this region: the earlier Japan-U.S. cooperative longline survey, and the ongoing NMFS domestic longline survey. These surveys compute relative population numbers (RPN's) and relative population weights (RPW's) of rockfish on the slope as indices of stock abundance. Rougheye and shortraker rockfish are the primary rockfish species caught. The results for both surveys concerning rockfish, however, should be viewed with some caution, as the analyses do not take into account possible effects of competition for hooks with other species caught on the longline.

The cooperative longline survey was conducted annually during 1979-94, but RPN's for rockfish are only available for the years 1979-87 (Sasaki and Teshima 1988). These data are highly variable and difficult to interpret, but suggest that abundance of rougheye and shortraker rockfish remained stable in the Gulf of Alaska (Clausen and Heifetz 1989). The data also indicate that rougheye and shortraker rockfish are most abundant in the eastern Gulf of Alaska.

The domestic longline survey has been conducted annually since 1988, and RPN's and RPW's have been computed for each year (Table 6-6[3]). For rougheye rockfish, Gulfwide RPN values from this survey have ranged from a low of ~13,000 in 1988 to a high of ~39,000 in 2000; for shortraker rockfish, Gulfwide RPN's have ranged from a low of ~11,000 in 1994 to a high of ~32,000 in 2000. Similarly, lowest and highest Gulfwide RPW values for each species were in these same years. Definite trends in these data over the years

[3] M. Sigler, National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratory, 11305 Glacier Hwy., Juneau AK 99801. Pers. commun. September 2000.

are difficult to discern, and the fluctuations in RPN and RPW may reflect random variations in the survey's catch rates, rather than true changes in abundance. It should be noted, however, that the four highest annual Gulfwide RPN's and RPW's for shortraker rockfish were in the most recent four surveys, in the years 1997-2000. Relatively high RPN's and RPW's for rougheye rockfish are also seen in these years. In particular, the highest Gulfwide RPN's and RPW's for both rougheye and shortraker rockfish occurred in the most recent survey, 2000. Similar to the cooperative longline survey, the domestic survey results show that abundance of shortraker and rougheye rockfish is highest in the eastern Gulf of Alaska: the Yakutat area consistently has the greatest RPN and RPW values for shortraker rockfish, and the Southeastern area is usually the best for rougheye rockfish.

6.3.2.2 Biomass Estimates from Triennial Trawl Surveys

Comprehensive triennial trawl surveys were conducted in the Gulf of Alaska in 1984, 1987, 1990, 1993, 1996, and 1999. These surveys covered all areas of the Gulf and provide much information on slope rockfish, including estimates of absolute abundance (biomass), age composition, and growth characteristics. Other trawl surveys have periodically been conducted in the Gulf of Alaska and have provided information on age and size composition of slope rockfish. Summaries of biomass estimates from the trawl surveys are provided in Tables 6-7 and 6-8.

6.3.2.2.1 1999 Triennial Trawl Survey

The 1999 trawl survey indicated that Pacific ocean perch was by far the most abundant species in the slope rockfish assemblage, with an estimated Gulfwide biomass of 726,785 mt, or 64.3% of the assemblage total (Table 6-7). Nine other slope species were also caught in some abundance. In descending order of Gulfwide biomass, these included: northern, rougheye, silvergrey, shortraker, sharpchin, redbanded, harlequin, redstripe, and yellowmouth rockfish. The other species in the assemblage combined accounted for only 0.08% of the Gulfwide total. On a regional basis, Pacific ocean perch was the most abundant slope rockfish species in 4 of the 5 statistical areas that were surveyed, the one exception being the Shumagin area, where northern rockfish predominated. The biomass of species in the "other slope rockfish" subgroup was mostly in the Eastern area (Yakutat and Southeastern statistical areas).

The biomass estimates for Pacific ocean perch and northern rockfish in 1999 were both greatly influenced by one extremely large catch. One haul in the Chirikof area had a catch for Pacific ocean perch of nearly 16 mt, which is the highest single catch ever recorded for this species in any of the triennial surveys. The large biomass for Pacific ocean perch in the Chirikof area in 1999 can be mostly attributed to this one haul. Likewise, one haul in the Kodiak area produced the largest catch of northern rockfish (nearly 8 mt) that has ever been seen in the triennial surveys, and it also resulted in an extremely large biomass estimate. In addition, these anomalously high catches were responsible for high variances associated with the Gulfwide biomass estimates for each species. These high variances are indicated by the extremely broad Gulfwide confidence intervals for Pacfic ocean perch and northern rockfish shown in Table 6-7.

6.3.2.2.2 Comparison of Trawl Surveys in 1984, 1987, 1990, 1993, 1996, and 1999

Gulfwide biomass estimates from each of the triennial trawl surveys are listed in Table 6-8 for all species of slope rockfish. Gulfwide biomass estimates and 95% confidence intervals are also shown graphically in Figure 6-2 for the assemblage's four most important commercial species. The 1984 survey results should be treated with some caution, as a different survey design was used in the eastern Gulf of Alaska. Also, 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 here, 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.

The biomass estimates for most species have often been highly variable from survey to survey. The most extreme example of this is harlequin rockfish, whose biomass estimate increased from 2,442 mt in 1984 to 63,833 mt in 1987, and then decreased to only 9,913 mt in 1990. Such wide fluctuations in biomass do not seem reasonable given the slow growth and low natural mortality rates of all *Sebastes* species; in the particular case of harlequin rockfish, fishing mortality was also considered to be very low over the period of these surveys. In past SAFE reports, we have speculated that a change in availability of rockfish to the survey, caused by unknown behavioral or environmental factors, may explain some of the observed variation in biomass. It seems prudent to repeat this speculation in the present report, while acknowledging that until more is known about rockfish behavior, the actual cause of changes in biomass estimates will remain the subject of conjecture.

Biomass estimates of Pacific ocean perch showed little change from 1984 to 1987, dropped substantially to 138,000 mt in 1990, increased markedly in both 1993 and 1996, and dropped slightly in 1999. It should be pointed out that were it not for the one large catch in 1999 that was discussed above, the decline in Pacific ocean perch biomass in 1999 would have been much greater. To examine these changes in more detail, the biomass estimates for Pacific ocean perch in each statistical area, along with Gulfwide 95% confidence intervals, are presented in Table 6-9. The decline in 1990 was mostly caused by reduced biomass in the Kodiak and Shumagin areas. The large rise in 1993, which the confidence intervals indicate was statistically significant compared with 1990, was primarily the result of big increases in biomass in the Central and Western Gulf of Alaska. The Kodiak area increased greater than ten-fold, from 15,221 mt in 1990 to 154,013 mt in 1993. The 1996 survey showed biomass increases in all areas, especially Kodiak, which more than doubled compared with 1993. In all areas except Yakutat, the biomass of Pacific ocean perch in 1996 was at a higher level than in any previous survey. In 1999, there was a substantial decline in biomass in all areas except Chirikof, where the previously mentioned single large catch occurred.

Biomass trends for the other species are quite variable (Table 6-8 and Figure 6-2). Of all the major species, biomass estimates for rougheye rockfish have been the most constant from survey to survey. The estimates for northern rockfish were generally similar for the years 1987-1996, but increased greatly in 1999. Similar to Pacific ocean perch, the biomass for northern rockfish in 1999 would have been much less, except for a single large catch in one haul. Both harlequin and sharpchin rockfish have shown large fluctuations in biomass between the surveys. To a lesser extent, the biomass of shortraker rockfish has also varied considerably. The estimates for shortraker rockfish are especially uncertain, as the major habitat for this species, the 300-500 m depth stratum on the continental slope, is largely untrawlable using the survey's nets. The biomass estimate of silvergrey rockfish has consistently increased in each survey, and in 1999 was nine times greater than it was in 1984.

The precision of the biomass estimates for the four most valuable species in the assemblage is shown by the confidence intervals depicted in Figure 6-2. Especially noteworthy are the very large confidence limits for Pacific ocean perch and northern rockfish in the 1999 survey. These confidence limits are much greater than in any of the previous surveys, and indicate that the point biomass estimates for these two species in 1999 should be viewed with considerable caution.

6.3.2.3 Survey Size Composition

Gulfwide population size compositions for Pacific ocean perch, northern rockfish, rougheye rockfish, and shortraker rockfish in the 1999 triennial survey are shown in Figures 6-3 through 6-6. For comparison, the size compositions for each species are also depicted for the previous three surveys. The size composition for Pacific ocean perch in 1999 was very similar to that in 1996, and mean length for each year was nearly identical. There was modest indication of recruitment each year, as indicated by the presence of fish <30 cm in length. The northern rockfish size composition in 1999 shows a unimodal pattern, with no indication of recruitment of small fish. The 1993 and 1996 compositions were similar, although the fish were slightly less in mean length. The size compositions of rougheye rockfish in 1993, 1996, and 1999 indicated that a sizeable portion of the population each year was <30 cm in length, which suggests that at least a moderate level of recruitment has been occurring. Mean length of the population has shown a consistent decline from 38.0 cm in 1990 to 33.8 cm in 1999. Some of this decline can be attributed to reduced numbers of large fish (>40 cm in length) since 1993. The fewer numbers of large fish may also explain the decrease in biomass estimates of rougheye rockfish from 1993 to 1999. All the shortraker rockfish size compositions have been unimodal, with almost no fish caught <40 cm in length. Mean length of shortraker rockfish has declined from 61.0 cm in 1990 to 57.3 in 1999.

6.3.2.4 Survey Age Composition

Age composition data are currently available only for Pacific ocean perch and northern rockfish (Tables 6-10 and 6-11 and Figure 6-7). In the following, we summarize age data for Pacific ocean perch and northern rockfish. Experimental aging of rougheye and shortraker rockfish is in progress, but has not yet moved into a production mode.

6.3.2.4.1 Pacific Ocean Perch

The age compositions from the 1984, 1987, and 1990 surveys showed that although the fish ranged in age up to 78 years, most of the population was relatively young; mean population age was 10.1 years in 1987 and 9.8 in 1990 (Clausen and Heifetz 1989; Heifetz et al. 1993). All three surveys identified a relatively strong 1976 year class and also showed a period of very weak year classes prior to 1976. The weak year classes of the early 1970's may have delayed recovery of Pacific ocean perch populations after they were depleted by the foreign fishery. The 1987 age compositions indicated that in addition to 1976, the 1980 year class was also especially prominent. The 1990 age data, however, showed an unexceptional 1980 year class, and suggested the 1986 year class may have been strong. The 1993, 1996 and 1999 surveys verified that the 1986 year class was exceptionally strong. Recruitment of the strong 1986 year class probably accounted for much of the increase in the estimated biomass for Pacific ocean perch in the 1993 and 1996 surveys.

6.3.2.3.2 Northern Rockfish

Age composition data for northern rockfish are available from the 1984, 1987, 1990, 1993, 1996, and 1999 triennial trawl surveys (Figure 6-7). The age results from the 1999 survey have only recently become available, and are presented here for the first time. Age results from all six surveys showed that although the maximum age of northern rockfish was much less than that of Pacific ocean perch, the overall population was considerably older. Mean age of northern rockfish in the surveys has consistently increased from 13.1 years in 1984 to 18.6 years in 1999. 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.

6.5 ASSESSMENT PARAMETERS

6.5.1 Natural Mortality, Maximum Age, Age of Recruitment, and Age and Size at 50% Maturity

Estimates of total mortality (Z) and natural mortality (M), maximum age, and recruitment age are shown in Table 6-12. Estimates of Z which were based on catch curves should be considered as upper bounds for M. Estimates of Z for Pacific ocean perch in Archibald et al. (1981) were from populations considered to be lightly exploited and thus are considered reasonable estimates of M. The method of Alverson and Carney (1975) was used to estimate an M of 0.06 for northern rockfish (Heifetz and Clausen 1991). McDermott (1994) used the gonad somatic index method to estimate a range of M for shortraker and rougheye rockfish.

Previously, age and size of maturity information for slope rockfish in the Gulf of Alaska was only available for Pacific ocean perch, and this information was over 20 years old and based on now obsolete aging methods. Recently, new information on female age and size at 50% maturity has become available for Pacific ocean perch, northern rockfish, and sharpchin rockfish from a study in the Gulf of Alaska that is based on the currently accepted break-and-burn method of determining age from otoliths[4]. These new data are summarized below (size is in cm fork length and age is in years):

Species	Management area	Sample size	Size at 50% maturity	Age at 50% maturity
POP	Gulfwide	802	35.7	10
Northern	Central	77	36.1	13
Sharpchin	Eastern	164	26.5	10

6.5.2 Length and Weight at Age

Length-weight coefficients and Von Bertalanffy parameters are shown in Tables 6-13a and 6-13b.

6.6 ANALYTIC APPROACH

Pacific ocean perch and northern rockfish are the only species of slope rockfish which are currently assessed using a formal modeling approach. All other species of slope rockfish are assessed based on trawl survey data. Courtney et al. (1999) presented a stock assessment model for northern rockfish using AD Model Builder software. This is the first year that this model will be used for the assessment of northern rockfish.

6.6.1 Pacific ocean perch

6.6.1.1 Model Structure

For Pacific ocean perch, Heifetz and Ianelli (1992) incorporated a variety of data sources into a age structured model using stock synthesis (Methot 1990). Their methods and results were amended in recent SAFE reports (Heifetz et al. 1994, 1995, 1996, 1997). In 1997, a new version of the stock synthesis computer program with better estimation properties was used (Heifetz et al. 1997). Last year the model was updated to include size composition from the 1999 fishery and the biomass estimate from the 1999 survey. The current SAFE includes updated catch for the 1999 and 2000 fishery.

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

Stock synthesis functions by simulating both the dynamics of the population and the processes by which the population is observed. This simulation, which incorporates both imprecision and bias in the observations, is used to predict expected values for the observations. These expected values are compared to the actual observations (data) from surveys and the fishery.

In stock synthesis numbers at age at the beginning of a year *N(a)* are calculated by a deterministic population model. *N(a)* values are transformed to provide expected values for comparison to the observed data. The basic population dynamics equations that describe the catch in numbers at age *C(a)*, total catch biomass *Y*, exploitable biomass *EB,* and female spawning biomass *B*, in a given year are

$$C(a) = N(a)\frac{Fs(a)}{Fs(a)+M}(1-\exp(-Fs(a)-M))$$

$$Y = \sum_{age=2}^{nages} W(a)C(a)$$

$$EB = \sum_{age=2}^{nages} N(a)s(a)W(a)$$

$$B = 0.5\sum_{age=2}^{nages} N(a)W(a)m(a)$$

where *s(a)* is selectivity at age, *F* is the fishing mortality rate for fully selected age groups (i.e., *s(a) = 1.0*), *M* is natural mortality, *W(a)* is weight at age, and *m(a)* is proportion of females mature at age.

The data sets used in this analysis include total catch biomass for years 1961-2000, size compositions from the fishery for 1963-78 and 1990-99, fishery CPUE for 1964-79, survey age compositions based on surface reading of otoliths (biased ages) for 1963-67, 78, and 79, survey "break and burn" (imprecise ages) age compositions for 1980-82, 84, 87, 90, 93, and 96, and survey biomass estimates for 1984, 87, 90, 93, 96, and 99. Ageing error, transformations from biased to imprecise ages, and standard errors of survey estimates of abundance were included in the model.

Depending on the data component, parameters of either a domed shaped or asymptotic selectivity pattern were estimated. Shifts in selectivity within a data component were modeled by enabling selectivity to change with time. Consecutive years where selectivity did not appear to change were aggregated to have the same selectivity pattern.

We have constructed a preliminary stock assessment model for Pacific ocean perch using AD Model Builder Software. We have configured the model similar to the stock synthesis model using the same data. Initial exploratory runs of the model have been completed. We anticipate that this model will be used for next year's assessment.

6.6.1.2 Model Selection

Relative to last year's assessment the only update is the inclusion of updated catch for 1999 and 2000. As in recent previous assessments, in last year's assessment we recognized that survey biomass estimates may be giving a reasonable representation of the trend but not a reliable estimate of absolute biomass. Thus we assumed that the survey biomass estimate is an index of abundance and estimated survey catchability *q*. Last year, we also estimated *q* and evaluated 3 different models:

Model 1	*q* fixed at the estimate from the 1998 SAFE; *q*= 2.78 (Heifetz et al., 1998)
Model 2	*q* fixed at 1.0
Model 3	*q* estimated

Log likelihood values for the fits to the various data components and *q* values, are summarized in the following.

	Model		
	1	2	3
Component			
Fishery Size Comp	-204.22	-203.12	-204.25
Canadian survey bias ages	-83.52	-80.57	-83.78
US survey biomass	2.33	-3.13	2.54
US survey imprecise ages	-235.18	-231.25	-235.77
US survey bias ages	-22.56	-23.81	-22.52
US Survey Size Com	-106.71	-121.66	-105.63
Fishery CPUE	9.62	5.72	9.75
Stock Recruit Model	-32.30	-31.98	-32.39
Stock Recruit Moments	5.89	6.47	5.79
TOTAL	-666.66	-683.34	-666.26
q	2.78	1.00	2.99

We selected Model 3 as the basis for our recommendations for ABC and overfishing. This model fit the data the best and keeps with the desire to remain conservative. The estimate of *q* from Model 3 was 2.99. Justification for an estimate of *q* greater than 1.0 is possible herding of fish into the trawl by the bridles and trawl doors and expansion of the trawl survey estimates to untrawlable areas (Krieger and Sigler 1996). Adult Pacific ocean perch concentrate over trawlable substrates (Krieger 1993).

6.6.1.3 Results for Pacific Ocean Perch

Fits of Model 3 to survey biomass estimates and survey age compositions are shown in Figures 6-8 and 6-9. The model fits survey biomass estimates and survey age composition relatively well. Estimates of the time series of female spawning biomass, biomass (age 6 and greater), catch/biomass, and number of age two recruits are shown in Table 6-14. Estimates of the trend in spawning biomass is shown in Figure 6-10. A summary of the current age composition, fishery and survey selectivity, maturity at age, and weight at age is in Table 6-15.

In this assessment, age-2 recruits through 1994 were estimated (i.e., the 1992 year-class). Thus, to estimate biomass in 2001 the number of age-2 recruits in 1995-2001 was projected using the average of the 1977 - 1992 year classes. Estimated female spawning biomass in 2001 is 95,760 mt, exploitable biomass is 211,160 mt, and estimated age 6+ biomass is 296,270 mt.

6.6.2 Northern Rockfish

6.6.2.1 Model Structure

For the first time the stock assessment for northern rockfish is based on an age-structured model constructed using AD Model Builder Software. The basic population dynamics equations are nearly identical to those used in Pacific ocean perch stock synthesis model described above. A detailed report describing the model configuration and preliminary results was presented in last year's SAFE report (Courtney et al. 1999). The model was fit to available fishery catch (Table 6-2) and size composition data (Table 6-5) and triennial trawl survey age compositions (Table 6-11). Catch was interpolated for missing years (Courtney et al. 1999). Triennial trawl survey biomass estimates were incorporated as an auxiliary index of abundance in order to scale the population estimates (Table 6-8). Similar to the Pacific ocean perch assessment the survey biomass estimates were used as an indices of abundance by estimating the parameter q:

(Expected Survey biomass) = q*(Estimated Total Biomass)

Natural mortality was fixed at an independently estimated value of 0.06 (Table 6-12) and a single selectivity was assumed for the fishery and the survey. Recruitment variability each year, fishing mortality variability each year, and selectivity at age were also constrained from within the overall model likelihood function, and ageing errors were incorporated into age-error and age-length transition matrices. The log parameters were estimated rather than parameters on the original scale for reliability in the estimation process (Kimura 1989, 1990). Additional structure was added to the model by incorporating a stock recruit relationship (Courtney et al. 1999). Recruitment variability around the stock recruitment relationship was incorporated by estimating recruitment deviations.

Prior distributions were incorporated as penalties in the overall model likelihood for initial values of recruitment variability, survey catchability, and steepness of the stock recruitment relationship (Courtney et al. 1999). It was assumed that the initial values and their prior distributions were similar for northern rockfish and Pacific ocean perch in the Gulf of Alaska. Consequently, prior estimates and their distributions were taken directly from initial formulations of the Pacific ocean perch AD model (Heifetz and Ianelli Pers. Comm. 1999).

6.6.2.2 Model Selection

Courtney et al. (1999) found that the 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 age and length compositions. In particular, the length compositions were composed of a single mode that progressed in size through time. 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. 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 minor modifications described below. New data added for this assessment include the 1999 survey age compositions, updated catch from the 1999 and 2000 fishery, and the 1999 fishery length data.

Last year the Gulf of Alaska Plan Team pointed out that the survey length composition data was already used in the model to expand the stratified survey age data. Consequently, survey length composition was removed from the model likelihood in this year's assessment. The model fit to survey age composition was improved by increasing the survey age composition likelihood weight from one to ten. Increasing the weight forced the model to fit the survey age data in a manner analogous to the method used for the alternate case from 1999. The actual value chosen for the weighting term was based upon a sensitivity analysis conducted last year (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 ability to fit the other data.

In this years's assessment, 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). In this year's assessment, 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.

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 (for example, the 1984 age compositions, Figure 13B in Courtney et. al. 1999). 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. The problem was corrected this year by scaling the number of hauls for fishery length data and for survey age data respectively to a maximum of one.

6.6.2.3 Results for Northern Rockfish

Fits of the northern rockfish age-structured assessment model to survey age compositions and survey biomass estimates are shown in Figures 6-11 and 6-12. 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 are shown in Table 6-16. Estimates of the trend in spawning biomass, and estimated number of recruits are shown in Figures 6-13 and 6-14, respectively. A summary of the current estimates of age composition, fishery and survey selectivity, maturity at age, and weight at age is in Table 6-17.

To estimate biomass in 2001 the number of age-2 recruits in 2001 was projected using the average of the 1977 - 1994 year classes. Estimated female spawning biomass in 2001 is 39,090 mt, exploitable biomass is 93,850 mt, and age 6+ total biomass is 97,810 mt.

Recruitment since 1988 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, Figure 6-7). 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 1990 and 1991), and spawning biomass is projected to decrease as these large year classes die off (based upon average recruitment from 1977-1994; Figure 6-13). Unless another strong year class appears, spawning biomass is projected to fall below $B_{40\%}$ in 2011 and yield is projected to fall below equilibrium yield at $F_{40\%}$ by 2006 (Figure 6-13).

The age-structured model for northern rockfish has improved our understanding of 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 2000 ending biomass estimated from the age structured model had a coefficient of variation of nearly 40% (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. For example, estimates age of maturity are uncertain because they are based on a small sample of fish (n=77) collected in one year. The calculation of $F_{40\%}$ and $B_{40\%}$ depend on estimates of maturity. In addition the model does take into account the possible errors in catch associated with missing data for some years (Courtney et al. 1999).

The fit to the survey abundance index is poor, and 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 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 (158,000 mt, CV 34%) was approximately 50% larger than the current assessment, and underscores the uncertainty in the current biomass estimate.

Survey catchability, q, in the current assessment was estimated to be 0.45 (CV 27.8%). This differs in size and direction from that estimated above for Pacific ocean perch (2.99) from a similar age structured model. One possible explanation is that northern rockfish may be less susceptible than Pacific ocean perch to the survey trawl gear because northern rockfish are thought to be associated with rougher habitat than Pacific ocean perch.

6.6.3 Shortraker and Rougheye Rockfish, and Other Slope Rockfish

As in the past, the average of the exploitable biomasses in the three most recent surveys (1993, 1996, and 1999) is used to determine current exploitable biomass of shortraker and rougheye rockfish and other slope rockfish (Table 6-18). These estimates are derived from the Gulfwide biomass estimates listed in Table 6-8, excluding the biomass in the 1-100 m depth stratum. The 1-100 m depth stratum was removed from the estimate because most slope rockfish in this stratum are small juvenile fish younger than the age of recruitment, and thus are not considered exploitable (Clausen and Heifetz 1989). These averages yield the following values of current exploitable biomass: for shortraker/rougheye rockfish, 70,885 mt and for other slope rockfish, 102,505 mt.

6.7 PROJECTIONS AND HARVEST ALTERNATIVES

6.7.1 Pacific Ocean Perch

As in last year's assessment, we recommend that $F_{40\%}$ be used as the basis for ABC calculations. A comparison of *last year's* assessment results for the three models described in section 6.6.12 is summarized in the following.

	Model		
	1	2	3*
$B_{40\%}$ (mt)	117,240	310,430	110,120
B_{2000} (mt)	101,020	322,460	92,920
$F_{40\%}$	0.078	0.083	0.078
F_{ABC} in 2000 (maximum allowable)	0.067	0.083	0.067
Yield in 2000 (mt; maximum allowable)	14,480	55,340	13,020

* recommended model for ABC determination, last year

Based on model 3, the projected current spawning biomass in 2001 B_{2001} is 95,760 mt. $B_{40\%}$ is determined from average recruitment of the 1977-92 year-classes. Since B_{2001} is less than $B_{40\%}$, the computation in tier 3b [i.e., $F_{ABC} \leq F_{40\%}(B/B_{40\%} - \alpha)/(1 - \alpha)$] is used to determine the maximum value of F_{ABC}. Setting $\alpha = 0.05$, results in $F_{ABC} \leq 0.067$ and an ABC $\leq$ 13,510 mt.. We recommend that the ABC for Pacific ocean perch for 2001 fishery in the Gulf of Alaska be set at 13,510 mt.

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).

For each scenario, the projections begin with the vector of 2000 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2001 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2000. 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 2000, 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 TACs.)

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 2001 recommended in the assessment to the *max* F_{ABC} for 2001. (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 1995-1999 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 overfished condition or is approaching an overfished 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 overfished. If the stock is expected to be above ½ of its MSY level in 2001 and above its MSY level in 2011 under this scenario, then the stock is not overfished.)

Scenario 7: In 2001 and 2002, 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 overfished condition. If the stock is expected to be above its MSY level in 2013 under this scenario, then the stock is not approaching an overfished condition)

A summary of the results of these scenarios for Pacific ocean perch is in Table 6-19. For Pacific ocean perch the stock is not overfished nor is it approaching an overfished condition.

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 (a reasonable assumption), the weight of a prior survey should be 2/3 the weight of the preceding survey. This resulted weights of 4:6:9 for the 1993, 96, and 99 surveys, respectively and apportionments of 14.1% for the Western area, 51.5% for the Central area, and 34.4% for the Eastern area. Dropping the 1990 survey and adding the 1999 survey results in apportionments of 9.5% for the Western area, 71.1 % for the Central area, and 19.4% for the Eastern area (Table 6-20). This results in recommended ABC's of 1,280 mt for the Western area, 9,610 mt for the Central area, and 2,620 mt for the Eastern area. However for two reasons an alternative apportionment scheme may be warranted. 1) The variance of the 1999 survey estimate is considerably higher than previous surveys. 2) Amendment 58, does not allow trawling in the Eastern area east of 140 degrees longitude. Since Pacific ocean perch are caught exclusively with trawl gear, it is possible that the entire Eastern area TAC could be taken in the small area in the Eastern area that is open to trawling. Thus, because of this amendment, alternative apportionment strategies may need to be evaluated.

6.7.2 Northern Rockfish

For the first time, the stock assessment for northern rockfish is based on an age-structured model constructed using AD Model Builder software. A detailed report describing the model configuration and preliminary results was presented in last year's SAFE report (Courtney et al. 1999). Based on this year's assessment model, the projected current spawning biomass in 2001 B_{2001} is 39,090 mt. $B_{40\%}$ is determined from average recruitment of the 1977-94 year-classes (Figure 6-14). Since B_{2001} is greater than $B_{40\%}$, the computation in tier 3a [i.e., $F_{ABC} \leq F_{40\%}$] is used to determine the maximum value of F_{ABC}. We recommend that the ABC for northern rockfish for the 2001 fishery in the Gulf of Alaska be set at the maximum allowable value of 4,880 mt. The corresponding reference values for northern rockfish are summarized in the following:

$B_{40\%}$ (mt)	21,830
B_{2001} (mt)	39,090
$F_{40\%}$	0.055
F_{ABC} (maximum allowable)	0.055
ABC (mt, maximum allowable)	4,880

Given the uncertainty in the biomass estimate obtained from the age structured model, the catch history, and the uncertain life history parameters, a model which results in an estimated ABC similar to that obtained last year appears to be reasonable. The declining stock trend and the weakness of recent recruitment estimates identified by the age structured model indicates that caution is warranted for management of this stock.

The standard set of projections described for Pacific ocean perch were run for northern rockfish. A summary of the results of these scenarios is in Table 6-21. For northern rockfish, projected B_{2001} is greater than $B_{35\%}$ and by the definitions above, the stock is not overfished. In addition, B_{2003} is greater than $B_{35\%}$ and by the definitions above the stock is not approaching an overfished condition.

Using the same method of apportionment as used for Pacific ocean perch results in ABC's of 600 mt (12.30%) in the Western area, 4,275 mt (87.61%) in the Central area, and 5 mt (0.09%) in the Eastern area (Table 6-20). For management purposes, the small ABC of northern rockfish in the Eastern area is combined with other slope rockfish.

6.7.3 Shortraker and Rougheye Rockfish

In the past, the recommended ABC for shortraker and rougheye rockfish was based on an exploitation rate set equal to natural mortality. Based on recommendations of the Scientific and Statistical Committee (SSC), estimates of M were obtained from Table 6-12 which lists estimates of total mortality Z based on catch curve analyses. The SSC estimated an M of 0.025 for rougheye rockfish based on the mid-point of the range of Z for British Columbia stocks and because there was no estimate of M or Z for shortraker rockfish, the ratio of maximum age of rougheye to shortraker (140/120) multiplied by 0.025 was used to estimate an M of 0.03.

Applying the definitions for ABC and OFL based on Amendment 44 on the Gulf of Alaska FMP places shortraker rockfish in tier 5 where $F_{ABC} \leq 0.75M$. Thus, the recommended F_{ABC} for shortraker rockfish is 0.023 (ie., 0.75 X 0.03). Applying tier 4 to rougheye rockfish (ie., $F_{ABC} \leq F_{40\%}$) results an F_{ABC}=M= 0.025 which is less than $F_{40\%}$=.032. Applying these F_{ABC}'s to the estimates of exploitable biomass based of 22,411 mt for shortraker rockfish and 48,404 mt for rougheye rockfish results in ABC's of 517 mt for shortraker rockfish and 1,210 mt for rougheye rockfish and a recommended ABC for the subgroup of 1,727 mt.

For species such as shortraker and rougheye rockfish that are not assessed with a age/length- structured model multi-year projections as done in Table 6-19 for Pacific ocean perch are not possible but yields for just the year 2001 can be computed (Table 6-22).

The same method of apportionment as used for Pacific ocean perch is used to apportion the shortraker and rougheye ABC among areas (Table 6-20). This results in ABC's of 210 mt for the Western area, 930 mt for the Central area, and 590 mt for the Eastern area.

6.7.4 Other Slope Rockfish

In the past, the recommended ABC for other slope rockfish was based on a harvest rate set equal to natural mortality M. Estimates of M obtained from Table 6-12 are 0.05 sharpchin rockfish and 0.10 for redstripe rockfish. The estimate of M of 0.04 for silvergrey rockfish is based on the midpoint of the range of Z (0.01-0.07) for British Columbia stocks. For harlequin and redbanded rockfish and minor species, an F=M of 0.06 is based on the average M for northern, sharpchin, redstripe, and silvergrey rockfish. Applying the new definitions for ABC and OFL based on Amendment 44 in the Gulf of Alaska FMP places sharpchin rockfish in tier 4 where $F_{ABC} \leq F_{40\%}$, and the other species of other slope rockfish in tier 5 where $F_{ABC} \leq 0.75M$. Applying $F_{ABC} = M = 0.05$ to the exploitable biomass of sharpchin rockfish and $F_{ABC} = 0.75M$ to the exploitable biomass of the other species results in a recommended combined ABC for other slope of 4,900 mt. Distributing this ABC based on the same method used for Pacific ocean perch results in ABC's of 20 mt in the Western area, 740 mt in the Central area, and 4,140 mt in the Eastern area (Table 6-20).

For species such as other slope rockfish that are not assessed with a age/length- structured model multi-year projections as done in Table 6-19 for Pacific ocean perch are not possible but yields for just the year 2001 can be computed (Table 6-22).

6.7.5 Overfishing Definition

6.7.5.1 Pacific ocean perch and northern rockfish

Based on the definitions for overfishing in Amendment 44 in tier 3b [i.e., $F_{OFL} = F_{35\%}(B/B_{40\%} - \alpha)/(1 - \alpha) = 0.080$], overfishing is set equal to 15,960 mt for Pacific ocean perch. The overfishing level is apportioned by area for Pacific ocean perch. Using the apportionment in Section 6.7.1, results in overfishing levels by area of 1,520 mt in the Western area, 11,350 mt in the Central area, and 3,090 mt in the Eastern area.

Based on the definitions for overfishing in Amendment 44 in tier 3a [i.e., $F_{OFL} = F_{35\%} = 0.065$], overfishing is set equal to 5,780 mt for northern rockfish.

6.7.5.2 Rougheye, shortraker and other slope rockfish

Based on Amendment 44 in the Gulf of Alaska FMP overfishing is defined to occur at the harvest rate set equal to $F_{35\%}$ (in terms of exploitable biomass per recruit) of 0.038 for rougheye rockfish. The F=M rate of 0.03 is used to define the overfishing level for shortraker rockfish because data are not available to determine $F_{30\%}$ for shortraker rockfish. These harvest rates are applied to estimates of current exploitable biomass to yield an overfishing catch limit of 2,510 mt for the shortraker/rougheye subgroup.

Overfishing is defined to occur at the $F_{35\%}$ (in terms of exploitable biomass per recruit) values of 0.064 for sharpchin rockfish. For the other species of other slope rockfish, overfishing is defined to occur at the F=M rate. Applying these F's, results in an overfishing catch limit of 6,390 mt for the other slope rockfish subgroup.

6.7.8 Summary

A summary of biomass levels, exploitation rates and recommended ABCs and OFLs for slope rockfish is in Table 6-23.

6.7.9 Rockfish work plan

Stock assessment of slope rockfish is hampered by limited information and considerable uncertainty as to current stock abundance and long-term productivity. The adequacy of current trawl survey methodology to assess rockfish biomass is questionable. These concerns have prompted the Alaska Fisheries Science Center to develop a comprehensive working plan to improve stock assessments for rockfish. The main focus of this plan is to develop and prioritized research proposals for improving rockfish assessment and management. Included in this plan are proposals for alternative survey designs that use the skill and fish-catching ability of a commercial fishing operation and experimental management schemes designed to provide a better understanding of stock dynamics. In cooperation with the University of Alaska Fairbanks, NMFS scientists are currently evaluating adaptive sampling as a possible method of improving trawl survey biomass estimates (Clausen et al., 1999; Quinn et al. 2000).

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Table 6-1.--Species comprising the slope rockfish assemblage in the Gulf of Alaska.

Common name	Scientific name	Management subgroup
Pacific ocean perch	*Sebastes alutus*	Pacific ocean perch
Shortraker rockfish	*S. borealis*	Shortraker/rougheye
Rougheye rockfish	*S. aleutianus*	Shortraker/rougheye
Northern rockfish	*S. polyspinis*	Northern rockfish
Sharpchin rockfish	*S. zacentrus*	Other slope rockfish
Redstripe rockfish	*S. proriger*	Other slope rockfish
Harlequin rockfish	*S. variegatus*	Other slope rockfish
Silvergrey rockfish	*S. brevispinis*	Other slope rockfish
Redbanded rockfish	*S. babcocki*	Other slope rockfish
Yellowmouth rockfish	*S. reedi*	Other slope rockfish
Bocaccio	*S.paucispinis*	Other slope rockfish
Greenstriped rockfish	*S. elongatus*	Other slope rockfish
Darkblotched rockfish	*S. crameri*	Other slope rockfish
Pygmy rockfish	*S. wilsoni*	Other slope rockfish
Splitnose rockfish	*S. diploproa*	Other slope rockfish
Aurora rockfish	*S. aurora*	Other slope rockfish
Blackgill rockfish	*S. melanostomus*	Other slope rockfish
Chilipepper	*S. goodei*	Other slope rockfish
Shortbelly rockfish	*S. jordani*	Other slope rockfish
Stripetail rockfish	*S. saxicola*	Other slope rockfish
Vermilion rockfish	*S. miniatus*	Other slope rockfish

Table 6-2a.BCommercial 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), 1977-2000. Catches in 2000 updated through September 30, 2000.

Year	Fishery category	Regulatory area Western	Regulatory area Central	Regulatory area Eastern	Gulfwide Total	Gulfwide Management value ABC	Gulfwide Management value 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

Table 6-2.--(Continued).

Year	Fishery category/ Management subgroup	Regulatory area Western	Central	Eastern	Gulfwide Total	Gulfwide Management value ABC	Quota
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
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	POP	477	1,140	443	2,060	3,378	2,560
	SR/RE	85	1,197	650	1,932	1,960	1,764
	Northern	902	3,778	145	4,825	5,760	5,760
	Other slope	342	2,423	2,658	5,423	8,300	5,383
1994	POP	165	920	768	1,853	3,030	2,550
	SR/RE	114	996	722	1,832	1,960	1,960
	Northern	1,394	4,519	55	5,968	5,760	5,760
	Other slope	101	715	797	1,613	8,300	2,235
1995	POP	1,422	2,598	1,722	5,742	6,530	5,630
	SR/RE	216	1,222	812	2,250	1,910	1,910
	Northern	113	5,476	45	5,634	5,270	5,270
	Other slope	31	883	483	1,397	7,110	2,235
1996	POP	987	5,145	2,246	8,378	8,060	6,959
	SR/RE	127	941	593	1,661	1,910	1,910
	Northern	173	3,146	24	3,343	5,270	5,270
	Other slope	19	618	244	881	7,110	2,020
1997	POP	1,832	6,720	979	9,531	12,990	9,190
	SR/RE	137	931	541	1,609	1,590	1,590
	Northern	62	2,870	15	2,947	5,000	5,000
	Other slope	68	941	208	1,217	5,260	2,170
1998	POP	850	7,501	610	8,961	12,820	10,776
	SR/RE	129	870	735	1,734	1,590	1,590
	Northern	67	2,974	10	3,051	5,000	5,000
	Other slope	46	701	114	861	5,260	2,170
1999	POP	1,935	7,910	627	10,472	13,120	12,590
	SR/RE	194	580	537	1,311	1,590	1,590
	Northern	574	4,825	c	5,399	4,990	4,990
	Other slope	39	614	135	788	5,270	5,270
2000	POP	1,151	8,337	618	10,106	13,020	13,020
	SR/RE	135	857	632	1,624	1,730	1,730
	Northern	748	2,649	c	3,397	5,120	5,120
	Other slope	50	360	155	565	4,900	4,900

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 1991-2000 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; SR/RE = shortraker/rougheye management subgroup; 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; in 1993-2000 consisted of all species in the slope rockfish assemblage except for Pacific ocean perch and shortraker, rougheye, and northern rockfish); Northern = northern rockfish management subgroup.

[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; 1994-2000 the 21 species comprising the slope rockfish assemblage.

[b]Quota defined as follows: 1977-86, optimum yield; 1987, target quota; 1988-2000 total allowable catch.

[c]Starting in 1999 in the Eastern area, northern rockfish is combined with other slope rockfish.

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; 1989-2000, National Marine Fisheries Service, Alaska Region, P.O. Box 21668, Juneau, AK 99802. ABC and Quota: 1977-1986 Karinen and Wing (1987); 1987-99, Heifetz et al. (1999); 2000, North Pacific Fishery Management Council Newsletter, Dec. 1999. 605 W. 4th Ave., Suite 306, Anchorage, Alaska 99501-2252.

Table 6-2b.–Catch (mt) of slope rockfish taken during research cruises in the Gulf of Alaska, 1977-99. (Does not include catches in longline surveys; tr=trace)

Year	Pacific ocean perch	Shortraker/ rougheye	Northern rockfish	Other slope rockfish
1977	13.0	0.7	tr	0.8
1978	5.7	2.8	0.5	9.5
1979	12.2	1.9	1.0	0.4
1980	12.6	1.9	0.5	0.4
1981	57.1	12.5	8.4	16.3
1982	15.2	5.4	6.4	2.9
1983	2.4	3.2	1.7	0.1
1984	76.5	23.7	11.3	3.4
1985	35.2	10.5	10.8	1.7
1986	14.4	2.6	0.7	0.0
1987	68.8	28.1	40.6	19.8
1988	0.3	0.0	0.0	0.7
1989	1.0	0.6	0.2	0.1
1990	25.5	7.6	19.2	11.8
1991	0.1	tr	0.0	tr
1992	0.0	0.1	0.0	0.0
1993	59.2	12.8	20.8	11.3
1994	tr	0.1	0.0	0.0
1995	tr	tr	0.0	0.0
1996	81.2	7.8	12.5	16.9
1997	tr	0.1	0.0	0.0
1998	305.0	65.6	2.5	2.4
1999	330.2	129.7	13.2	51.6

Table 6-3.--Species composition (percent by weight) of the “other slope rockfish” and “shortraker/rougheye” management subgroups in the Gulf of Alaska commercial catch, 1992-99, based on vessels that had observer coverage. (tr=trace; Redbanded rockfish is not included in the 1992 and 1993 data.)

	Regulatory area			
Species	Western	Central	Eastern	Gulf of Alaska
Other slope rockfish:				
		1992		
Northern rockfish	92.9	88.7	14.8	82.3
Sharpchin rockfish	0.4	2.3	29.5	4.6
Redstripe rockfish	0.0	1.0	21.3	2.8
Harlequin rockfish	6.6	7.5	12.9	7.9
Silvergrey rockfish	tr	0.1	14.0	1.4
Yellowmouth rockfish	0.1	0.5	7.2	1.1
Other species	tr	tr	0.2	tr
		1993		
Northern rockfish	(removed from subgroup in 1993)			
Sharpchin rockfish	1.8	23.9	28.6	24.8
Redstripe rockfish	5.6	25.2	22.3	22.5
Harlequin rockfish	92.3	48.0	14.5	34.4
Silvergrey rockfish	tr	2.3	15.9	8.2
Yellowmouth rockfish	tr	0.7	18.1	9.2
Other species	0.2	tr	0.6	0.3
		1994		
Sharpchin rockfish	2.1	14.8	27.9	20.5
Redstripe rockfish	0.0	3.9	22.5	12.9
Harlequin rockfish	97.3	77.7	17.0	49.0
Silvergrey rockfish	0.0	0.6	26.9	13.6
Yellowmouth rockfish	0.1	0.9	4.2	2.5
Redbanded rockfish	0.5	2.0	1.0	1.4
Other species	tr	tr	0.5	0.2
		1995		
Sharpchin rockfish	6.1	26.0	23.0	24.5
Redstripe rockfish	1.5	6.4	29.2	14.1
Harlequin rockfish	73.1	63.6	17.2	47.8
Silvergrey rockfish	0.0	0.2	25.0	8.8
Yellowmouth rockfish	6.6	0.1	2.5	1.1
Redbanded rockfish	12.6	1.2	1.6	1.6
Other species	1.6	2.5	1.5	2.2

Table 6-3.--(Continued).

Species	Western	Central	Eastern	Gulf of Alaska
	Regulatory area			
		1996		
Sharpchin rockfish	18.3	29.0	48.1	31.6
Redstripe rockfish	6.8	14.7	19.2	15.2
Harlequin rockfish	67.6	52.0	7.1	45.7
Silvergrey rockfish	0.0	0.6	2.8	0.9
Yellowmouth rockfish	0.0	tr	4.8	0.7
Redbanded rockfish	6.6	2.4	8.2	3.4
Other species	0.7	1.3	9.9	2.6
		1997		
Sharpchin rockfish	36.2	26.3	22.6	26.0
Redstripe rockfish	37.0	26.3	8.2	23.9
Harlequin rockfish	21.8	44.9	17.7	40.4
Silvergrey rockfish	0.0	1.5	11.2	2.8
Yellowmouth rockfish	0.5	tr	35.5	5.2
Redbanded rockfish	3.3	0.8	3.5	1.2
Other species	1.1	0.3	1.2	0.5
		1998		
Sharpchin rockfish	23.6	41.7	tr	37.0
Redstripe rockfish	0.5	1.2	51.4	5.9
Harlequin rockfish	72.5	52.1	35.8	51.5
Silvergrey rockfish	tr	0.6	3.7	0.9
Yellowmouth rockfish	0.0	tr	0.4	0.1
Redbanded rockfish	3.4	2.2	3.0	2.3
Other species	0.0	2.2	5.7	2.4
		1999		
Sharpchin rockfish	6.0	25.9	18.7	21.5
Redstripe rockfish	23.1	11.1	14.4	13.6
Harlequin rockfish	45.0	58.7	53.2	55.6
Silvergrey rockfish	0.0	0.7	10.1	2.4
Yellowmouth rockfish	0.0	0.1	1.0	0.3
Redbanded rockfish	1.5	3.2	2.1	2.7
Other species	24.3	0.2	0.5	4.0

Table 6-3.--(Continued).

Species	Regulatory area Western	Central	Eastern	Gulf of Alaska
	Shortraker/rougheye:			
		1992		
Shortraker rockfish	45.8	49.1	70.1	55.5
Rougheye rockfish	54.2	50.9	29.9	44.5
		1993		
Shortraker rockfish	73.3	62.7	82.8	69.9
Rougheye rockfish	26.7	37.3	17.2	30.1
		1994		
Shortraker rockfish	58.3	62.6	85.4	71.3
Rougheye rockfish	41.7	37.4	14.6	28.7
		1995		
Shortraker rockfish	44.3	65.8	81.1	69.3
Rougheye rockfish	55.7	34.2	18.9	30.7
		1996		
Shortraker rockfish	57.9	55.7	80.0	62.8
Rougheye rockfish	42.1	44.3	20.0	37.2
		1997		
Shortraker rockfish	82.5	52.8	78.6	63.6
Rougheye rockfish	17.5	47.2	21.4	36.4
		1998		
Shortraker rockfish	61.4	30.8	94.3	51.0
Rougheye rockfish	38.6	69.2	5.7	49.0
		1999		
Shortraker rockfish	79.7	62.6	85.1	72.5
Rougheye rockfish	20.3	37.4	14.9	27.5

Table 6-4. Fishery length frequency data for Pacific ocean perch in the Gulf of Alaska.

Length class (cm)	Year											
	77	78	90	91	92	93	94	95	96	97	98	99
<15	0	0	104	11	23	0	0	0	1	8	0	0
15	0	0	58	3	8	0	0	0	0	3	0	0
16	2	0	33	16	20	0	0	0	0	23	0	0
17	1	0	21	31	29	0	0	0	0	35	0	0
18	2	0	54	17	24	0	0	0	0	69	0	0
19	3	0	15	56	33	0	0	0	0	25	1	0
20	9	0	41	118	26	0	0	1	0	25	3	1
21	14	0	64	145	50	0	0	0	2	27	7	0
22	20	0	66	149	62	0	0	1	1	30	4	0
23	56	1	148	233	65	0	1	9	4	37	6	4
24	100	2	214	253	82	0	0	21	6	34	19	7
25	134	4	239	252	106	0	0	36	18	52	25	7
26	198	12	378	339	116	0	0	65	27	80	36	14
27	314	33	473	266	134	0	1	50	38	120	29	12
28	484	67	599	204	134	0	2	46	42	126	35	18
29	630	130	935	217	193	1	4	67	68	164	49	29
30	890	263	1,455	199	283	3	2	68	103	227	53	21
31	1,306	415	2,123	297	449	5	3	132	196	259	97	22
32	1,710	484	3,161	470	705	14	11	255	326	345	138	53
33	2,026	429	4,459	663	1,288	17	40	535	728	641	277	119
34	2,131	286	5,389	1,074	1,825	25	94	844	1,361	1,074	769	252
35-38	7,492	173	21,463	5,507	5,889	60	610	3,389	6,480	7,861	8,761	2,054
>38	1,866	0	10,181	3,387	1,519	5	128	1,043	1,462	3,312	3,210	720

Table 6 - 5. Fishery length frequency data for northern rockfish in the Gulf of Alaska.

Length class (cm)	Year									
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
15-24	8	4	0	2	1	42	1	8	18	7
25	8	9	1	4	0	47	2	34	2	5
26	4	21	3	10	1	74	0	72	6	13
27	18	33	4	11	5	97	3	106	5	15
28	36	64	17	23	14	88	5	109	9	7
29	73	110	38	57	29	110	9	109	14	7
30	80	288	78	112	57	134	30	90	24	15
31	96	529	173	248	135	164	26	57	23	20
32	151	967	385	484	246	222	66	62	60	37
33	207	1,733	670	830	568	453	162	108	109	80
34	333	2,550	1,247	1,132	946	864	351	206	211	122
35	547	2,741	1,912	1,631	1,421	1,364	706	426	475	173
36	800	2,008	2,162	1,754	1,623	1,652	1,026	618	891	361
37	738	1,222	2,128	1,359	1,391	1,714	1,041	681	1,160	534
38	550	610	1,824	1,073	811	1,371	785	616	1,069	685
39	360	288	1,286	729	431	863	544	371	771	567
40	168	131	810	514	203	400	346	207	445	449
41	79	87	443	359	96	211	191	95	207	271
42	37	27	165	189	55	162	95	43	82	134
43	18	47	59	49	38	117	48	19	46	77
44	8	32	55	9	28	97	22	9	19	31
45-50	8	86	64	3	39	222	68	2	6	57
Total	4,327	13,587	13,524	10,582	8,138	10,468	5,527	4,048	5,652	3,667

Table 6-6.--Relative population number (RPN) and relative population weight (RPW) for rougheye and shortraker rockfish in the Gulf of Alaska domestic longline survey. Data are for the upper continental slope only, 201-1,000 m. depth (gullies are not included). Most of the data for 1990-95 are revised compared to what was listed previously in the RPN/RPW tables in the SAFE's before 1997.

	Year												
	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Rougheye RPN:													
Shumagin	2,663	5,355	4,832	3,670	7,425	6,774	3,923	9,487	5,686	7,027	5,983	6,303	10,748
Chirikof	937	1,922	1,034	1,091	970	1,507	743	1,476	1,009	1,244	1,163	1,670	2,021
Kodiak	2,523	3,198	5,522	5,005	4,196	4,028	1,951	4,526	4,494	4,290	5,065	4,987	7,852
Yakutat	2,921	4,092	3,557	4,934	4,097	5,100	2,973	4,169	4,616	4,945	3,753	5,512	5,294
Southeast	4,453	9,322	5,390	11,370	4,996	6,027	10,184	7,555	10,224	16,922	9,632	11,132	13,461
Total	13,497	23,889	20,335	26,070	21,684	23,436	19,773	27,214	26,029	34,428	25,596	29,604	39,375
Rougheye RPW:													
Shumagin	3,177	6,609	5,352	3,914	7,681	6,303	3,970	11,624	5,519	8,095	6,872	6,273	10,787
Chirikof	1,185	2,414	1,281	1,287	1,279	1,743	914	1,787	1,375	1,619	1,527	2,053	2,416
Kodiak	2,786	3,751	6,409	5,338	4,504	4,091	1,994	4,728	4,621	4,224	5,598	4,900	7,705
Yakutat	3,815	5,116	4,398	6,480	4,513	5,025	3,313	4,394	5,069	5,495	4,271	5,629	6,051
Southeast	5,975	13,069	7,412	15,555	6,871	8,807	15,593	10,311	14,001	23,754	12,728	14,372	19,450
Total	16,938	30,959	24,852	32,574	24,849	25,970	25,784	32,843	30,585	43,187	30,996	33,227	46,408
Shortraker RPN:													
Shumagin	4,492	3,272	3,015	3,074	1,660	1,523	2,549	5,765	4,098	2,888	4,630	5,011	9,481
Chirikof	1,290	858	773	776	572	229	613	531	646	918	973	823	1,298
Kodiak	2,332	2,691	3,476	2,412	1,374	1,067	1,040	1,325	2,231	2,200	2,498	3,078	2,904
Yakutat	5,830	6,492	9,281	10,575	9,130	7,121	5,222	7,992	8,409	12,408	15,295	13,394	13,995
Southeast	1,420	1,972	1,403	2,247	1,479	2,199	1,862	2,427	1,967	2,459	3,258	3,167	4,025
Total	15,364	15,285	17,948	19,085	14,214	12,139	11,286	18,039	17,352	20,873	26,654	25,473	31,703
Shortraker RPW:													
Shumagin	4,869	4,301	5,004	5,953	2,078	2,192	3,956	7,940	5,946	4,468	6,716	6,954	15,050
Chirikof	2,591	1,449	1,216	1,384	914	293	1,174	812	1,007	1,471	1,422	1,165	1,607
Kodiak	5,043	5,833	6,787	4,874	2,802	1,912	2,649	2,554	4,657	4,273	5,201	5,562	5,553
Yakutat	13,320	13,335	19,093	20,585	17,033	14,411	11,046	15,248	17,352	26,830	30,685	26,500	28,754
Southeast	2,474	3,384	2,214	3,546	2,053	4,124	3,102	4,034	3,377	3,970	5,818	4,569	7,099
Total	28,297	28,302	34,313	36,343	24,880	22,932	21,927	30,588	32,338	41,013	49,842	44,750	58,063

Table 6-7.--Estimated biomass (mt), by area, for slope rockfish in the 1999 triennial trawl survey of the Gulf of Alaska. Gulfwide 95% confidence bounds (mt) are also listed. Note: data in this table are for total biomass in the survey. For exploitable biomass, see Table 6-16.

	Statistical areas						95% Gulfwide Confidence Bounds	
Species	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern	Gulfwide Total	Lower	Upper
Pacific ocean perch	37,670	402,307	209,704	32,735	44,369	726,785	0	1,566,111
Shortraker rockfish	2,208	3,931	8,460	9,788	3,845	28,232	16,799	39,666
Rougheye rockfish	6,155	3,449	17,369	8,552	4,131	39,655	28,065	51,245
Shortraker/rougheye	8,363	7,380	25,829	18,340	7,976	67,887	52,211	83,564
Northern rockfish	45,148	29,948	166,656	118	0	241,870	0	562,418
Sharpchin rockfish	0	15	2,842	15,126	2,860	20,842	0	54,404
Redstripe rockfish	0	8	131	40	8,048	8,226	0	16,619
Harlequin rockfish	7	167	8,397	1,046	261	9,877	1,313	18,441
Silvergrey rockfish	0	0	6,746	6,456	24,441	37,643	12,372	62,915
Redbanded rockfish	118	45	360	1,344	9,077	10,943	1,352	20,534
Splitnose rockfish	0	0	0	2	5	7	0	17
Darkblotched rockfish	0	0	0	16	256	272	0	553
Greenstriped rockfish	0	0	0	12	455	467	21	913
Pygmy rockfish	0	0	6	128	54	187	0	389
Yellowmouth rockfish	0	0	0	18	5,552	5,570	0	17,517
Total, other slope	126	234	18,481	24,187	51,007	94,034	53,572	134,496
Total, all species	91,307	439,869	420,669	75,379	103,353	1,130,576	315,041	1,946,111

Table 6-8.--Comparison of biomass estimates (mt) for slope rockfish species in the Gulf of Alaska in the 1984, 1987, 1990, 1993, 1996, and 1999 triennial trawl surveys. For a comparison of exploitable biomass estimates for these surveys, see Table 6-16.

Species	1984	1987	1990	1993	1996	1999
Pacific ocean perch	232,694	214,827	138,003	460,755	778,663	726,785
Shortraker rockfish	17,721	41,457	10,809	19,025	20,261	28,232
Rougheye rockfish	46,999	43,929	46,142	64,077	45,806	39,655
Subtotal, shortraker/rougheye	64,720	85,386	56,951	83,102	66,067	67,887
Northern rockfish	40,564	140,049	112,948	109,835	98,947	241,870
Sharpchin rockfish	7,219	70,160	37,050	22,562	64,666	20,842
Redstripe rockfish	4,803	23,706	24,681	26,737	14,965	8,226
Harlequin rockfish	2,442	63,833	17,194	9,913	20,042	9,877
Silvergrey rockfish	4,145	4,710	13,774	16,991	24,145	37,643
Redbanded rockfish	1,400	1,561	3,173	3,544	4,603	10,943
Darkblotched rockfish	6	33	184	300	121	272
Splitnose rockfish	0	2	3	0	0	7
Greenstriped rockfish	16	62	156	250	352	467
Vermilion rockfish	0	0	0	21	0	0
Bocaccio	502	38	176	95	137	0
Pygmy rockfish	0	366	76	3	284	187
Yellowmouth rockfish	516	241	1,900	3,460	923	5,570
Subtotal, other slope rockfish	21,049	164,712	98,367	83,876	130,238	94,034
Total, all species	359,027	604,974	406,269	737,568	1,073,915	1,130,576

Table 6-9.--Biomass estimates (mt) for Pacific ocean perch in the Gulf of Alaska based on trawl surveys.

	Western	Central		Eastern		Total	95% Confidence interval
	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern		
1984	59,710	9,672	36,976	94,055	32,280	232,694	101,550 - 363,838
1987	62,906	19,666	44,441	35,612	52,201	214,827	125,499 - 304,155
1990	24,375	15,991	15,221	35,635	46,780	138,003	70,993 - 205,013
1993	79,294	104,495	154,013	33,600	89,353	460,755	255,253 - 665,987
1996	92,608	147,711	326,298	50,396	161,650	778,663	358,923 - 1,198,403
1999	37,670	402,307	209,704	32,735	44,369	726,785	0 - 1,566,111

Table 6-10 . Survey age composition (% frequency) data for Pacific ocean perch in the Gulf of Alaska. Age compositions for 1978 and 1979 are based on surface reading of otoliths. Age compositions for 1980-99 are based on "break and burn" reading of otoliths.

Age class	Year										
	78	79	80	81	82	84	87	90	93	96	99
2	16.08	0.00	0.00	0.14	0.00	0.81	0.73	0.52	0.69	1.72	0.60
3	0.24	0.55	0.39	0.40	0.00	0.53	4.63	6.03	1.97	1.61	2.03
4	1.04	0.81	3.32	5.94	0.17	12.51	6.70	10.90	2.42	3.54	4.54
5	0.63	2.69	5.78	3.42	4.24	2.76	6.18	7.18	7.43	4.25	5.16
6	1.89	5.72	3.01	3.34	8.63	3.82	9.45	12.61	10.98	6.22	2.56
7	6.08	14.52	2.10	2.10	5.27	8.03	19.34	15.54	14.77	3.73	4.06
8	12.02	21.94	7.01	1.34	1.41	38.37	7.30	9.45	11.44	8.72	5.91
9	11.32	17.34	8.37	2.59	3.77	4.01	8.36	7.26	12.77	14.32	9.46
10	9.63	10.72	15.51	6.49	5.47	2.20	10.91	7.88	7.62	18.32	5.40
11	5.42	7.51	9.75	16.93	7.06	0.76	11.40	3.58	4.88	10.91	11.38
12	4.79	4.49	6.40	15.90	11.07	1.98	2.10	2.50	7.55	7.93	14.37
13	5.06	2.72	4.91	5.76	9.52	1.53	1.12	2.55	3.05	3.40	8.61
14	5.44	2.30	2.57	4.19	6.64	1.71	1.02	4.99	1.94	3.60	6.66
15	4.76	1.89	3.24	3.01	4.46	0.66	0.78	1.18	1.82	2.73	4.55
16	4.50	1.66	2.81	1.68	2.39	0.34	0.86	1.01	0.80	0.57	3.99
17	3.57	1.45	1.53	1.03	1.54	1.09	1.27	0.50	3.05	1.27	2.28
18	3.36	1.21	1.69	0.73	1.35	0.71	0.45	0.44	0.62	0.86	1.33
19	2.01	0.91	1.88	1.39	1.00	0.24	0.31	0.47	0.19	1.34	0.32
20	0.92	0.61	1.54	2.75	2.26	0.45	0.36	0.60	0.22	1.29	1.22
21	0.68	0.48	1.83	0.29	1.39	0.39	0.30	0.40	0.14	0.34	0.69
22	0.24	0.28	1.24	0.48	0.79	0.17	0.16	0.15	0.55	0.38	0.79
23	0.12	0.12	0.35	0.70	0.05	0.42	0.18	0.21	0.23	0.25	1.16
24	0.19	0.07	0.86	0.39	0.78	0.20	0.09	0.14	0.33	0.00	0.45
25+	0.00	0.03	13.90	19.01	20.73	16.30	6.00	3.91	4.53	2.69	2.49

Table 6 -11. Observed survey age composition (% frequency) for northern rockfish in the Gulf of Alaska.

Age class	Year					
	1984	1987	1990	1993	1996	1999
2	0.00	0.00	0.00	0.03	0.28	0.00
3	0.00	0.37	0.06	0.28	0.30	0.03
4	0.00	1.78	0.19	0.31	0.12	0.16
5	1.39	5.53	2.91	0.85	0.21	1.05
6	3.86	4.05	5.41	1.07	1.13	0.27
7	8.39	2.96	2.65	1.08	0.58	0.94
8	17.28	0.28	4.08	6.34	2.06	0.89
9	10.21	2.88	5.38	11.98	4.10	4.23
10	4.78	10.10	4.47	6.54	5.31	2.77
11	4.37	11.21	5.77	10.31	8.52	7.92
12	2.44	11.15	3.52	4.45	7.58	6.92
13	6.81	3.43	5.36	4.90	7.72	5.42
14	6.42	4.28	8.24	4.02	4.02	5.62
15	5.99	1.40	9.71	2.44	3.29	7.82
16	3.82	3.66	5.09	5.19	3.87	9.16
17	1.87	10.31	5.08	3.14	1.65	1.56
18	1.79	4.09	0.67	3.97	3.41	7.21
19	0.55	7.98	1.12	2.81	5.44	1.88
20	0.72	2.72	6.56	0.40	8.78	1.30
21	0.30	2.55	6.63	2.32	2.77	3.00
22	0.95	0.70	4.58	3.41	3.07	2.19
23	3.06	0.65	1.92	4.45	3.02	2.51
24	2.03	0.29	0.89	4.46	3.33	3.03
25+	12.98	7.63	9.71	15.26	19.43	24.12

Table 6-12. Mortality rates, maximum age, and age of recruitment for slope rockfish. Area indicates location of study; West Coast of USA (WC), British Columbia (BC), Gulf of Alaska (GOA), Aleutians (AL), Bering Sea (BS). All mortality rates except where noted are for instantaneous rate of total mortality (Z) estimated with catch-curves.

Species	Mortality rate	Maximum age	Age of recruitment	Area	Reference
Pacific ocean	0.02-0.08	90	-	BC	1,2
perch	-	-	10	GOA	3
	-	84	-	GOA	4
	-	98	-	AL	5
Northern	0.06[a]	44	-	GOA	4
	-	57	-	AL	4
Rougheye	0.01-0.04	140	-	BC	1,2
	0.04	95	30	GOA	6,7
	0.030-0.039[b]	-	-	WC,BS,AL,GOA	8
Shortraker	-	120	-	BC	2
	0.027-0.042[b]	-	-	WC,BS,AL,GOA	8
Sharpchin	0.05	46	-	BC	1
	-	58	-	GOA	4
Yellowmouth	0.06	71	-	BC	1,2
Darkblotched	0.07	48	-	BC	1
Harlequin	-	43	-	BC	2
	-	34	-	GOA	4
Redstripe	0.1	41	-	BC	1,2
Silvergrey	0.01-0.07	80	-	BC	1,2
	-	75	-	GOA	4

1) Archibald et al. 1981; 2) Chilton and Beamish 1982; 3) Heifetz et al. 1994; 4) Malecha and Heifetz 2000; 5) Ito 1987; 6) Nelson and Quinn 1987; 7) Nelson 1986; 8) McDermott 1994. [a]The mortality rate for northern rockfish is for the instantaneous rate of natural mortality (M) estimated by the method of Alverson and Carney (1975). [b]M based on the gonad somatic index method (McDermott 1994).

Table 6-13a. Length-weight coefficients for some species of slope rockfish. Length-weight coefficients are the formula $W = aL^b$ where W = weight in kg and L = length in cm.

Species	Sex	a	b	Reference
Pacific ocean perch	combined	1.54×10^{-5}	2.95	1
	combined	1.91×10^{-5}	2.90	2
	males	1.57×10^{-5}	2.95	2
	females	2.04×10^{-5}	2.89	2
Northern	combined	1.63×10^{-5}	2.98	3
	combined	1.37×10^{-5}	3.04	2
	males	1.55×10^{-5}	2.99	2
	females	1.53×10^{-5}	3.01	2
Rougheye	combined	1.98×10^{-5}	2.94	2
	males	2.04×10^{-5}	2.94	2
	females	1.89×10^{-5}	2.97	2
Sharpchin	combined	1.13×10^{-5}	3.07	2
	males	8.89×10^{-6}	3.15	2
	females	1.19×10^{-5}	3.06	2
Shortraker	combined	9.85×10^{-6}	3.13	2
	males	1.26×10^{-5}	3.07	2
	females	1.02×10^{-5}	3.12	2

1) Ito 1982; 2) Martin 1997; 3) Clausen and Heifetz 1989.

Table 6-13b. Von Bertalanffy parameters for some species of slope rockfish, by area and sex. (BC = British Columbia; GOA = Gulf of Alaska; AL = Aleutian Islands; and BS = Eastern Bering Sea.)

Species	Area	Sex	t_0	k	L_{inf} (cm)	Reference
Pacific ocean perch	BC	combined	-8.22	0.088	44.80	1
	BC	combined	-5.22	0.126	42.60	1
	GOA	combined	-0.32	0.207	41.10	2
	GOA	combined	-0.37	0.204	40.74	3
	GOA	male	-0.29	0.220	39.56	3
	GOA	female	-0.41	0.191	42.00	3
	AL	combined	-0.82	0.169	39.24	3
	BS	combined	-1.66	0.140	39.96	3
Northern	GOA	combined	-1.51	0.190	35.60	2
	GOA	combined	-0.64	0.165	39.16	3
	GOA	male	-0.26	0.187	37.83	3
	GOA	female	-0.87	0.152	40.22	3
	AL	combined	-7.16	0.103	34.27	3
Rougheye	GOA	combined	-4.21	0.050	54.70	4
	GOA	combined	0.63	0.108	49.63	3
	GOA	male	1.14	0.119	49.79	3
	GOA	female	0.18	0.100	49.57	3
Sharpchin	BC	combined	-2.21	0.095	34.90	1
	GOA	combined	-0.81	0.131	32.64	3
	GOA	male	-0.48	0.167	28.44	3
	GOA	female	-0.75	0.122	35.02	3
Silvergray	GOA	combined	-1.68[a]	0.100	59.80	3
	GOA	male	-1.68[a]	0.110	57.14	3
	GOA	female	-1.68[a]	0.093	62.25	3
Harlequin	GOA	combined	-3.86	0.099	31.51	3
	GOA	male	-4.76	0.091	30.60	3
	GOA	female	-3.26	0.110	32.32	3

1) Archibald et al. 1981; 2) Heifetz and Clausen 1991; 3) Malecha and Heifetz 2000; 4) Nelson 1986.

[a]t_0 for silvergray rockfish could not be accurately estimated from the data, therefore t_0 was constrained at the average value for all other rockfish species.

Table 6-14. Estimated time series of female spawning biomass, 6+ biomass (age 6 and greater), catch/6 + biomass, and number of age two recruits for Pacific ocean perch in the Gulf of Alaska. Estimates are shown for the current assessment and from the previous SAFE.

Year	Spawning biomass (mt)		6+ Biomass (mt)		catch/6+ biomass		Age two recruits (1000's)	
	Current	Previous	Current	Previous	Current	Previous	Current	Previous
1977	23,511	23,511	88,122	88,122	0.245	0.245	6,137	6,137
1978	19,790	19,790	70,455	70,455	0.114	0.114	42,227	42,227
1979	19,600	19,600	64,409	64,409	0.129	0.129	17,917	17,917
1980	19,025	19,025	57,633	57,633	0.187	0.187	8,251	8,251
1981	17,087	17,087	48,348	48,348	0.217	0.217	7,328	7,328
1982	14,492	14,492	49,829	49,829	0.108	0.108	64,403	64,403
1983	14,058	14,058	50,978	50,978	0.055	0.055	12,323	12,323
1984	14,564	14,564	52,093	52,093	0.053	0.053	31,242	31,242
1985	15,221	15,221	52,639	52,639	0.015	0.015	50,482	50,482
1986	16,562	16,562	71,769	71,769	0.031	0.031	66,458	66,458
1987	18,813	18,813	76,463	76,463	0.059	0.059	32,768	32,768
1988	20,138	20,138	83,813	83,813	0.102	0.102	145,799	145,799
1989	20,494	20,494	93,040	93,040	0.127	0.127	94,371	94,371
1990	20,509	20,509	104,721	104,721	0.125	0.125	60,544	60,544
1991	21,175	21,175	106,675	106,675	0.062	0.062	27,417	27,417
1992	24,206	24,206	148,083	148,083	0.042	0.042	73,139	73,139
1993	30,263	30,263	179,706	179,706	0.011	0.011	53,283	53,283
1994	39,156	39,156	206,873	206,873	0.009	0.009	58,370	58,370
1995	49,498	49,498	223,567	223,567	0.026	0.026	50,256	164,197 *
1996	59,165	59,165	247,165	247,165	0.034	0.034	50,256	50,256
1997	69,235	69,235	261,992	261,992	0.036	0.036	50,256	50,256
1998	78,521	78,521	275,952	275,952	0.032	0.032	50,256	50,256
1999	87,075	87,075	284,337	321,051	0.037	0.033	50,256	50,256
2000	90,757	96,441	290,085	333,201	0.035		50,256	50,256
2001	95,480		296,268				50,256	

*This recruitment value was used in error in last year's assessment. The value 50,256 should have been used.

Table 6-15. Estimated numbers (thousands) in 2001, fishery selectivity, and survey selectivity of Pacific ocean perch in the Gulf of Alaska based on the stock synthesis model. Also shown are schedules of age specific weight and female maturity.

Age	Numbers in 2001 (1,000's)	Percent mature	wt grams	Fishery selectivity	Survey selectivity
2	50,256	0	53	0.2	1.5
3	47,798	0	116	0.4	6.6
4	45,453	0	194	0.8	14.7
5	42,329	0	279	1.8	26.7
6	37,777	0	363	4.2	43.6
7	32,450	12	442	9.3	65.3
8	29,475	20	515	19.5	90.5
9	40,267	30	579	37.6	100.0
10	34,301	42	635	61.8	100.0
11	43,428	56	683	84.1	100.0
12	14,837	69	724	96.8	100.0
13	29,588	79	759	100.0	100.0
14	41,453	87	788	97.8	100.0
15	57,469	92	812	93.1	100.0
16	11,581	95	832	87.6	100.0
17	20,957	97	848	81.9	100.0
18	13,986	98	861	76.4	100.0
19	7,375	99	872	71.2	100.0
20	2,377	99	881	66.2	100.0
21	9,758	100	889	61.4	100.0
22	854	100	895	57.0	100.0
23	742	100	900	52.9	100.0
24	1,263	100	904	49.0	100.0
25+	7,210	100	907	45.3	100.0

Table 6 -16. Estimated time series of female spawning 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. Estimates are shown for the current assessment which is the first with an age structured model.

Year	Spawning biomass (mt)	6+ Total Biomass (mt)	Catch / (6+ Total biomass)	Age two recruits (1000's)
1977	24,803	92,655	0.007	37,392
1978	25,565	93,936	0.006	55,369
1979	26,782	99,414	0.007	29,396
1980	28,374	100,555	0.008	8,484
1981	30,257	107,469	0.014	10,108
1982	32,145	117,982	0.033	22,854
1983	33,311	121,479	0.029	18,368
1984	34,507	120,721	0.008	38,873
1985	36,470	122,072	0.001	12,867
1986	38,670	126,227	0.002	54,896
1987	40,806	129,123	0.004	20,674
1988	42,824	135,858	0.008	9,160
1989	44,529	136,764	0.011	17,824
1990	45,963	145,691	0.012	15,443
1991	47,186	148,078	0.030	3,108
1992	47,236	144,824	0.052	12,579
1993	46,049	139,613	0.034	2,174
1994	45,698	136,398	0.043	3,779
1995	44,852	129,212	0.043	3,814
1996	43,961	123,802	0.027	10,797
1997	43,651	118,233	0.025	16,400
1998	43,260	113,022	0.027	16,400
1999	42,521	107,450	0.049	16,400
2000	40,533	100,953	0.033	16,400
2001	39,088	97,815		16,400

Table 6-17. Estimated numbers (thousands) in 2001, 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 in 2001 (1000's)	Percent mature	Weight (g)	Fishery and survey selectivity
2	16,400	1	63	2
3	15,432	2	103	5
4	14,502	3	153	10
5	13,608	4	210	18
6	12,729	6	273	28
7	7,808	9	336	41
8	2,558	13	399	57
9	2,337	18	458	77
10	1,230	25	512	93
11	6,469	33	561	100
12	1,450	43	603	100
13	6,541	52	641	100
14	6,853	62	672	100
15	3,191	71	699	100
16	6,525	78	722	100
17	15,747	84	740	100
18	3,369	89	756	100
19	9,352	92	769	100
20	4,089	95	780	100
21	4,735	96	788	100
22	1,953	97	795	100
23+	48,540	98	801	100

Table 6-18.--Estimates of exploitable biomass of shortraker and rougheye rockfish and other slope rockfish in the Gulf of Alaska, by NPFMC regulatory area, based on the 1993 - 99 triennial trawl surveys. Results of the age structured modeling are used to determine exploitable biomass of Pacific ocean perch and northern rockfish.

	Exploitable biomass (mt)			
Species	Western	Central	Eastern	Total
		1993		
Shortraker rockfish	2,726	7,636	8,588	18,950
Rougheye rockfish	11,230	42,326	9,854	63,410
Subtotal, shortraker/rougheye	13,956	49,962	18,442	82,360
Sharpchin rockfish	22	7,943	14,490	22,455
Redstripe rockfish	0	111	26,620	26,731
Harlequin rockfish	30	8,060	530	8,619
Silvergrey rockfish	0	448	16,433	16,880
Redbanded rockfish	11	444	3,089	3,544
Minor species	0	0	4,105	4,105
Subtotal, other slope rockfish	63	17,006	65,267	82,334
		1996		
Shortraker rockfish	1,906	10,134	8,221	20,261
Rougheye rockfish	3,404	27,405	13,803	44,612
Subtotal, shortraker/rougheye	5,310	37,539	22,024	64,873
Sharpchin rockfish	39	2,015	62,579	64,633
Redstripe rockfish	0	89	14,722	14,811
Harlequin rockfish	772	1,937	16,372	19,081
Silvergrey rockfish	0	1,555	22,478	24,033
Redbanded rockfish	61	203	4,298	4,562
Minor species	152	20	4,036	4,208
Subtotal, other slope rockfish	1,024	5,819	124,485	131,328
		1999		
Shortraker rockfish	2,208	12,391	13,633	28,232
Rougheye rockfish	6,036	18,781	12,373	37,189
Subtotal, shortraker/rougheye	8,244	31,172	26,005	65,421
Sharpchin rockfish	0	2,857	17,985	20,842
Redstripe rockfish	0	125	8,077	8,201
Harlequin rockfish	7	8,560	1,307	9,874
Silvergrey rockfish	0	6,746	30,755	37,500
Redbanded rockfish	118	404	10,421	10,943
Minor species	0	6	6,483	6,489
Subtotal, other slope rockfish	126	18,698	75,027	93,850

Table 6-19. Set of projections of spawning biomass (SB) and yield for Pacific ocean perch in the Gulf of Alaska. This set of projections 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). For a description of scenarios see section 6.7.1. All units in mt. $B_{40\%}$ = 110,120 mt, $B_{35\%}$ = 96,360 mt, $F_{40\%}$ = 0.078, and $F_{35\%}$ = 0.093.

Year	1 Maximum permissible F	2 Author's F	3 Half maximum F	4 5-year average F	5 No fishing	6 Overfished	7 Approaching overfished?
Spawning biomass (mt)							
2000	90,757	90,757	90,757	90,757	90,757	90,757	90,757
2001	95,756	95,756	96,660	96,054	97,574	95,419	95,756
2002	98,748	98,748	102,425	100,009	106,307	97,420	98,748
2003	100,744	100,744	107,207	103,120	114,430	98,496	100,381
2004	102,031	102,031	111,166	105,585	121,976	98,966	100,631
2005	102,918	102,918	114,567	107,649	129,065	99,152	100,602
2006	103,146	103,146	117,154	108,998	135,261	98,797	100,043
2007	103,602	103,602	119,818	110,502	141,459	98,767	99,830
2008	104,067	104,067	122,327	111,947	147,358	98,831	99,732
2009	104,480	104,480	124,793	113,411	153,119	98,885	99,643
2010	104,673	104,673	126,915	114,520	158,604	98,831	99,472
2011	104,933	104,933	128,685	115,520	163,199	98,836	99,374
2012	105,017	105,017	130,326	116,301	167,709	98,843	99,302
2013	106,011	106,011	133,377	118,751	173,442	99,451	99,841
Fishing mortality							
2000	0.052	0.052	0.052	0.052	0.052	0.052	0.052
2001	0.067	0.067	0.034	0.056	0.000	0.080	0.067
2002	0.070	0.070	0.036	0.056	0.000	0.082	0.070
2003	0.071	0.071	0.038	0.056	0.000	0.083	0.085
2004	0.072	0.072	0.039	0.056	0.000	0.083	0.085
2005	0.073	0.073	0.039	0.056	0.000	0.083	0.085
2006	0.073	0.073	0.039	0.056	0.000	0.083	0.084
2007	0.073	0.073	0.039	0.056	0.000	0.083	0.084
2008	0.074	0.074	0.039	0.056	0.000	0.083	0.084
2009	0.074	0.074	0.039	0.056	0.000	0.083	0.084
2010	0.074	0.074	0.039	0.056	0.000	0.083	0.084
2011	0.074	0.074	0.039	0.056	0.000	0.083	0.084
2012	0.074	0.074	0.039	0.056	0.000	0.083	0.084
2013	0.075	0.075	0.039	0.056	0.000	0.084	0.084
Yield (mt)							
2000	10,133	10,133	10,133	10,133	10,133	10,133	10,133
2001	13,510	13,510	6,850	11,327	-	15,958	13,510
2002	13,972	13,972	7,485	11,450	-	16,170	13,972
2003	14,138	14,138	7,974	11,463	-	16,067	16,695
2004	14,095	14,095	8,330	11,395	-	15,768	16,301
2005	13,962	13,962	8,346	11,298	-	15,417	15,860
2006	13,782	13,782	8,355	11,219	-	15,056	15,418
2007	13,672	13,672	8,366	11,157	-	14,811	15,105
2008	13,562	13,562	8,377	11,108	-	14,590	14,826
2009	13,519	13,519	8,395	11,076	-	14,466	14,655
2010	13,529	13,529	8,427	11,077	-	14,409	14,560
2011	13,491	13,491	8,503	11,138	-	14,330	14,451
2012	13,204	13,204	8,470	11,046	-	13,985	14,082
2013	13,527	13,527	8,673	11,254	-	14,288	14,372

Table 6-20. Percentage of exploitable biomass by area for slope rockfish based on the 1993, 96, and 99 triennial trawl surveys. Weighted average uses weights of 4:6:9 for the 1993, 1996 and 1999 survey, respectively.

	Western	Central	Eastern
1993			
Pacific ocean perch	16.68%	56.21%	27.11%
Rougheye/shortraker rockfish	16.95%	60.66%	22.39%
Northern rockfish	3.71%	96.25%	0.04%
Other slope rockfish	0.08%	20.65%	79.27%
1996			
Pacific ocean perch	11.48%	61.11%	27.41%
Rougheye/shortraker rockfish	8.19%	57.87%	33.95%
Northern rockfish	26.28%	73.51%	0.21%
Other slope rockfish	0.78%	4.43%	94.79%
1999			
Pacific ocean perch	5.00%	84.37%	10.63%
Rougheye/shortraker rockfish	12.60%	47.65%	39.75%
Northern rockfish	6.78%	93.18%	0.04%
Other slope rockfish	0.13%	19.92%	79.94%
Weighted average			
Pacific ocean perch	9.51%	71.10%	19.40%
Rougheye/shortraker rockfish	12.12%	53.62%	34.26%
Northern rockfish	12.29%	87.61%	0.09%
Other slope rockfish	0.32%	15.18%	84.49%

Table 6-21. Northern rockfish spawning biomass, fishing mortality, and yield for seven harvest scenarios. The reference spawning biomass used to determine if the population is over fished, $B_{35\%}$, is 21,198 mt, target spawning biomass, $B_{40\%}$, is 24,226 mt.

Year	1 Maximum permissible F	2 Author's F	3 Half maximum F	4 5-year average F	5 No fishing	6 Overfished	7 Approaching overfished?
Spawning biomass (mt)							
2000	40,479	40,479	40,479	40,479	40,479	40,479	40,479
2001	38,942	38,942	38,942	38,942	38,942	38,942	38,942
2002	36,573	36,573	37,583	37,652	38,621	36,194	36,573
2003	34,215	34,215	36,124	36,256	38,140	33,513	34,215
2004	31,913	31,913	34,607	34,796	37,531	30,942	31,584
2005	29,727	29,727	33,094	33,334	36,848	28,536	29,121
2006	27,703	27,703	31,637	31,922	36,143	26,337	26,867
2007	25,901	25,901	30,310	30,634	35,496	24,398	24,877
2008	24,328	24,328	29,128	29,484	34,921	22,721	23,151
2009	23,025	23,025	28,154	28,540	34,503	21,338	21,723
2010	22,002	22,002	27,418	27,831	34,287	20,289	20,617
2011	21,254	21,254	26,912	27,350	34,276	19,559	19,835
2012	20,768	20,768	26,625	27,087	34,474	19,099	19,331
2013	20,510	20,510	26,545	27,030	34,882	18,865	19,058
Fishing mortality							
2000	0.036	0.036	0.036	0.036	0.036	0.036	0.036
2001	0.055	0.055	0.027	0.026	0.000	0.065	0.055
2002	0.055	0.055	0.027	0.026	0.000	0.065	0.055
2003	0.055	0.055	0.027	0.026	0.000	0.065	0.065
2004	0.055	0.055	0.027	0.026	0.000	0.065	0.065
2005	0.055	0.055	0.027	0.026	0.000	0.065	0.065
2006	0.055	0.055	0.027	0.026	0.000	0.065	0.065
2007	0.055	0.055	0.027	0.026	0.000	0.065	0.065
2008	0.055	0.055	0.027	0.026	0.000	0.065	0.065
2009	0.055	0.055	0.027	0.026	0.000	0.063	0.064
2010	0.054	0.054	0.027	0.026	0.000	0.060	0.061
2011	0.053	0.053	0.027	0.026	0.000	0.058	0.059
2012	0.051	0.051	0.027	0.026	0.000	0.057	0.057
2013	0.050	0.050	0.027	0.026	0.000	0.056	0.056
Yield (mt)							
2000	3,397	3,397	3,397	3,397	3,397	3,397	3,397
2001	4,806	4,806	2,435	2,273	0	5,695	4,806
2002	4,450	4,450	2,315	2,165	0	5,219	4,450
2003	4,136	4,136	2,209	2,070	0	4,804	4,901
2004	3,861	3,861	2,115	1,984	0	4,442	4,530
2005	3,624	3,624	2,032	1,910	0	4,132	4,211
2006	3,433	3,433	1,967	1,852	0	3,882	3,952
2007	3,298	3,298	1,926	1,815	0	3,704	3,767
2008	3,220	3,220	1,910	1,802	0	3,596	3,652
2009	3,183	3,183	1,913	1,807	0	3,440	3,533
2010	3,129	3,129	1,928	1,822	0	3,268	3,354
2011	3,048	3,048	1,946	1,841	0	3,158	3,230
2012	2,996	2,996	1,968	1,863	0	3,102	3,162
2013	2,976	2,976	1,992	1,887	0	3,089	3,137

Table 6-22. Set of projections of yield for slope rockfish for 2001 in the Gulf of Alaska. This set of projections encompasses scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). For a description of scenarios see section 6.7.1. All units in mt.

	Exploitable	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
Species	Biomass	F	Yield	F	Yield	F	Yield	F	Yield
Shortraker	22,481	0.023	517	0.023	517	0.012	259		
Rougheye	48,404	0.032	1,549	0.025	1,210	0.016	774		
total shortraker rougheye	70,885		**2,066**		**1,727**		**1,033**	0.025	**1,781**
Sharpchin	35,977	0.053	1,907	0.050	1,799	0.027	953		
Redstripe	16,581	0.075	1,244	0.075	1,244	0.038	622		
Harlequin	12,525	0.045	564	0.045	564	0.023	282		
Silvergrey	26,138	0.030	784	0.030	784	0.015	392		
Redbanded	6,350	0.045	286	0.045	286	0.023	143		
Minor spp	4,934	0.045	222	0.045	222	0.023	111		
total other slope rockfish	102,505		**5,006**		**4,898**		**2,503**	0.010	**980**

Table 6-23. Summary of computations of ABC's and overfishing levels for slope rockfish for 2000. Since ABC's and overfishing levels are based on subgroups, individual species are shown only for illustrative purposes.

Species	Exploitable biomass (mt)	ABC F	ABC Yield (mt)	Overfishing F	Overfishing Yield (mt)
Pacific ocean perch	211,160	$F=F_{40\%}(B/B_{40\%}-\alpha)/(1-\alpha)=0.067$	13,510	$F=F_{35\%}(B/B_{40\%}-\alpha)/(1-\alpha)=0.080$	15,960
Shortraker rockfish	22,481	F=0.75M=0.023	517	F=M=0.030	674
Rougheye rockfish	48,404	F=M=0.025	1,210	F35%=0.038	1,839
Subtotal rougheye/shortraker	70,885		1,727		2,513
Northern rockfish	93,850	$F=F_{40\%}=0.055$	4,880	F35%=0.065	5,780
Sharpchin rockfish	35,977	F=M=0.050	1,799	F35%=0.064	2,303
Redstripe rockfish	16,581	F=0.75M=0.075	1,244	F=M=0.100	1,658
Harlequin rockfish	12,525	F=0.75M=0.045	563	F=M=0.060	752
Silvergrey rockfish	26,138	F=0.75M=0.030	784	F=M=0.040	1,046
Redbanded rockfish	6,350	F=0.75M=0.045	286	F=M=0.060	331
Minor species	4,934	F=0.75M=0.045	222	F=M=0.060	296
Subtotal other slope rockfish	102,505		4,898		6,386
Total	478,400		25,015		30,639

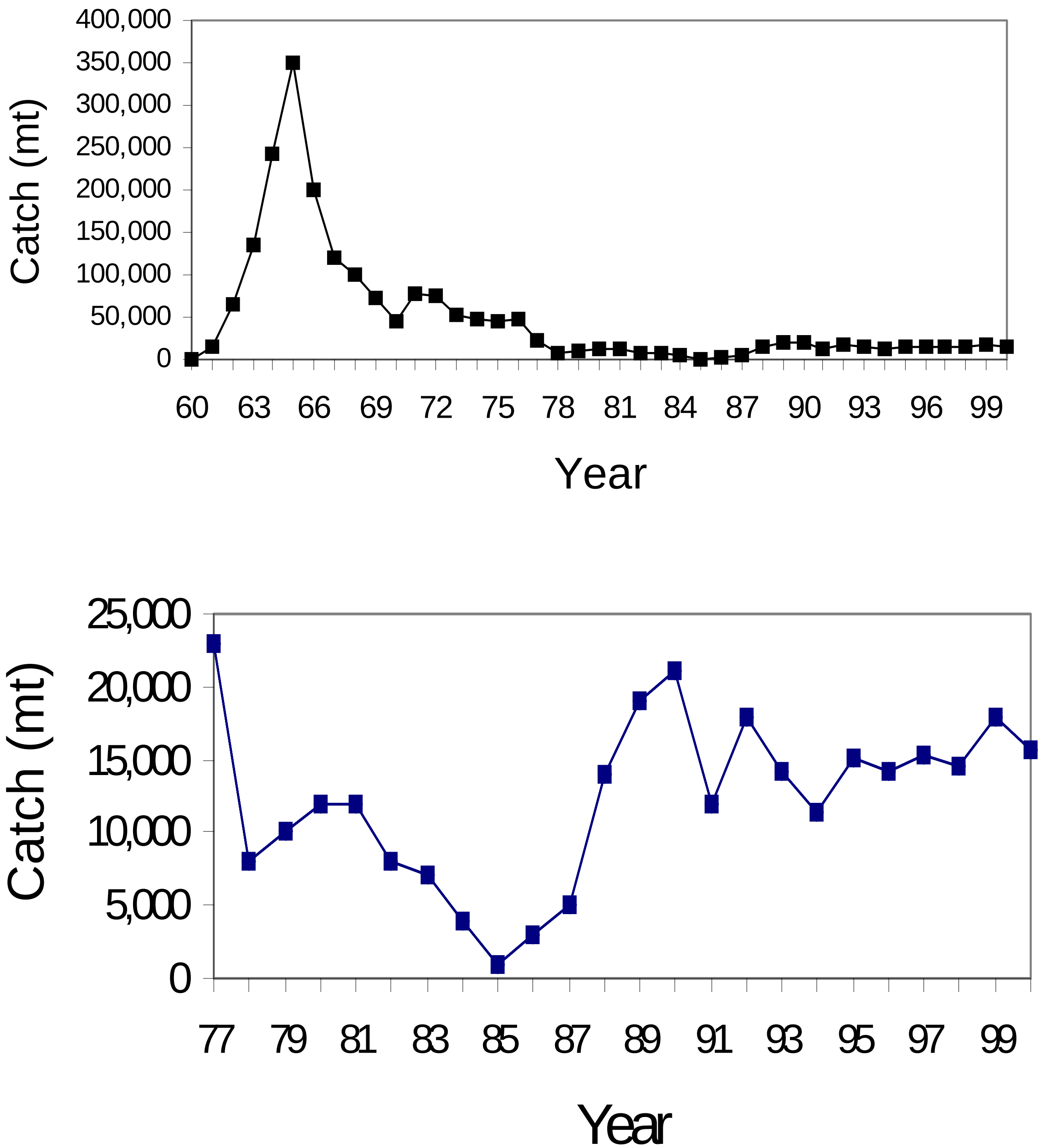

Figure 6-1.-- All nation catch of Pacific ocean perch and slope rockfish in the Gulf of Alaska as of September 30, 2000. Long term catch history shown in upper panel nd recent catch history shown in lower panel.

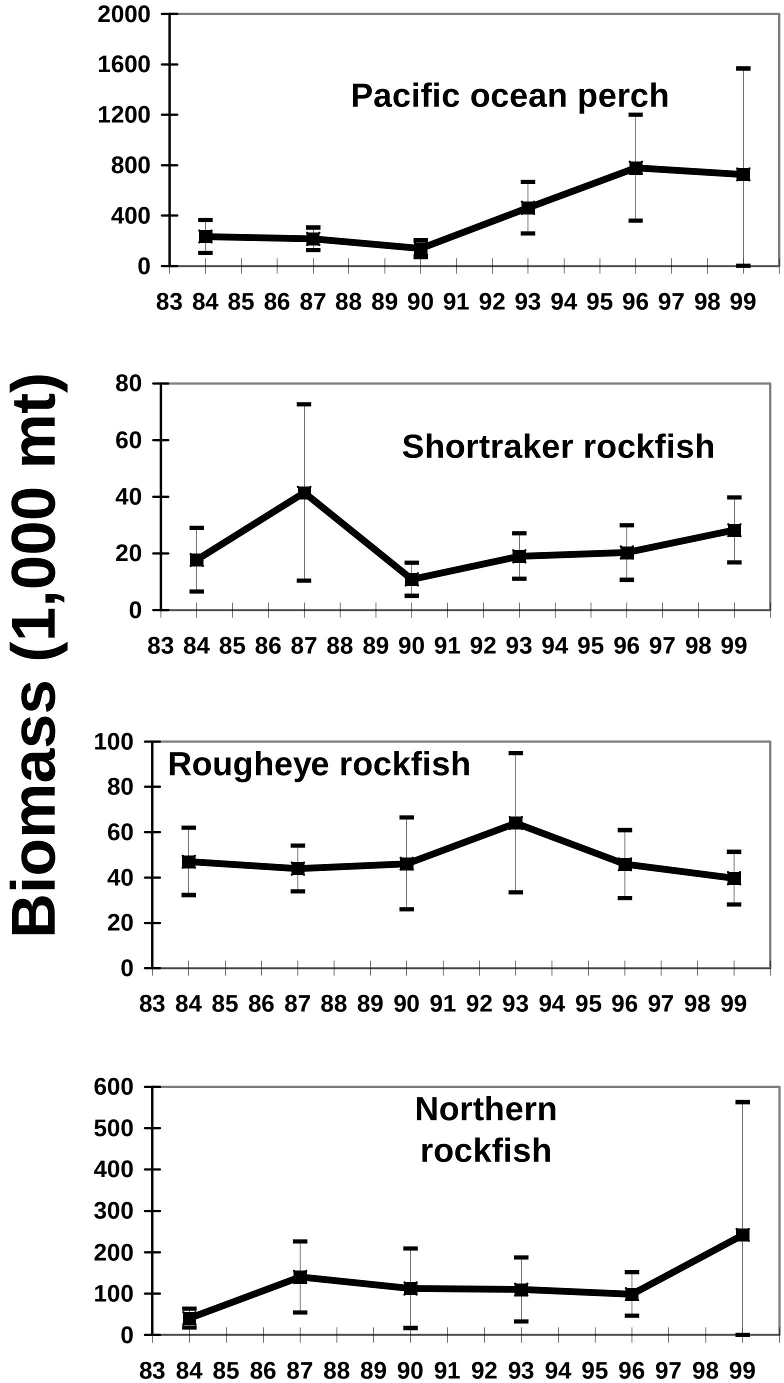

Figure 6-2. -- Estimated biomass of Pacific ocean perch, shortraker rockfish, rougheye rockfish, and northern rockfish in the Gulf of Alaska, based on results of the 1984, 1987, 1990, 1993, 1996, and 1999 triennial trawl surveys. The vertical bars show 95% confidence limits associated with each estimate.

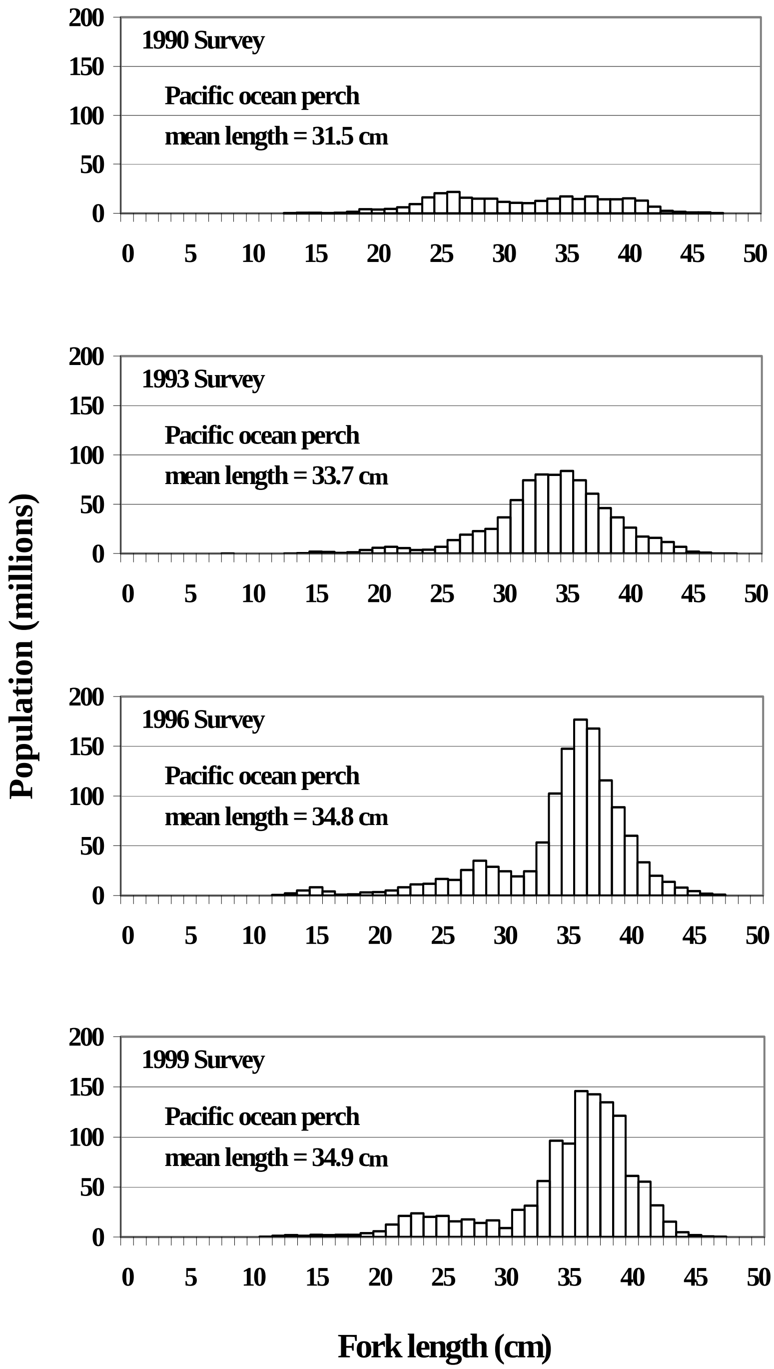

Figure 6-3.--Length frequency distribution of the estimated population of Pacific ocean perch in the Gulf of Alaska, based on the 1990, 1993, 1996, and 1999 triennial trawl surveys.

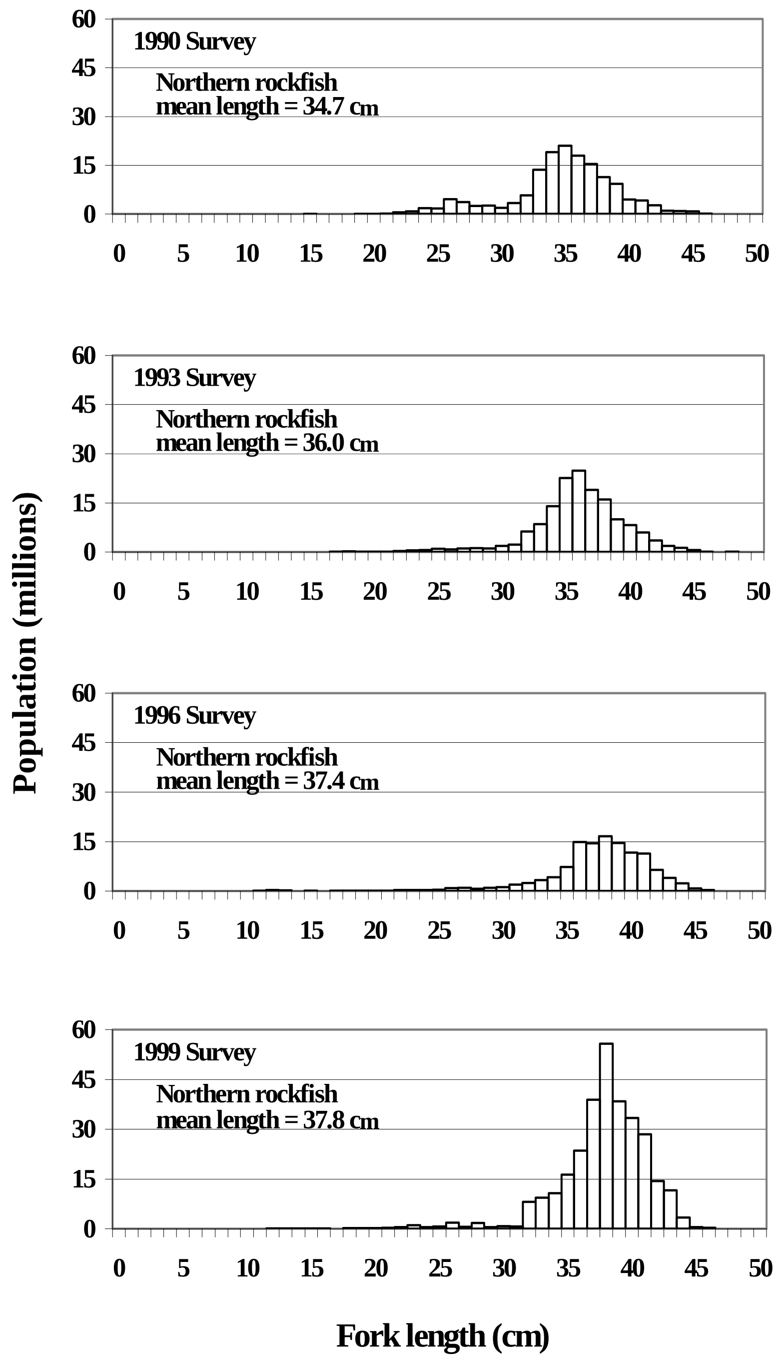

Figure 6-4.--Length frequency distribution of the estimated population of northern rockfish in the Gulf of Alaska, based on the 1990, 1993, 1996, and 1999 triennial trawl surveys.

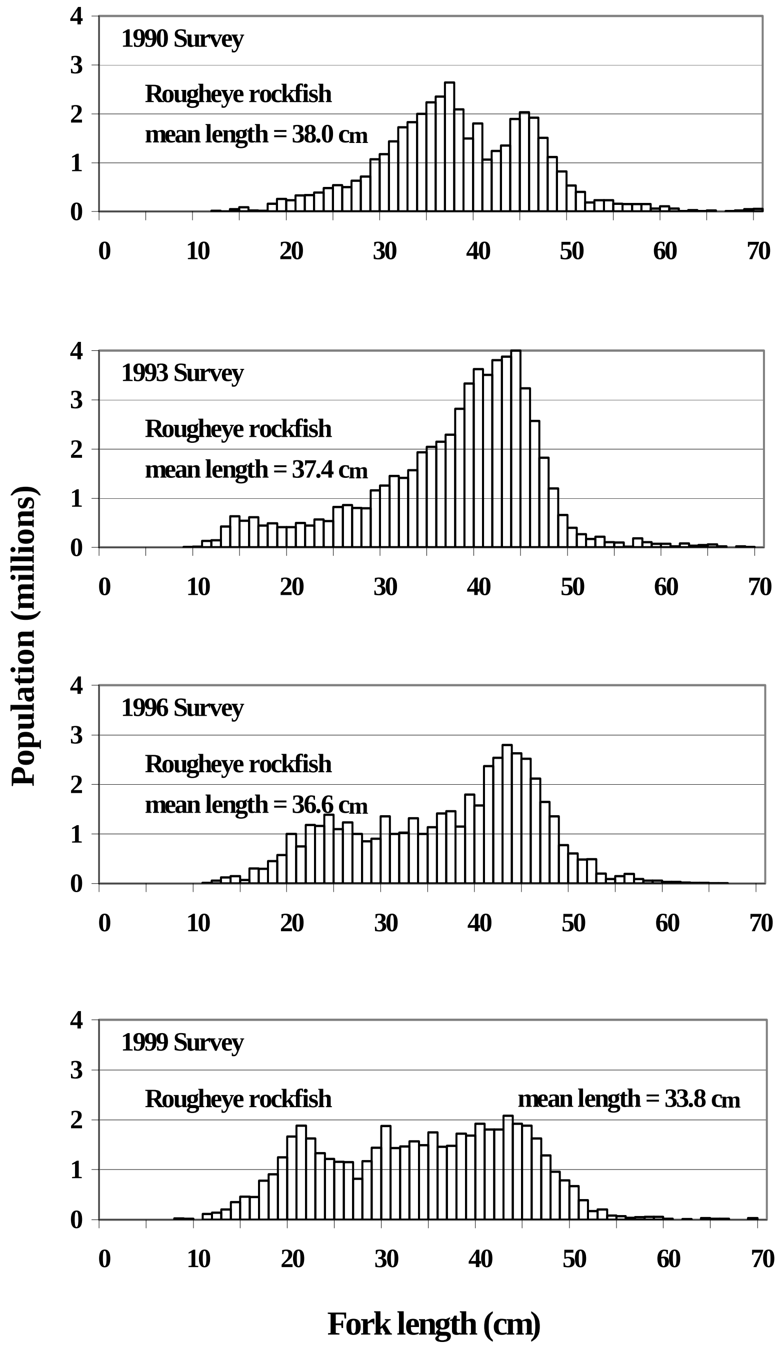

Figure 6-5.--Length frequency distribution of the estimated population of rougheye rockfish in the Gulf of Alaska, based on the 1990, 1993, 1996, and 1999 triennial trawl surveys.

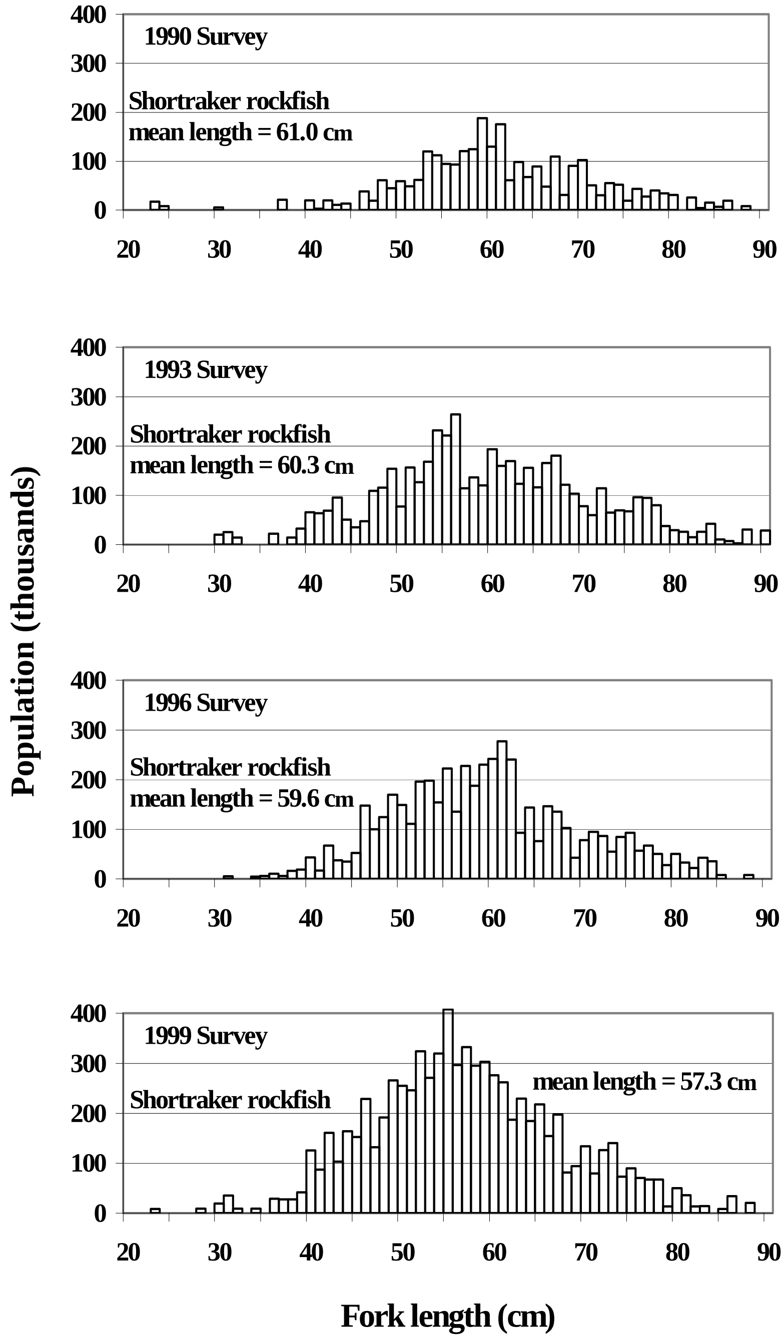

Figure 6-6.--Length frequency distribution of the estimated population of shortraker rockfish in the Gulf of Alaska, based on the 1990, 1993, 1996, and 1999 triennial trawl surveys.

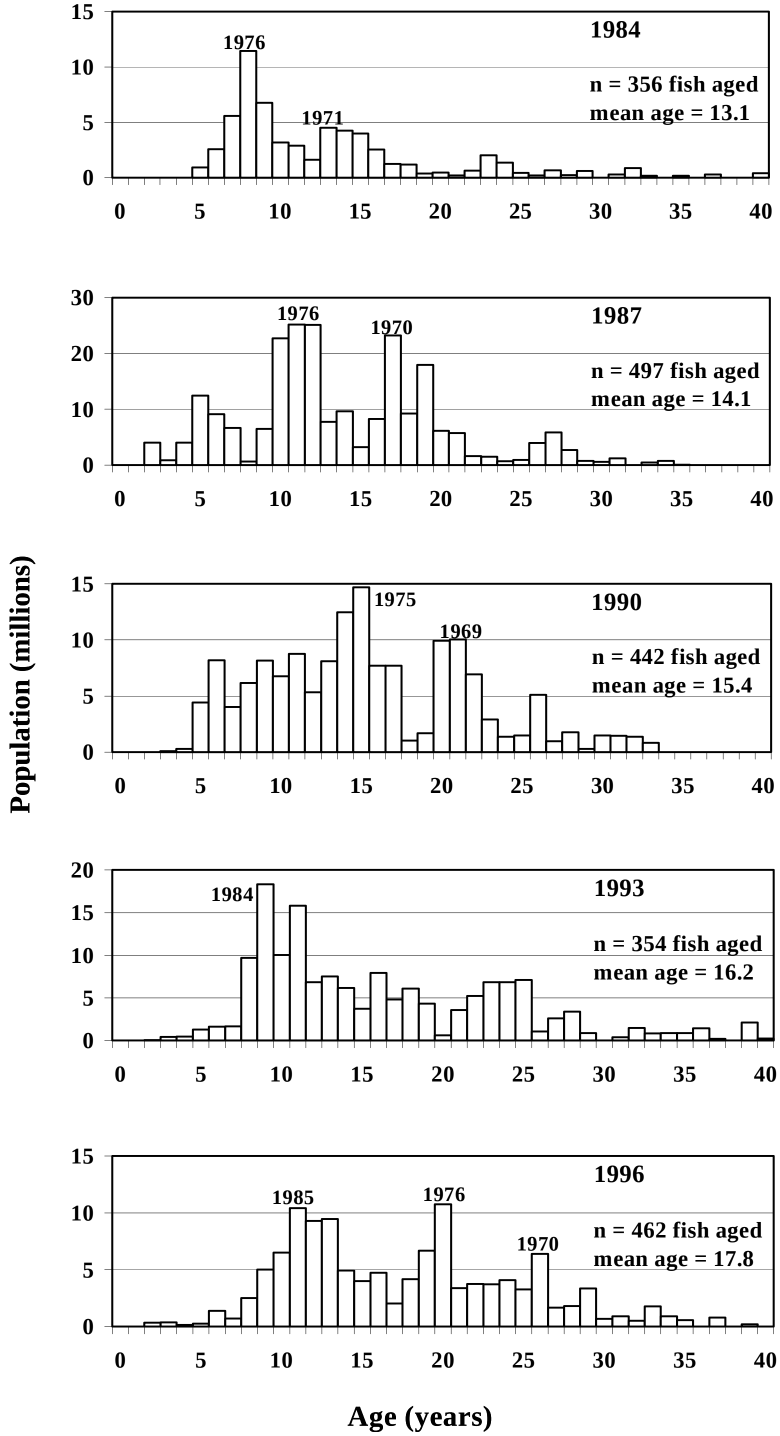

Figure 6-7.--Age composition of the estimated population of northern rockfish in the Gulf of Alaska, based on the 1984, 1987, 1990, 1993, 1996, and 1999 triennial trawl surveys. The numbers next to prominent bars identify year classes that may be strong. (Figure is continued on next page.)

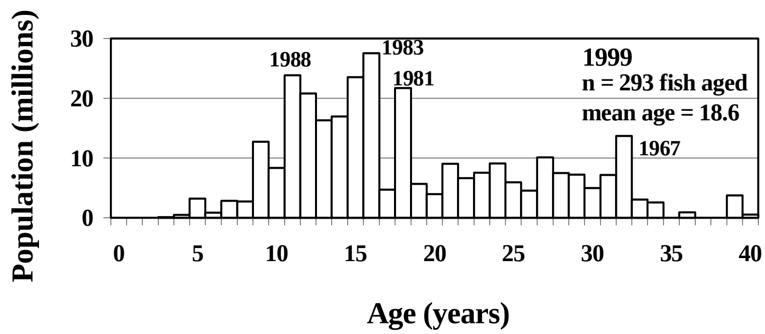

Figure 6-7.--(continued).

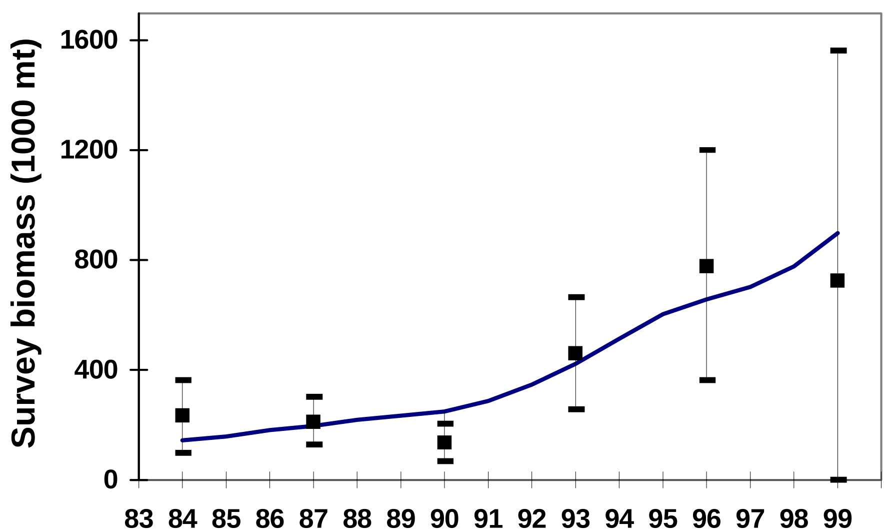

Figure 6-8.--Observed and predicted survey biomass estimates for Pacific ocean perch in the Gulf of Alaska based on the stock synthesis model with *q* estimated. Ninety-five percent confidence limit is shown for each observed biomass estimate.

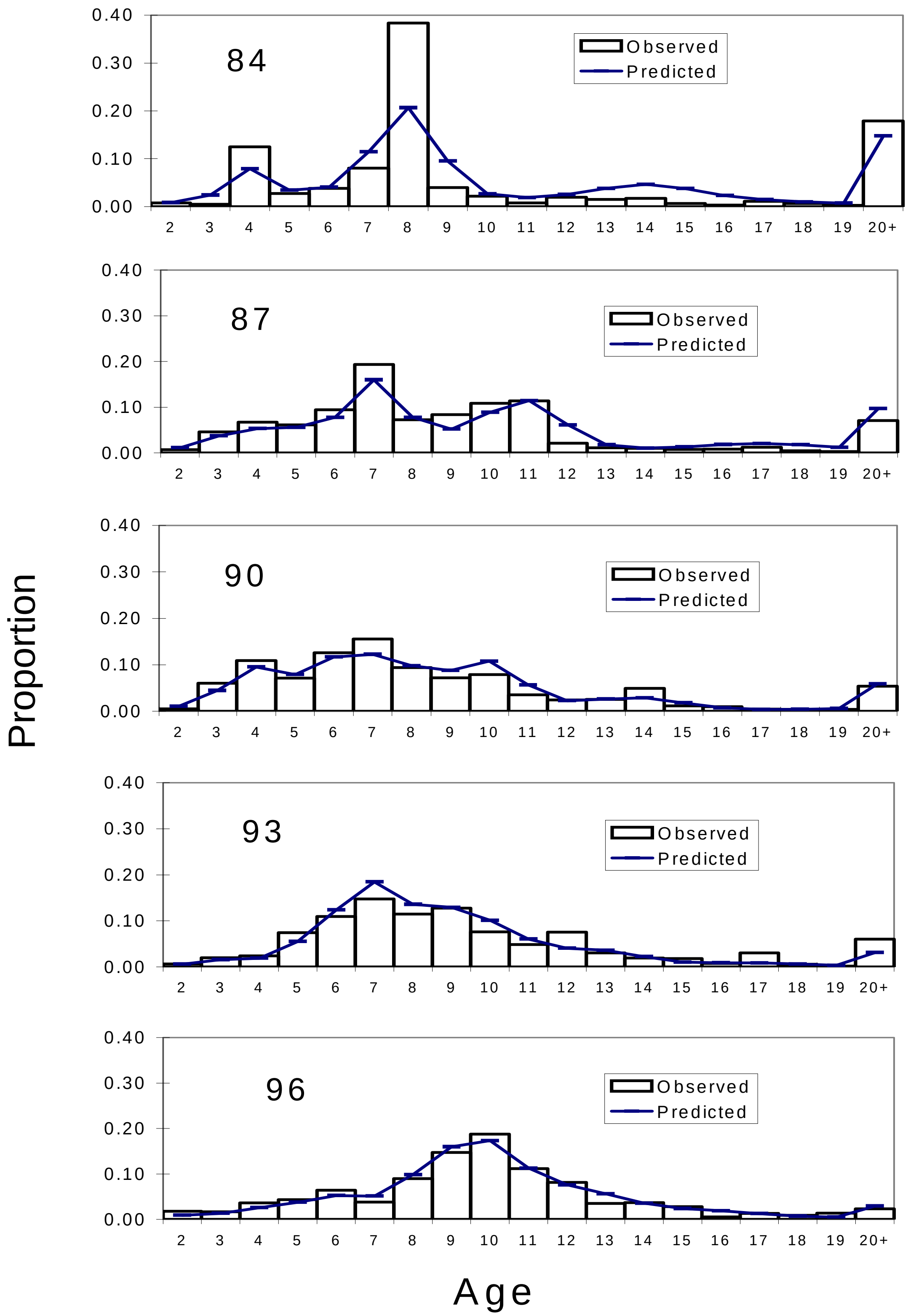

Figure 6-9.--Observed and predicted triennial survey age composition for Pacific ocean perch in the Gulf of Alaska based on the stock synthesis model.

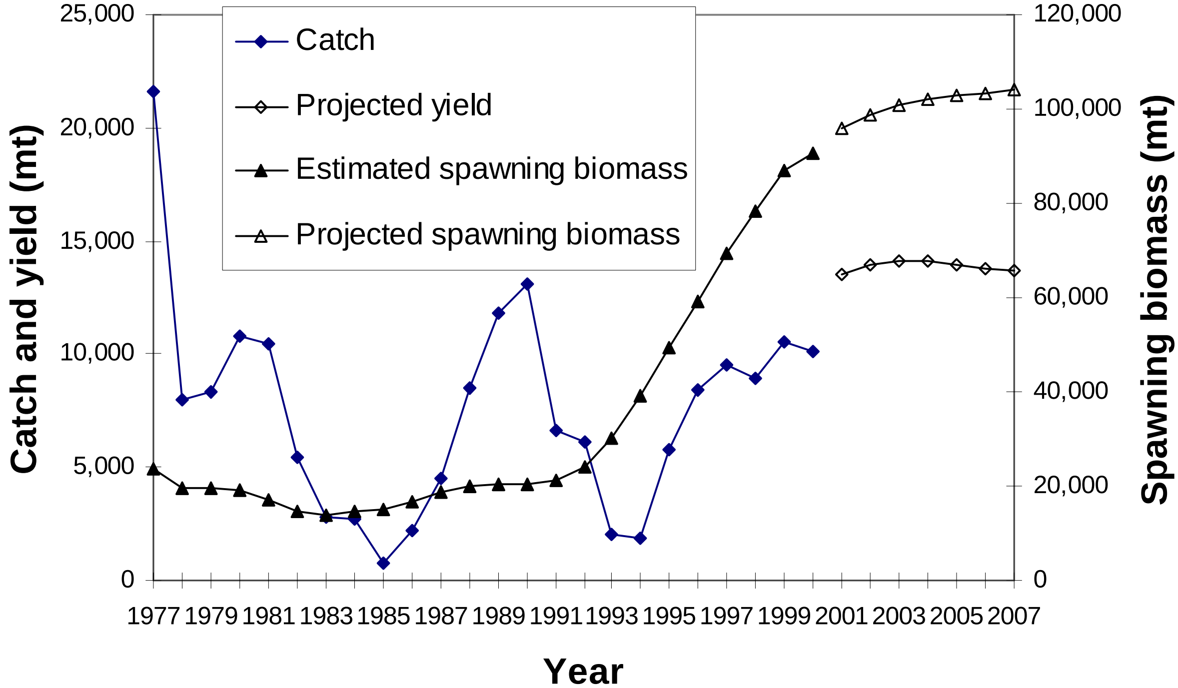

Figure 6-10.– Recent trend and short-term projection of catch, yield, and spawning biomass of Pacific ocean perch in the Gulf of Alaska.

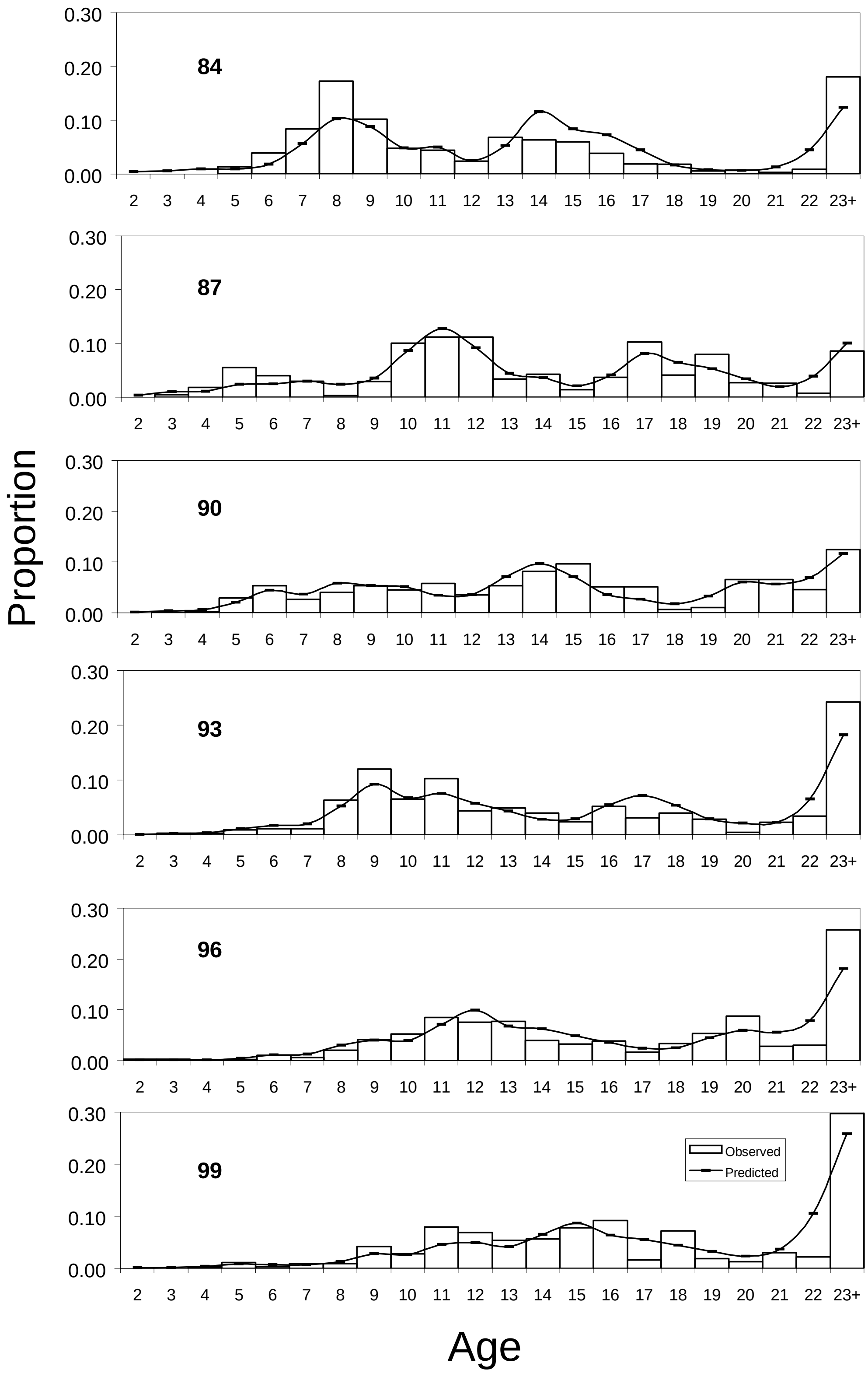

Figure 6 – 11 . Observed and predicted triennial survey age composition for northern rockfish in the Gulf of Alaska based on the age structured model.

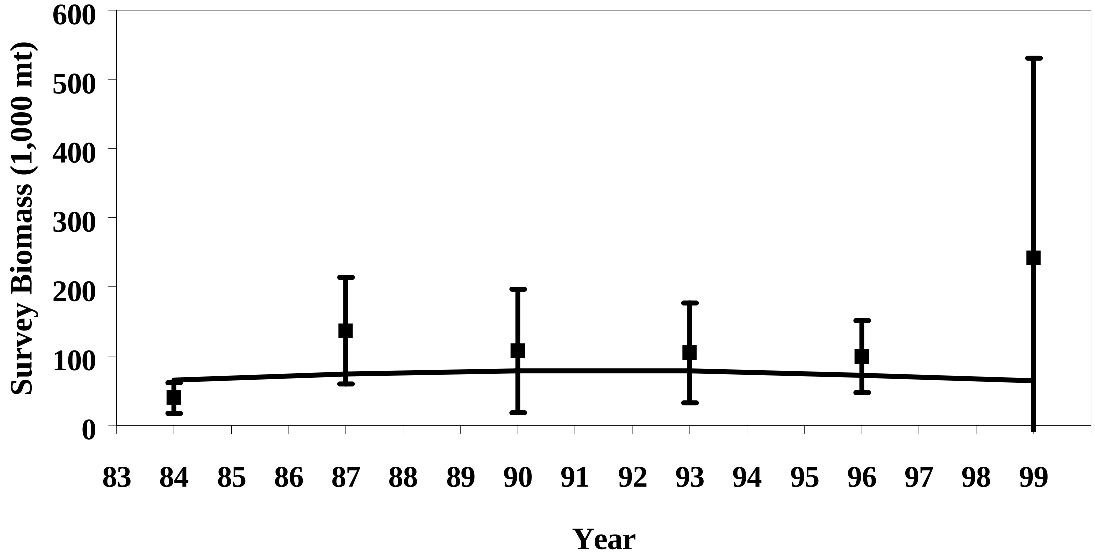

Figure 6-12. Observed and predicted survey biomass for northern rockfish in the Gulf of Alaska based on an age structured model. Ninety-five percent confidence limit is shown for each observed biomass estimate.

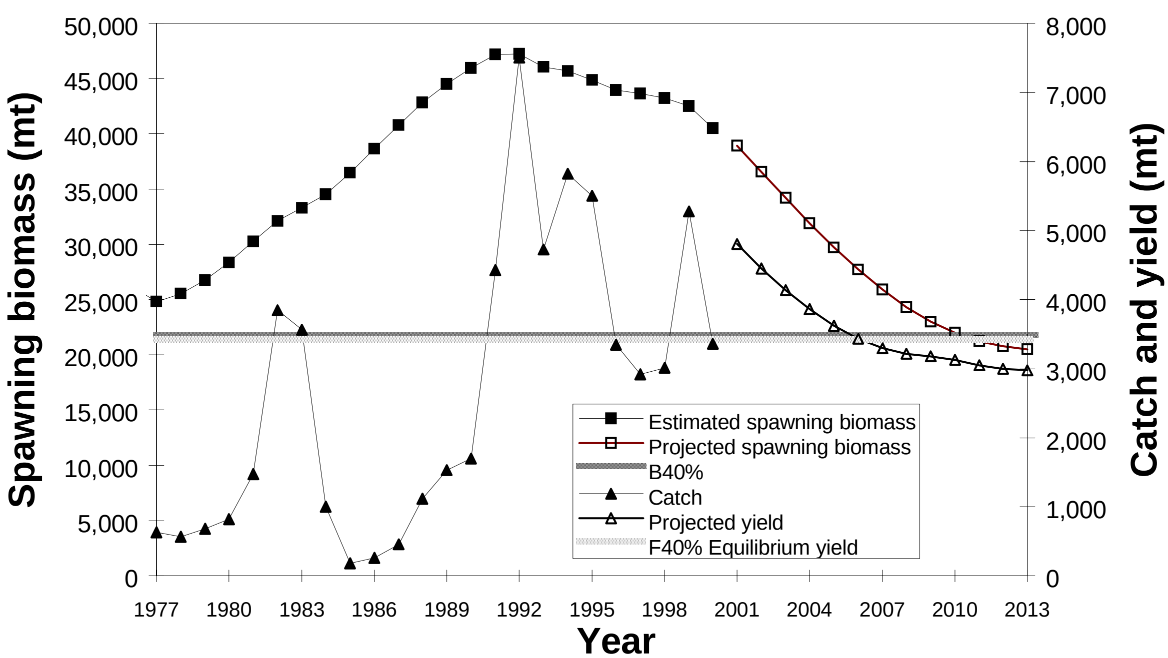

Figure 6-13. Recent trend and long-term projection of spawning biomass and yield of northern rockfish in the Gulf of Alaska based on tier 3 computations. At average recruitment (based on 1977-1994 year classes) the spawning biomass is projected to fall below $B_{40\%}$ in 2011 and the catch is projected to fall below $F_{40\%}$ equilibrium yield in 2006.

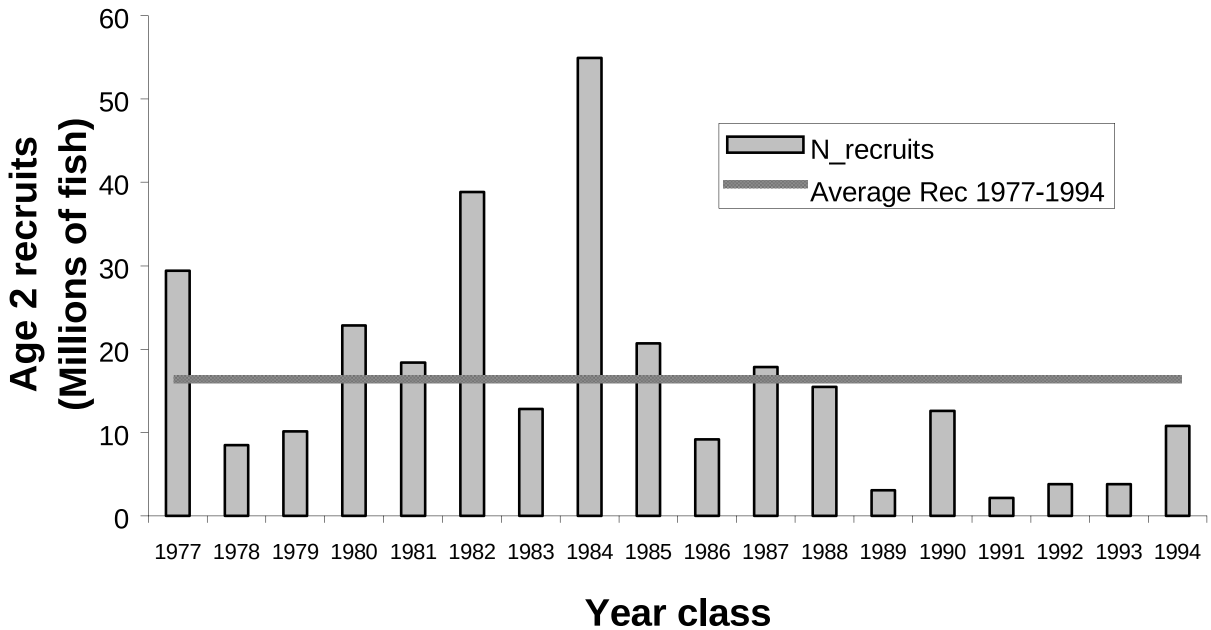

Figure 6-14. Number of recruits and average recruitment for Gulf of Alaska northern rockfish for year classes 1977 through 1994 from the age structured model.