Section 6

SUMMARY OF MAJOR CHANGES IN THE SLOPE ROCKFISH ASSESSMENT

By
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**Executive Summary**

Relative to the 1999 final SAFE, the following substantial changes have been made:

The stock assessment for slope rockfish was updated to include results from the 1999 trawl survey. The trawl survey 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.

For Pacific ocean perch the model configuration and implementation software has remained the same. Three alternative models were evaluated that focused on estimation of survey catchability, *q:*

Model 1 — *q* fixed at 2.78, the estimate from last year's assessment,
Model 2 — *q* fixed at 1.0,
Model 3 — *q* estimated.

A comparison of assessment results for the three models 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 |
| $F_{ABC}$ (maximum allowable) | 0.067 | 0.083 | 0.067 |
| ABC (mt; maximum allowable) | 14,480 | 55,340 | 13,020 |

* recommended model for ABC determination

As in last years assessment, we selected Model 3 as the basis for our recommendations for ABC and overfishing. The estimate of *q* from Model 3 was 2.99 with an ABC of 13,020 mt.

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.

In the past, exploitable biomass for shortraker and rougheye rockfish, northern 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. We continue to use this method for shortraker/ rougheye rockfish and other slope rockfish. 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.

We used an alternative method for determining exploitable biomass of northern rockfish because variance of the 1999 survey was exceptionally large, approximately 30 and 15 times larger than the 1996 and 1993 survey variances. This large variance is due entirely to one very large haul in one strata. The biomass estimate for this strata makes up 78% of the total exploitable biomass estimate of northern rockfish in the Gulf of Alaska. To account for the increased level of uncertainty in the 1999 survey estimate, exploitable biomass this year is estimated using a weighted average, where weights for each survey estimate are in proportion to the inverse of their respective variances. This weighted average results in an estimate of 85,357 mt of exploitable biomass for northern rockfish. Applying F=M=0.06 results in an ABC of 5,120 mt for northern rockfish.

An age structured stock assessment model for northern rockfish has been constructed using AD Model Builder Software. A detailed report describing the model configuration and preliminary results is in Appendix 6-1. We anticipate that this model will be used for next year’s northern rockfish assessment.

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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. 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. 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 1988-99; 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 1993-99, 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 | | | |
|---|---|---|---|---|
| | 1996 | 1997 | 1998 | 1999 |
| Pacific ocean perch | 49 | 28 | 32 | 41 |
| Northern rockfish | 32 | 32 | 53 | 44 |

Factory trawlers continued to take almost all 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 1992-98 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 |
|---|---|---|---|---|---|---|---|
| Northern rockfish | 7,770 | - | - | - | - | - | - |
| Sharpchin rockfish | 434 | 1,345 | 330 | 342 | 278 | 316 | 319 |
| Redstripe rockfish | 261 | 1,222 | 207 | 198 | 134 | 291 | 51 |
| Harlequin rockfish | 745 | 1,864 | 789 | 667 | 403 | 492 | 443 |
| Silvergrey rockfish | 130 | 487 | 219 | 123 | 8 | 34 | 8 |
| Yellowmouth rockfish | 102 | 498 | 40 | 15 | 6 | 63 | 1 |
| Redbanded rockfish | - | - | 23 | 22 | 30 | 15 | 20 |
| Other species | 2 | 16 | 4 | 31 | 23 | 6 | 21 |

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 1994-98, 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. Also, the 1998 closure of the Gulf to trawling east of 140 degrees longitude may have caused a decrease in catches of "other slope rockfish", as most of the biomass for these species is located in this area.

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[1] National Marine Fisheries Service, Alaska Region, Fishery Management Section, P.O. Box 21668, Juneau, AK 99802-1688. Data are from weekly production and observer reports through October 3, 1999.

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, 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] for the four slope rockfish management subgroups in the commercial fishery for 1991-99 are listed as follows:

| | % discarded | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
| Pacific ocean perch | 15.7 | 21.5 | 79.2 | 60.3 | 19.8 | 17.2 | 14.3 | 14.0 | 13.6 |
| Shortraker/rougheye | 42.0 | 10.4 | 26.8 | 44.8 | 30.7 | 22.2 | 22.0 | 27.9 | 32.0 |
| Northern rockfish | - | - | 26.5 | 17.7 | 12.7 | 16.5 | 27.8 | 18.3 | 10.8 |
| Other slope rockfish | 20.0 | 29.7 | 48.9 | 65.6 | 72.5 | 75.6 | 52.1 | 66.3 | 69.0 |

The high discard rates for Pacific ocean perch in 1993 and 1994 can be attributed to its "by-catch only" status for most of this time period. Relatively high discard rates are also seen for "other slope rockfish" in 1993-99, 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 October 9, 1999.

## 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 has 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

[3] M. Sigler, National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratory, 11305 Glacier Hwy., Juneau AK 99801. Pers. commun. September 1999.

have ranged from a low of ~13,000 in 1988 to a high of ~34,000 in 1997; for shortraker rockfish, Gulfwide RPN's have ranged from a low of ~11,000 in 1994 to a high of ~27,000 in 1998. Similarly, lowest and highest Gulfwide RPW values for each species were in these same years. Definite trends in these data over the years 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 three highest annual Gulfwide RPN's and RPW's for shortraker rockfish were in the most recent three surveys, 1997, 1998, and 1999. Relatively high RPN's and RPW's for rougheye rockfish are also seen in these years. 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 recently completed 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 and Clausen 1992).  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 and 1996 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 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, and 1996 triennial trawl surveys (Figure 6-7).  The age results from the 1996 survey have only recently become available, and are presented here for the first time. Age results from all five 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 17.8 years in 1996. The age compositions from each survey indicate that recruitment of northern rockfish is highly variable. All surveys except 1993 agree there appeared to be two periods of especially strong year classes for this fish in the Gulf of Alaska, 1968-71 and 1975-77, although they differ as to which specific years were greatest, perhaps due to aging errors. The 1993 and 1996 age compositions indicate the 1984 or 1985 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 | 10.5 |
| Northern | Central | 77 | 36.1 | 12.8 |
| Sharpchin | Eastern | 164 | 26.5 | 10.1 |

### 6.5.2 Length and Weight at Age

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

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## 6.6 ANALYTIC APPROACH

Pacific ocean perch is the only species of slope rockfish which is currently assessed using a formal modeling approach. All other species of slope rockfish are assessed based on a trawl survey data. Presently Courtney et al (1999) are constructing a stock assessment model for northern rockfish using

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

AD Model Builder Software.. We anticipate that this model will be used for next year's assessment of northern rockfish.

6.6.1 Pacific ocean perch

6.6.1.1 Model Structure

Heifetz and Ianelli (1992) incorporated age-composition information from a variety of sources into a stock synthesis model (Methot 1990) of Pacific ocean perch in the Gulf of Alaska. 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). Here we update the model by including the updated catch from 1998-99 fishery, size composition from the 1999 survey and fishery and the biomass estimate from the 1999 survey.

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

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

$$Y = \sum_{age=1}^{nages} W(a)C(a) \quad (2)$$

$$EB = \sum_{age=1}^{nages} N(a)s(a)W(a) \quad (3)$$

$$B = 0.5\sum_{age=1}^{nages} N(a)W(a)m(a) \quad (4)$$

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 1961-1999, 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 size compositions for 1978-99, 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, and 96. 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 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

As in last year's assessment we recognize 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 $q$.  The estimate of $q$ last year was 2.78.  Justification for an estimate of $q$ greater than 1.0 was based on 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).   For the current assessment,  we also estimate $q$ and evaluate 3 different models:

| | |
|---|---|
| Model 1 | $q$ fixed at the estimate from last year's assessment; $q$= 2.78 |
| 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, re 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.

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 are shown for the current assessment and from the previous SAFE. Estimates of the trend in spawning biomass is shown in Figure 6-11. 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 2000 the number of age-2 recruits in 1995-2000 was projected. The values used for these recruitment years have little effect on current exploitable biomass and current spawning biomass because less than 6% of age 2-6 year old Pacific ocean perch are selected by the fishery and few < 8 years old are mature Estimated spawning biomass in 2000 is 92,920 mt, exploitable biomass is 200,310 mt, and estimated age 6+ biomass is 321,051 mt.

6.6.2 Northern rockfish

In the past, exploitable biomass for northern 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 (Clausen and Heifetz 1989). Variance of the 1999 survey, however, was exceptionally large, approximately 30 and 15 times larger than the 1996 and 1993 survey variances. This large variance is due entirely to one very large haul in one strata. The biomass estimate for this strata makes up 78% of the total exploitable biomass estimate of northern rockfish in the Gulf of Alaska. To account for the increased level of uncertainty in the 1999 survey estimate, exploitable biomass in 2000 is estimated using a weighted average, where weights for each survey estimate are in proportion to the inverse of their respective variances. This weighted average results in an estimate of 85,357 mt of exploitable biomass for Gulf of Alaska northern rockfish. In contrast the unweighted average results in an exploitable biomass of 123,706 mt for northern rockfish.

6.6.3 Shortraker and Rougheye Rockfish, and Other Slope Rockfish

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 shortraker and rougheye rockfish and other slope rockfish (Table 6-16). 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 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 |
| $F_{ABC}$ (maximum allowable) | 0.067 | 0.083 | 0.067 |
| ABC (mt; maximum allowable) | 14,480 | 55,340 | 13,020 |

* recommended model for ABC determination

Based on model 3, current spawning biomass ($B_{2000}$ = 92,920 mt) is less than $B_{40\%}$ (110,120 mt), where B40% is determined from average recruitment of the 1977-92 year-classes (Figure 6-11). Since $B_{2000}$ 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 $F_{ABC} \leq 0.065$ and an ABC $\leq$ 13,020 mt.. We recommend that the ABC for Pacific ocean perch for 2000 fishery in the Gulf of Alaska be set at 13,020 mt.

This year, a standard set of projections is required for each stock managed under Tiers 1, 2, or 3 of Amendment 56. 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 1999 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2000 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 1999. 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 2000 recommended in the assessment to the *max* $F_{ABC}$ for 2000. (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 1994-1998 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 2000 and above its MSY level in 2010 under this scenario, then the stock is not overfished.)

*Scenario 7*:  In 2000 and 2001, $F$ 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 2012 under this scenario, then the stock is not approaching an overfished condition)

A summary of the results of these scenarios is in Table 6-17a.  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.  In last year's assessment this resulted in 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, 71.0 % for the Central area, and 19.4% for the Eastern area (Table 6-18). This results in recommended ABC's of 1,240 mt for the Western area, 9,240 mt for the Central area, and 2,540 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) Currently, Amendment 58, which will not allow trawling in the Eastern area east of 140 degrees longitude, is in the final approval stages. 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 will remain open to trawling. Thus, with adoption of this amendment, alternative apportionment strategies need to be evaluated.

6.7.2 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 6-17a for Pacific ocean perch are not possible but yields for just the year 2000 can be computed (Table 6-17b).

The same method of apportionment as used for Pacific ocean perch is used to apportion the shortraker and rougheye ABC among areas (Table 6-18). 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.

6.7.3 Northern Rockfish

As in the past, the recommended ABC in 2000 for northern rockfish is based on a harvest rate set equal to natural mortality M (0.06). Applying the new definitions for ABC and OFL based on Amendment 44 in the Gulf of Alaska FMP places northern rockfish in tier 4 where $F_{ABC} \leq F_{40\%}$. This results an $F_{ABC} = M =$ 0.06 which is less than $F_{40\%}$=0.075. In the past, exploitable biomass for northern rockfish has been estimated by the unweighted average of the last three trawl survey results. Variance of the 1999 survey, however, was exceptionally large, approximately 30 and 15 times larger than the 1996 and 1993 survey variances. This large variance is due entirely to one very large haul in one strata. The biomass estimate for this strata makes up 78% of the total exploitable biomass estimate of northern rockfish in the Gulf of Alaska. To account for the increased level of uncertainty in the 1999 survey estimate, exploitable biomass this year is estimated using a weighted average, where weights for each survey estimate are in proportion to the inverse of their respective variances. This weighted average results in an estimate of 85,357 mt of exploitable biomass for Gulf of Alaska northern rockfish.

Applying the F=0.06 harvest rate to the estimated exploitable biomass of 85,357 mt results in an ABC of 5,120 mt for northern rockfish. Using the same method of apportionment as used for Pacific ocean perch results in ABC's of 630 in the Western area, 4,485 mt in the Central area, and 5 mt in the Eastern area (Table 6-18). For management purposes, the small ABC of northern rockfish in the Eastern is combined with other slope rockfish.

For species such as northern rockfish that are not assessed with a age/length- structured model multi-year projections as done in Table 6-17a for Pacific ocean perch are not possible but yields for just the year 2000 can be computed (Table 6-17b).

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 6-9 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 6-18).

For species such as other slope rockfish that are not assessed with a age/length- structured model multi-year projections as done in Table 6-17a for Pacific ocean perch are not possible but yields for just the year 2000 can be computed (Table 6-17b).

6.7.5 Overfishing Definition

6.7.5.1 Pacific ocean perch

Based on the definitions for overfishing in Amendment 44 in tier 3b [i.e., $F_{OFL} = F_{35\%}(B/B_{40\%} - \alpha)/(1 - \alpha) = 0.078$], overfishing is set equal to 15,390 mt. For Pacific ocean perch the overfishing level is apportioned by area. Using the apportionment in Section 6.7.1, results in overfishing levels by area of 1,460 mt in the Western area, 10,930 mt in the Central area, and 3,000 mt in the Eastern area.

6.7.5.2 Rougheye, shortraker, northern 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..088 for northern rockfish and 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 7,510 for northern rockfish and 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 6-19.

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).

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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.–Commercial catch[a] (mt) of fish in the slope rockfish assemblage in the Gulf of Alaska, wi
Gulfwide values of acceptable biological catch (ABC) and fishing quotas[b] (mt), 1977-99. Catches in
1999 updated through October 14, 1999.

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

Table 6-2.--(Continued).

| Year | Fishery category/ Management subgroup | Regulatory area Western | Regulatory area Central | Regulatory area Eastern | Gulfwide Total | Gulfwide Management value ABC | Gulfwide Management value 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 | 1,914 | 7,994 | 626 | 10,534 | 13,120 | 12,590 |
| | SR/RE | 194 | 574 | 496 | 1,264 | 1,590 | 1,590 |
| | Northern | 556 | 4,751 | c | 5,307 | 4,990 | 4,990 |
| | Other slope | 40 | 640 | 132 | 812 | 5,270 | 5,270 |

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 1991-99 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 managemen 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 1993-99 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 f 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; 1994-99 the 21 species comprising the slope rockfish assemblage.

[b]Quota defined as follows: 1977-86, optimum yield; 1987, target quota; 1988-99 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; 1989-97, National Marine Fisheries Service, Alaska Region, P.O. Box 21668, Juneau, AK 99802. ABC and Quota: 1977-1986 Karinen and Wing (1987); 1987-98, Heifetz et al. (1998); 1999, North Pacific Fishery Management Council Newsletter, Dec. 17, 1998. 605 W. 4th Ave., Suite 30 Anchorage, Alaska 99501-2252.

Table 6-2b.–Catch (mt) of slope rockfish taken during research cruises in the Gulf of Alaska, 1977-98. (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 |

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, 1992-98, based on vessels that had observer coverage. (tr=trace; Redbanded rockfish is not included in the 1992 and 1993 data.)

| Species | Regulatory area: 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 | Regulatory area Western | Central | Eastern | Gulf of Alaska |
|---|---|---|---|---|
| | | 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 |

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 |

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 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 |
| 15-24 | 8 | 4 | 0 | 2 | 1 | 42 | 1 | 8 | 18 |
| 25 | 8 | 9 | 1 | 4 | 0 | 47 | 2 | 34 | 2 |
| 26 | 4 | 21 | 3 | 10 | 1 | 74 | 0 | 72 | 6 |
| 27 | 18 | 33 | 4 | 11 | 5 | 97 | 3 | 106 | 5 |
| 28 | 36 | 64 | 17 | 23 | 14 | 88 | 5 | 109 | 9 |
| 29 | 73 | 110 | 38 | 57 | 29 | 110 | 9 | 109 | 14 |
| 30 | 80 | 288 | 78 | 112 | 57 | 134 | 30 | 90 | 24 |
| 31 | 96 | 529 | 173 | 248 | 135 | 164 | 26 | 57 | 23 |
| 32 | 151 | 967 | 385 | 484 | 246 | 222 | 66 | 62 | 60 |
| 33 | 207 | 1,733 | 670 | 830 | 568 | 453 | 162 | 108 | 109 |
| 34 | 333 | 2,550 | 1,247 | 1,132 | 946 | 864 | 351 | 206 | 211 |
| 35 | 547 | 2,741 | 1,912 | 1,631 | 1,421 | 1,364 | 706 | 426 | 475 |
| 36 | 800 | 2,008 | 2,162 | 1,754 | 1,623 | 1,652 | 1,026 | 618 | 891 |
| 37 | 738 | 1,222 | 2,128 | 1,359 | 1,391 | 1,714 | 1,041 | 681 | 1,160 |
| 38 | 550 | 610 | 1,824 | 1,073 | 811 | 1,371 | 785 | 616 | 1,069 |
| 39 | 360 | 288 | 1,286 | 729 | 431 | 863 | 544 | 371 | 771 |
| 40 | 168 | 131 | 810 | 514 | 203 | 400 | 346 | 207 | 445 |
| 41 | 79 | 87 | 443 | 359 | 96 | 211 | 191 | 95 | 207 |
| 42 | 37 | 27 | 165 | 189 | 55 | 162 | 95 | 43 | 82 |
| 43 | 18 | 47 | 59 | 49 | 38 | 117 | 48 | 19 | 46 |
| 44 | 8 | 32 | 55 | 9 | 28 | 97 | 22 | 9 | 19 |
| 45-50 | 8 | 86 | 64 | 3 | 39 | 222 | 68 | 2 | 6 |
| Total | 4,327 | 13,587 | 13,524 | 10,582 | 8,138 | 10,468 | 5,527 | 4,048 | 5,652 |

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 is for upper continental slope only, 201-1,000 m. depth. 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 |
| 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 |
| Chirikof | 937 | 1,922 | 1,034 | 1,091 | 970 | 1,507 | 743 | 1,476 | 1,009 | 1,244 | 1,163 | 1,670 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| Chirikof | 1,185 | 2,414 | 1,281 | 1,287 | 1,279 | 1,743 | 914 | 1,787 | 1,375 | 1,619 | 1,527 | 2,053 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| Chirikof | 1,290 | 858 | 773 | 776 | 572 | 229 | 613 | 531 | 646 | 918 | 973 | 823 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| Chirikof | 2,591 | 1,449 | 1,216 | 1,384 | 914 | 293 | 1,174 | 812 | 1,007 | 1,471 | 1,422 | 1,165 |
| 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 |
| 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 |
| 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 |
| 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 |

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 1980-96 are based on "break and burn" reading of otoliths.

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

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

| Age class | Year | | | | |
|---|---|---|---|---|---|
| | 1984 | 1987 | 1990 | 1993 | 1996 |
| 2 | 0.00 | 0.00 | 0.00 | 0.03 | 0.28 |
| 3 | 0.00 | 0.37 | 0.06 | 0.28 | 0.30 |
| 4 | 0.00 | 1.78 | 0.19 | 0.31 | 0.12 |
| 5 | 1.39 | 5.53 | 2.91 | 0.85 | 0.21 |
| 6 | 3.68 | 4.05 | 5.41 | 1.07 | 1.13 |
| 7 | 8.39 | 2.96 | 2.65 | 1.08 | 0.58 |
| 8 | 17.28 | 0.28 | 4.08 | 6.34 | 2.06 |
| 9 | 10.21 | 2.88 | 5.38 | 11.98 | 4.10 |
| 10 | 4.78 | 10.10 | 4.47 | 6.63 | 5.31 |
| 11 | 4.37 | 11.21 | 5.77 | 10.31 | 8.52 |
| 12 | 2.44 | 11.15 | 3.52 | 4.45 | 7.58 |
| 13 | 6.81 | 3.43 | 5.36 | 4.90 | 7.72 |
| 14 | 6.42 | 4.28 | 8.24 | 4.02 | 4.02 |
| 15 | 5.99 | 1.40 | 9.71 | 2.44 | 3.29 |
| 16 | 3.82 | 3.66 | 5.09 | 5.19 | 3.87 |
| 17 | 1.87 | 10.31 | 5.08 | 3.14 | 1.65 |
| 18 | 1.79 | 4.09 | 0.67 | 3.97 | 3.41 |
| 19 | 0.55 | 7.98 | 1.12 | 2.81 | 5.44 |
| 20 | 0.72 | 2.72 | 6.56 | 0.40 | 8.78 |
| 21 | 0.30 | 2.55 | 6.63 | 2.32 | 2.77 |
| 22 | 0.95 | 0.70 | 4.58 | 3.41 | 3.07 |
| 23 | 3.06 | 0.65 | 1.92 | 4.45 | 3.02 |
| 24 | 2.03 | 0.29 | 0.89 | 4.46 | 3.33 |
| 25+ | 12.98 | 7.63 | 9.71 | 15.26 | 19.43 |

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 perch | 0.02-0.08 | 90 | - | BC | 1,2 |
| | - | 79 | 10 | GOA | 3 |
| | - | 98 | - | AL | 4 |
| Northern | 0.06[a] | 49 | - | GOA | 7 |
| Rougheye | 0.01-0.04 | 140 | - | BC | 1,2 |
| | 0.04 | 95 | 30 | GOA | 5,6 |
| | 0.030-0.039[b] | - | - | WC,BS,AL,GOA | 8 |
| Shortraker | - | 120 | - | BC | 2 |
| | 0.027-0.042b | - | - | WC,BS,AL,GOA | 8 |
| Sharpchin | 0.05 | 46 | - | BC | 1 |
| Yellowmouth | 0.06 | 71 | - | BC | 1,2 |
| Darkblotched | 0.07 | 48 | - | BC | 1 |
| Harlequin | - | 43 | - | BC | 2 |
| Redstripe | 0.1 | 41 | - | BC | 1,2 |
| Silvergrey | 0.01-0.07 | 80 | - | BC | 1,2 |

1) Archibald et al. 1981; 2) Chilton and Beamish 1982; 3) Heifetz et al. 1994; 4) Ito 1987; 5) Nelson and Quinn 1987; 6) Nelson 1986; 7) Heifetz and Clausen 1991; 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 | $1.54 \times 10^{-5}$ | 2.96 | 1,2 |
| | combined | $1.91 \times 10^{-5}$ | 2.90 | 5 |
| | males | $1.57 \times 10^{-5}$ | 2.95 | 5 |
| | females | $2.04 \times 10^{-5}$ | 2.89 | 5 |
| Northern | combined | $1.63 \times 10^{-5}$ | 2.98 | 3,4 |
| | combined | $1.37 \times 10^{-5}$ | 3.04 | 5 |
| | males | $1.55 \times 10^{-5}$ | 2.99 | 5 |
| | females | $1.53 \times 10^{-5}$ | 3.01 | 5 |
| Rougheye | combined | $1.98 \times 10^{-5}$ | 2.94 | 5 |
| | males | $2.04 \times 10^{-5}$ | 2.94 | 5 |
| | females | $1.89 \times 10^{-5}$ | 2.97 | 5 |
| Sharpchin | combined | $1.13 \times 10^{-5}$ | 3.07 | 5 |
| | males | $8.89 \times 10^{-6}$ | 3.15 | 5 |
| | females | $1.19 \times 10^{-5}$ | 3.06 | 5 |
| Shortraker | combined | $9.85 \times 10^{-6}$ | 3.13 | 5 |
| | males | $1.26 \times 10^{-5}$ | 3.07 | 5 |
| | females | $1.02 \times 10^{-5}$ | 3.12 | 5 |

1) Archibald et al. 1981; 2) Ito 1982; 3) Clausen and Heifetz 1989; 4) Heifetz and Clausen 1991; 5) Martin 1997.

Table 6-13b. Von Bertalanffy parameters for some species of slope rockfish.

| Species | Sex | $t_0$ | k | $L_{inf}$ (cm) | Reference |
|---|---|---|---|---|---|
| Pacific ocean perch | combined | -8.22 | 0.088 | 44.80 | 1,2 |
| | combined | -5.22 | 0.126 | 42.60 | 1 |
| | combined | -0.32 | 0.207 | 41.10 | 3 |
| | combined | -0.38 | 0.204 | 40.74 | 6 |
| | male | -0.29 | 0.220 | 39.56 | 6 |
| | female | -0.41 | 0.191 | 42.00 | 6 |
| Northern | combined | -1.51 | 0.190 | 35.60 | 3,5 |
| | combined | -0.70 | 0.163 | 39.90 | 6 |
| | male | -0.26 | 0.187 | 37.83 | 6 |
| | female | -0.87 | 0.152 | 40.22 | 6 |
| Rougheye | combined | -4.21 | 0.050 | 54.70 | 4 |
| | combined | 0.68 | 0.109 | 49.63 | 6 |
| | male | 1.14 | 0.119 | 49.79 | 6 |
| | female | 0.18 | 0.100 | 49.57 | 6 |
| Sharpchin | combined | -2.21 | 0.095 | 34.90 | 1 |
| | combined | -2.69 | 0.118 | 32.38 | 6 |
| | male | -2.55 | 0.137 | 28.70 | 6 |
| | female | -2.43 | 0.112 | 34.77 | 6 |
| Silvergray | combined | -1.68[a] | 0.109 | 58.43 | 6 |
| | male | -1.68[a] | 0.119 | 55.76 | 6 |
| | female | -1.68[a] | 0.102 | 60.80 | 6 |

1) Archibald et al. 1981; 2) Ito 1982; 3) Clausen and Heifetz 1989; 4) Nelson 1986; 5) Heifetz and Clausen 1991; 6) Patrick Malecha, personal comm., ABL. [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/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/biomass | | Age two recruits (1000's) | |
|---|---|---|---|---|---|---|---|---|
| | Current | Previous | Current | Previous | Current | Previous | Current | Previous |
| 1977 | 23,511 | 23,340 | 126,993 | 88,059 | 0.170 | 0.245 | 6,137 | 6,469 |
| 1978 | 19,790 | 19,674 | 88,122 | 70,794 | 0.091 | 0.113 | 42,227 | 56,268 |
| 1979 | 19,600 | 19,546 | 70,455 | 64,943 | 0.118 | 0.128 | 17,917 | 12,933 |
| 1980 | 19,025 | 19,045 | 64,409 | 58,412 | 0.168 | 0.185 | 8,251 | 9,325 |
| 1981 | 17,087 | 17,216 | 57,633 | 49,308 | 0.182 | 0.213 | 7,328 | 6,692 |
| 1982 | 14,492 | 14,758 | 48,348 | 54,938 | 0.112 | 0.098 | 64,403 | 71,385 |
| 1983 | 14,058 | 14,716 | 49,829 | 55,259 | 0.057 | 0.051 | 12,323 | 11,576 |
| 1984 | 14,564 | 15,433 | 50,978 | 56,933 | 0.054 | 0.048 | 31,242 | 36,542 |
| 1985 | 15,221 | 16,385 | 52,093 | 57,488 | 0.015 | 0.014 | 50,482 | 54,185 |
| 1986 | 16,562 | 18,009 | 52,639 | 78,763 | 0.042 | 0.028 | 66,458 | 75,739 |
| 1987 | 18,813 | 20,712 | 71,769 | 83,575 | 0.063 | 0.054 | 32,768 | 47,467 |
| 1988 | 20,138 | 22,372 | 76,463 | 92,674 | 0.112 | 0.092 | 145,799 | 160,930 |
| 1989 | 20,494 | 23,103 | 83,813 | 103,328 | 0.141 | 0.114 | 94,371 | 97,854 |
| 1990 | 20,509 | 23,510 | 93,040 | 118,134 | 0.141 | 0.111 | 60,544 | 63,771 |
| 1991 | 21,175 | 24,739 | 104,721 | 125,081 | 0.063 | 0.053 | 27,417 | 25,384 |
| 1992 | 24,206 | 28,628 | 106,675 | 172,085 | 0.058 | 0.036 | 73,139 | 83,616 |
| 1993 | 30,263 | 35,832 | 148,083 | 206,210 | 0.014 | 0.010 | 53,283 | 74,713 |
| 1994 | 39,156 | 45,981 | 179,706 | 235,487 | 0.010 | 0.008 | 58,370 | 81,878 |
| 1995 | 49,498 | 57,721 | 206,873 | 252,412 | 0.028 | 0.023 | 50,256 | 57,074 |
| 1996 | 59,165 | 68,739 | 223,567 | 279,431 | 0.037 | 0.030 | 50,256 | 57,074 |
| 1997 | 69,235 | 80,279 | 247,165 | 301,084 | 0.039 | 0.032 | 50,256 | 57,074 |
| 1998 | 78,521 | 91,155 | 261,992 | 323,121 | 0.034 | 0.027 | 50,256 | 57,074 |
| 1999 | 87,075 | 101,526 | 275,952 | 338,330 | 0.038 | | 50,256 | 57,074 |
| 2000 | 92,920 | | 321,051 | | | | 50,256 | |

Table 6-15. Estimated numbers (thousands) in 2000, 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 1999 (1,000's) | Percent mature | wt grams | Fishery selectivity | Survey selectivity |
|---|---|---|---|---|---|
| 2 | 50,256 | 0 | 53 | 0.2 | 1.5 |
| 3 | 47,805 | 0 | 116 | 0.4 | 6.6 |
| 4 | 45,473 | 0 | 194 | 0.8 | 14.7 |
| 5 | 43,256 | 0 | 279 | 1.8 | 26.7 |
| 6 | 41,146 | 0 | 363 | 4.2 | 43.6 |
| 7 | 45,222 | 12 | 442 | 9.3 | 65.3 |
| 8 | 39,050 | 20 | 515 | 19.5 | 90.5 |
| 9 | 50,433 | 30 | 579 | 37.6 | 100.0 |
| 10 | 17,630 | 42 | 635 | 61.8 | 100.0 |
| 11 | 35,850 | 56 | 683 | 84.1 | 100.0 |
| 12 | 50,806 | 69 | 724 | 96.8 | 100.0 |
| 13 | 70,687 | 79 | 759 | 100.0 | 100.0 |
| 14 | 14,221 | 87 | 788 | 97.8 | 100.0 |
| 15 | 25,626 | 92 | 812 | 93.1 | 100.0 |
| 16 | 17,010 | 95 | 832 | 87.6 | 100.0 |
| 17 | 8,919 | 97 | 848 | 81.9 | 100.0 |
| 18 | 2,859 | 98 | 861 | 76.4 | 100.0 |
| 19 | 11,671 | 99 | 872 | 71.2 | 100.0 |
| 20 | 1,016 | 99 | 881 | 66.2 | 100.0 |
| 21 | 879 | 100 | 889 | 61.4 | 100.0 |
| 22 | 1,488 | 100 | 895 | 57.0 | 100.0 |
| 23 | 2,757 | 100 | 900 | 52.9 | 100.0 |
| 24 | 312 | 100 | 904 | 49.0 | 100.0 |
| 25+ | 5,355 | 100 | 907 | 45.3 | 100.0 |

able 6-16.--Estimates of exploitable biomass of shortraker and rougheye rockfish, northern 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 stock synthesis model are used to determine exploitable biomass of Pacific ocean perch .

| | 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 |
| Northern rockfish | 2,849 | 73,941 | 28 | 76,818 |
| 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 |
| Northern rockfish | 22,324 | 62,437 | 181 | 84,942 |
| 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 |
| Northern rockfish | 14,190 | 195,077 | 93 | 209,359 |
| 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 6-17a. 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. $B_{40\%}$ = 110,140 mt, $B_{35\%}$ = 96,360 mt, $F_{40\%}$ = 0.078, and $F_{35\%}$ = 0.093.

| Year | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Scenario 5 | Scenario 6 | Scenario 7 |
|---|---|---|---|---|---|---|---|
| Spawning biomass | | | | | | | |
| 1999 | 84,319 | 84,319 | 84,319 | 84,319 | 84,319 | 84,319 | 84,319 |
| 2000 | 92,919 | 92,919 | 93,755 | 93,147 | 94,600 | 92,607 | 92,919 |
| 2001 | 98,715 | 98,715 | 102,206 | 99,767 | 105,887 | 97,453 | 98,715 |
| 2002 | 103,722 | 103,722 | 110,070 | 105,958 | 117,151 | 101,510 | 103,344 |
| 2003 | 107,837 | 107,837 | 117,221 | 111,573 | 128,162 | 104,708 | 106,336 |
| 2004 | 111,143 | 111,143 | 123,819 | 116,629 | 138,917 | 107,120 | 108,532 |
| 2005 | 113,032 | 113,032 | 129,090 | 120,356 | 148,535 | 108,107 | 109,311 |
| 2006 | 113,854 | 113,854 | 133,109 | 122,910 | 156,885 | 108,070 | 109,087 |
| 2007 | 114,099 | 114,099 | 136,332 | 124,755 | 164,358 | 107,578 | 108,437 |
| 2008 | 113,912 | 113,912 | 138,775 | 125,970 | 170,787 | 106,826 | 107,552 |
| 2009 | 113,701 | 113,701 | 140,881 | 126,973 | 176,629 | 106,188 | 106,804 |
| 2010 | 113,690 | 113,690 | 142,900 | 127,999 | 182,142 | 105,840 | 106,365 |
| 2011 | 113,546 | 113,546 | 144,564 | 128,752 | 187,109 | 105,417 | 105,867 |
| 2012 | 113,594 | 113,594 | 146,239 | 129,583 | 191,922 | 105,224 | 105,611 |
| F | | | | | | | |
| 1999 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 | 0.055 |
| 2000 | 0.065 | 0.065 | 0.033 | 0.056 | 0.000 | 0.078 | 0.065 |
| 2001 | 0.070 | 0.070 | 0.036 | 0.056 | 0.000 | 0.082 | 0.070 |
| 2002 | 0.073 | 0.073 | 0.039 | 0.056 | 0.000 | 0.086 | 0.087 |
| 2003 | 0.076 | 0.076 | 0.039 | 0.056 | 0.000 | 0.088 | 0.090 |
| 2004 | 0.078 | 0.078 | 0.039 | 0.056 | 0.000 | 0.091 | 0.092 |
| 2005 | 0.078 | 0.078 | 0.039 | 0.056 | 0.000 | 0.091 | 0.092 |
| 2006 | 0.078 | 0.078 | 0.039 | 0.056 | 0.000 | 0.091 | 0.092 |
| 2007 | 0.078 | 0.078 | 0.039 | 0.056 | 0.000 | 0.091 | 0.091 |
| 2008 | 0.078 | 0.078 | 0.039 | 0.056 | 0.000 | 0.090 | 0.090 |
| 2009 | 0.078 | 0.078 | 0.039 | 0.056 | 0.000 | 0.089 | 0.089 |
| 2010 | 0.077 | 0.077 | 0.039 | 0.056 | 0.000 | 0.088 | 0.088 |
| 2011 | 0.076 | 0.076 | 0.039 | 0.056 | 0.000 | 0.087 | 0.087 |
| 2012 | 0.076 | 0.076 | 0.039 | 0.056 | 0.000 | 0.086 | 0.087 |
| Yield | | | | | | | |
| 1999 | 10,535 | 10,535 | 10,535 | 10,535 | 10,535 | 10,535 | 10,535 |
| 2000 | 13,020 | 13,020 | 6,598 | 11,276 | 0 | 15,385 | 13,020 |
| 2001 | 14,359 | 14,359 | 7,665 | 11,763 | 0 | 16,641 | 14,359 |
| 2002 | 15,637 | 15,637 | 8,763 | 12,288 | 0 | 17,813 | 18,466 |
| 2003 | 16,779 | 16,779 | 9,331 | 12,811 | 0 | 18,824 | 19,402 |
| 2004 | 17,403 | 17,403 | 9,684 | 13,174 | 0 | 19,430 | 19,923 |
| 2005 | 17,278 | 17,278 | 9,838 | 13,262 | 0 | 19,338 | 19,727 |
| 2006 | 16,905 | 16,905 | 9,833 | 13,142 | 0 | 18,754 | 19,051 |
| 2007 | 16,456 | 16,456 | 9,752 | 12,936 | 0 | 18,026 | 18,255 |
| 2008 | 16,019 | 16,019 | 9,661 | 12,736 | 0 | 17,345 | 17,520 |
| 2009 | 15,626 | 15,626 | 9,593 | 12,586 | 0 | 16,814 | 16,948 |
| 2010 | 15,335 | 15,335 | 9,558 | 12,491 | 0 | 16,444 | 16,547 |
| 2011 | 15,113 | 15,113 | 9,541 | 12,429 | 0 | 16,165 | 16,247 |
| 2012 | 14,973 | 14,973 | 9,555 | 12,412 | 0 | 16,010 | 16,076 |

Table 6-17b. Set of projections of yield for slope rockfish for 2000 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 SR/RE Rockfish** | 70,885 | | **2,066** | | **1,727** | 0.026 | **1,853** | | **1,033** |
| **Northern Rockfish** | **85,357** | 0.075 | 6,400 | 0.060 | **5,120** | 0.047 | **4,010** | 0.038 | **3,240** |
| 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 RF** | 102,505 | | **5,006** | | **4,898** | 0.010 | **1,071** | | **2,503** |

Table 6-18 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 6-19  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 | 200,310 | $F=F_{40\%}(B/B_{40\%}-\alpha)/(1-\alpha)=0.065$ | 13,020 | $F=F_{35\%}(B/B_{40\%}-\alpha)/(1-\alpha)=0.078$ | 15,390 |
| 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 | 85,357 | F=M=0.060 | 5,120 | F35%=0.088 | 7,511 |
| 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 | 449,657 | | 24,345 | | 31,260 |

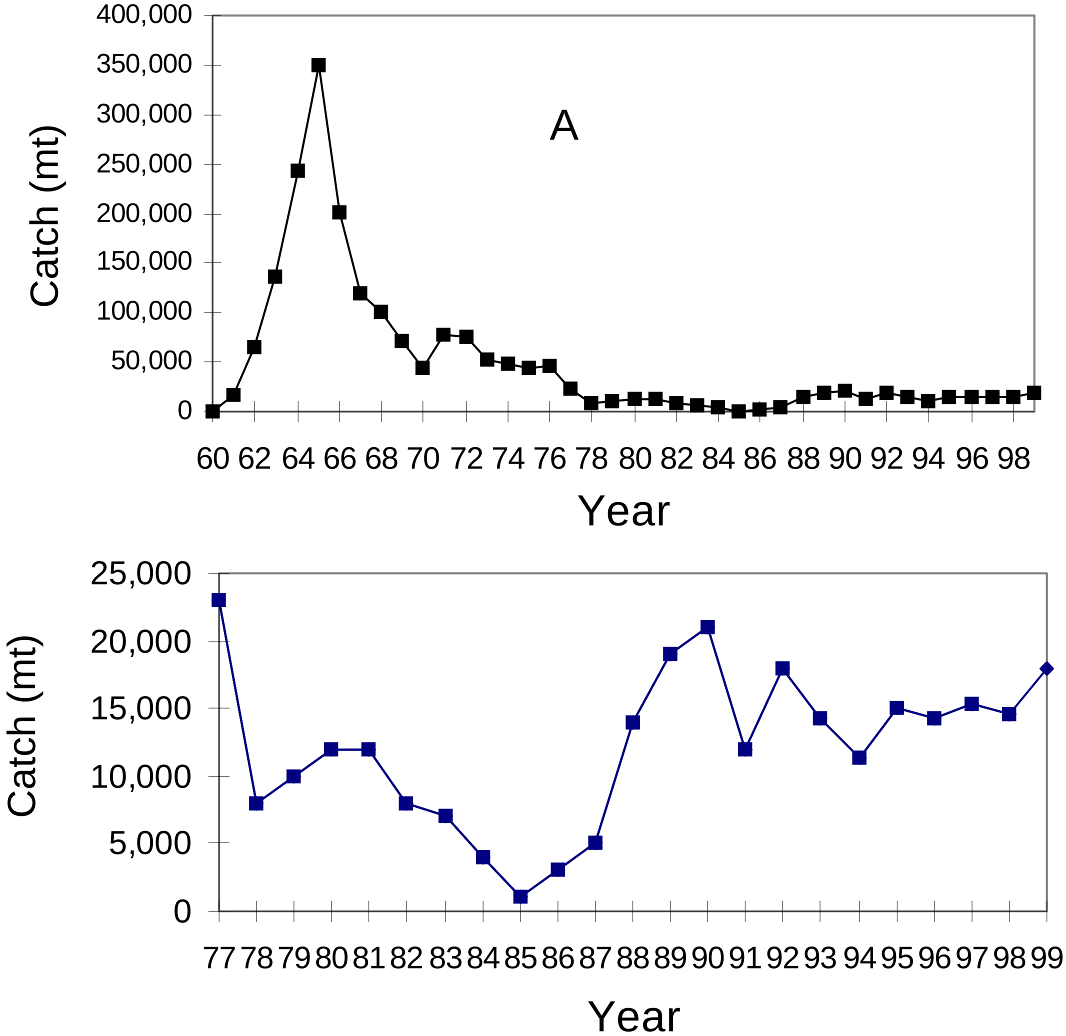


Figure 6-1.-- All nation catch of Pacific ocean perch and slope rockfish in the Gulf of Alaska as of October 21, 1999. Long term catch history shown in panel A and recent catch history shown in panel B.

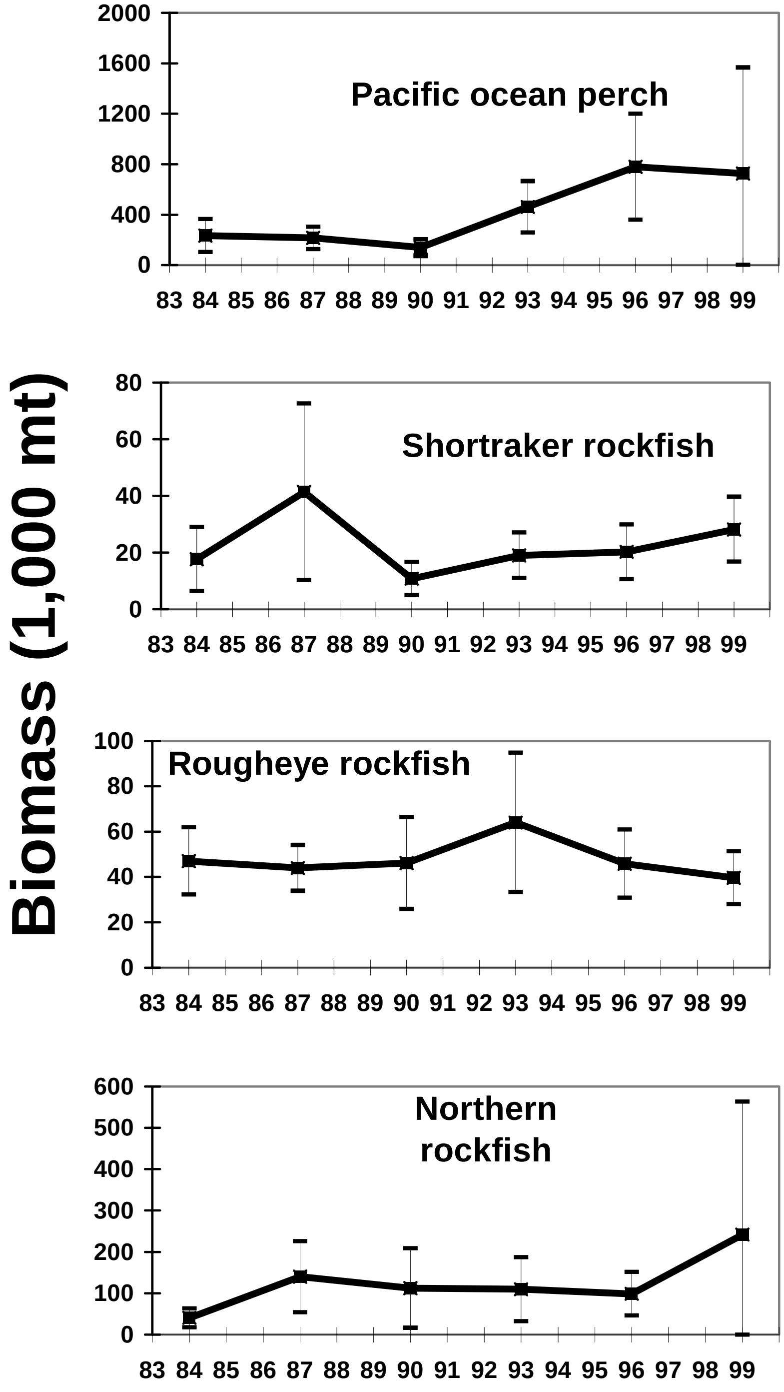


Figure 6-2. -- Estimated biomass of Pacific ocean perch, shortraker rockfish, rougheye rockfish, and northern rockfish in the Gulf of Alaska, based on results of the 1984, 1987, 1990, 1993, 1996, and 1999 triennial trawl surveys. The vertical bars show 95% confidence limits associated with each estimate.

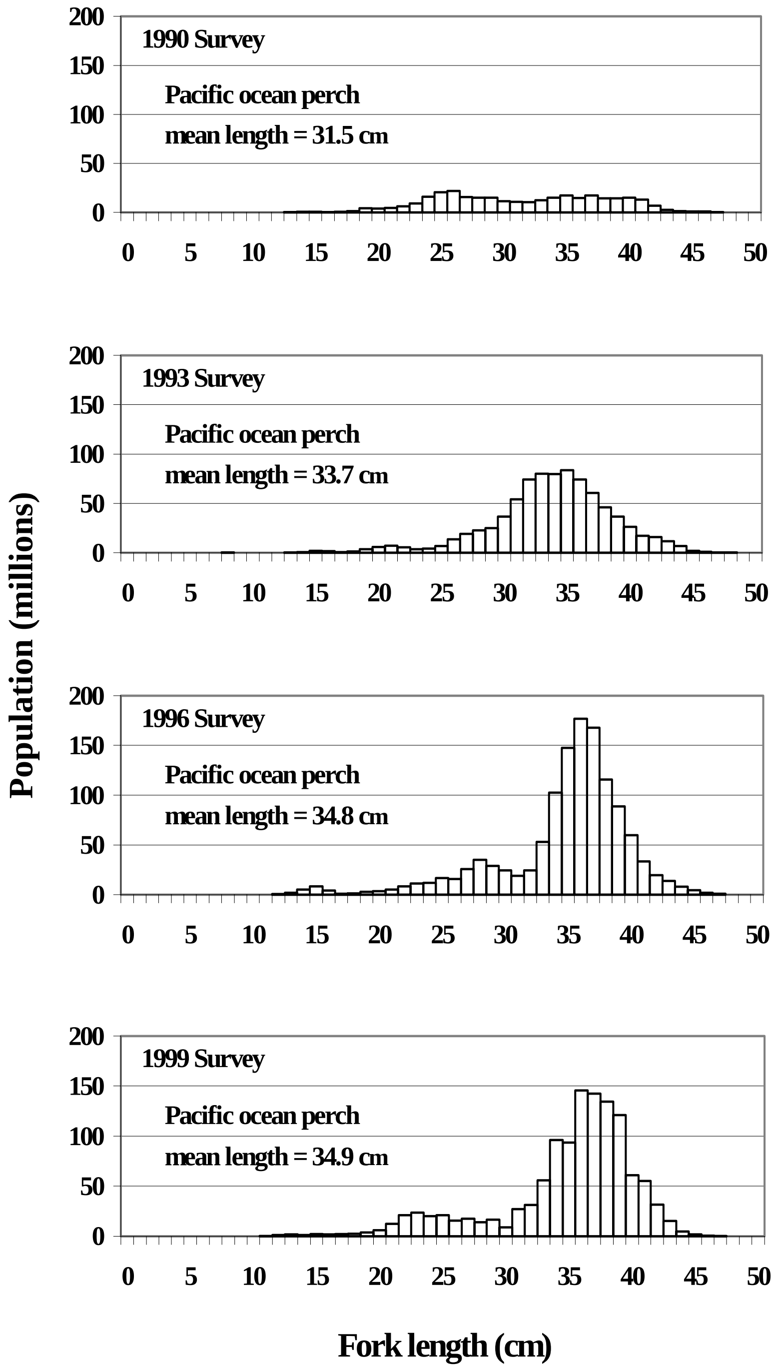


Figure 6-3.--Length frequency distribution of the estimated population of Pacific ocean perch in the Gulf of Alaska, based on the 1990, 1993, 1996, and 1999 triennial trawl surveys.

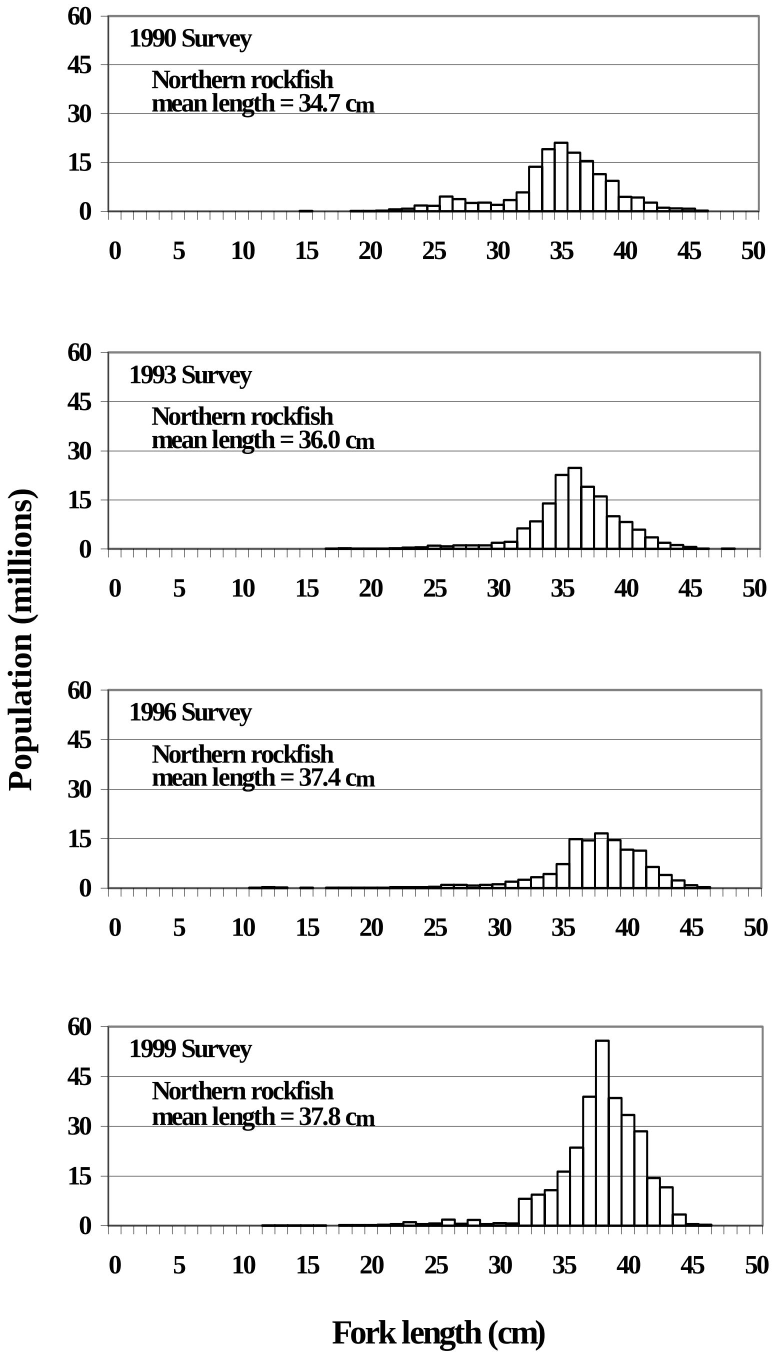


Figure 6-4.--Length frequency distribution of the estimated population of northern rockfish in the Gulf of Alaska, based on the 1990, 1993, 1996, and 1999 triennial trawl surveys.

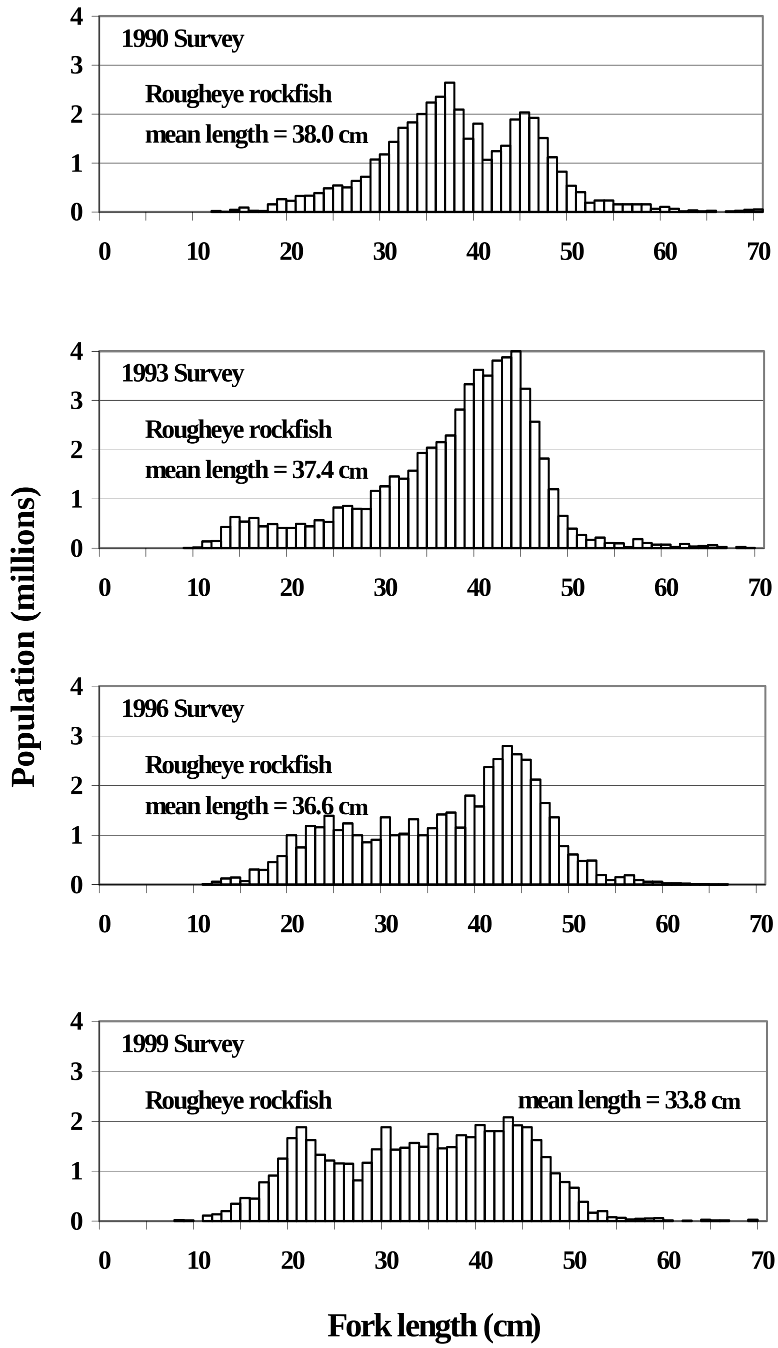


Figure 6-5.--Length frequency distribution of the estimated population of rougheye rockfish in the Gulf of Alaska, based on the 1990, 1993, 1996, and 1999 triennial trawl surveys.

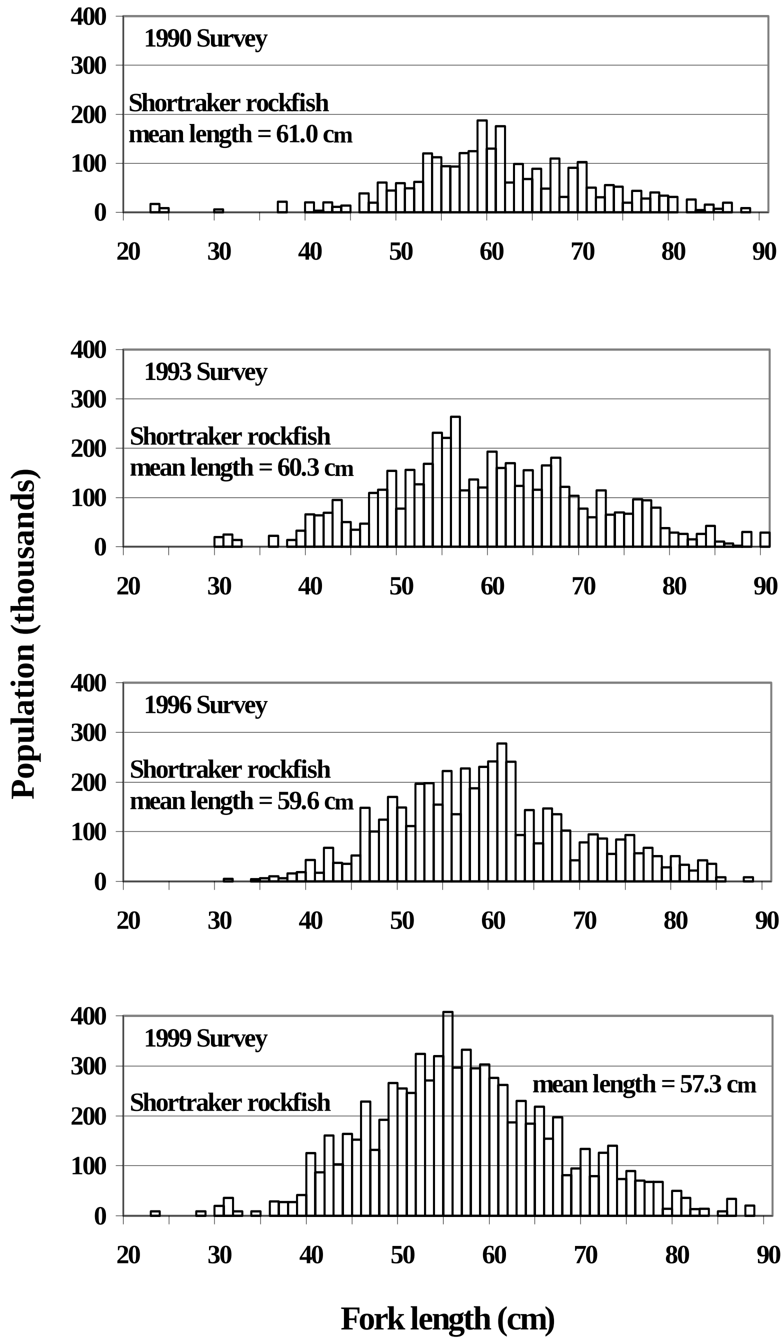


Figure 6-6.--Length frequency distribution of the estimated population of shortraker rockfish in the Gulf of Alaska, based on the 1990, 1993, 1996, and 1999 triennial trawl surveys.

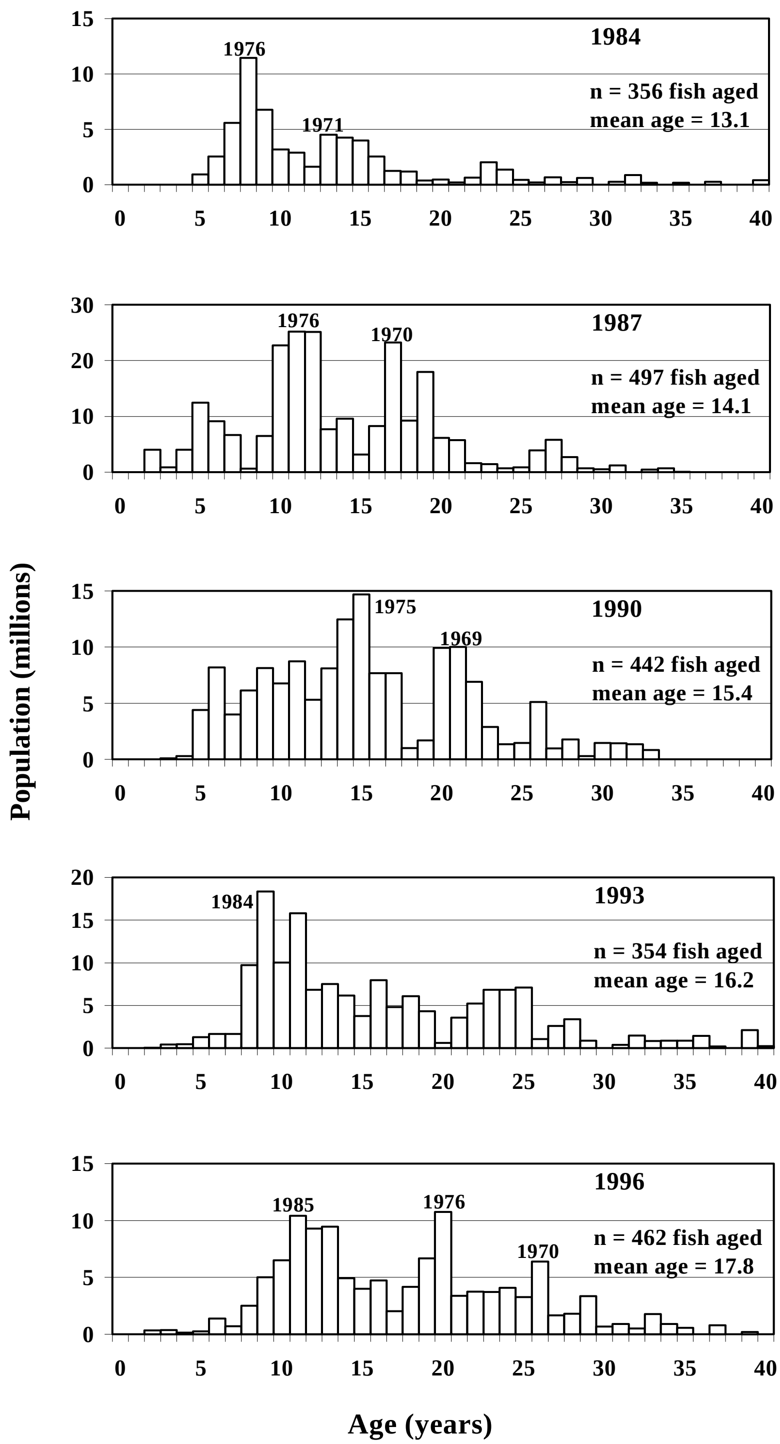


Figure 6-7.--Age composition of the estimated population of northern rockfish in the Gulf of Alaska, based on the 1984, 1987, 1990, 1993, and 1996 triennial trawl surveys. The numbers next to prominent bars identify apparently strong year classes.

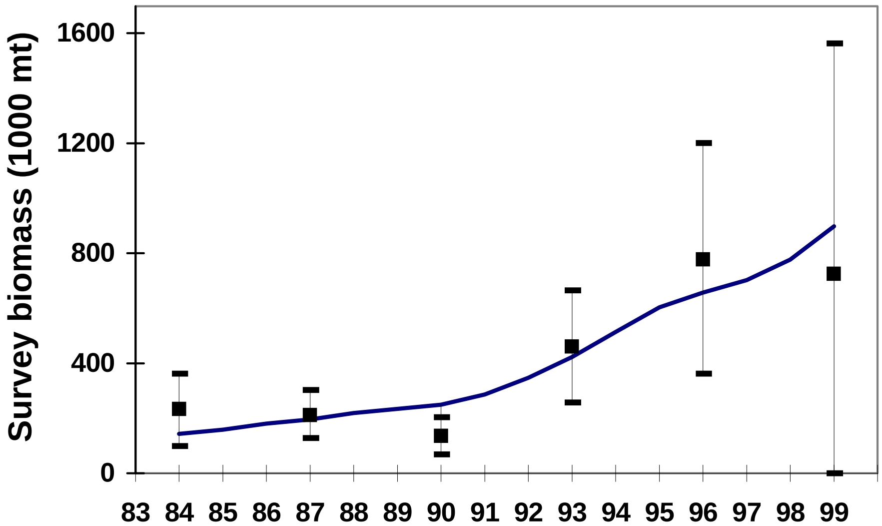


Figure 6-8.--Observed and predicted survey biomass estimates for Pacific ocean perch in the Gulf of Alaska based on the stock synthesis model with *q* estimated. Ninety-five percent confidence limit is shown for each observed biomass estimate.

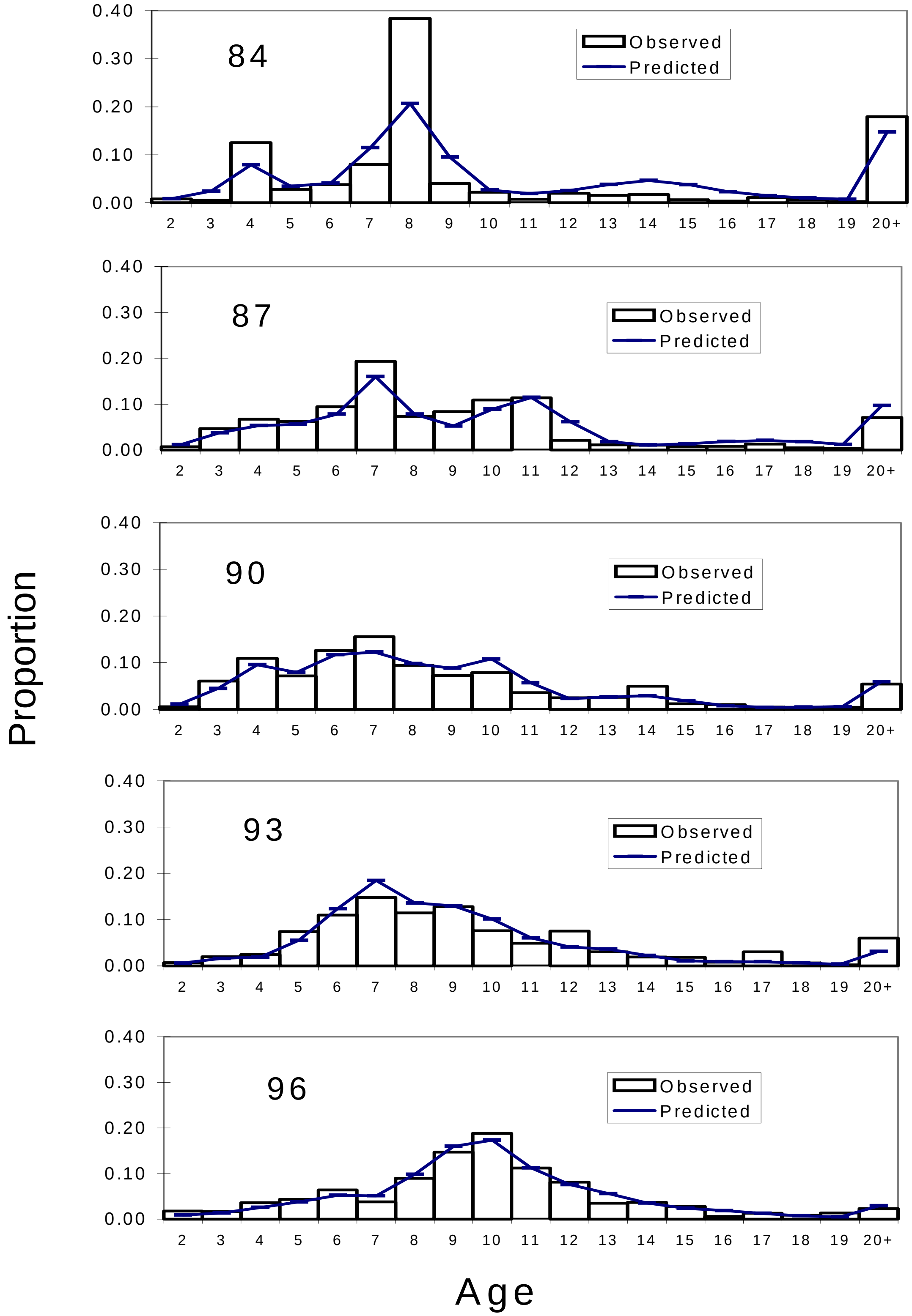


Figure 6-9.--Observed and predicted triennial survey age composition for Pacific ocean perch in the Gulf of Alaska based on the stock synthesis model.

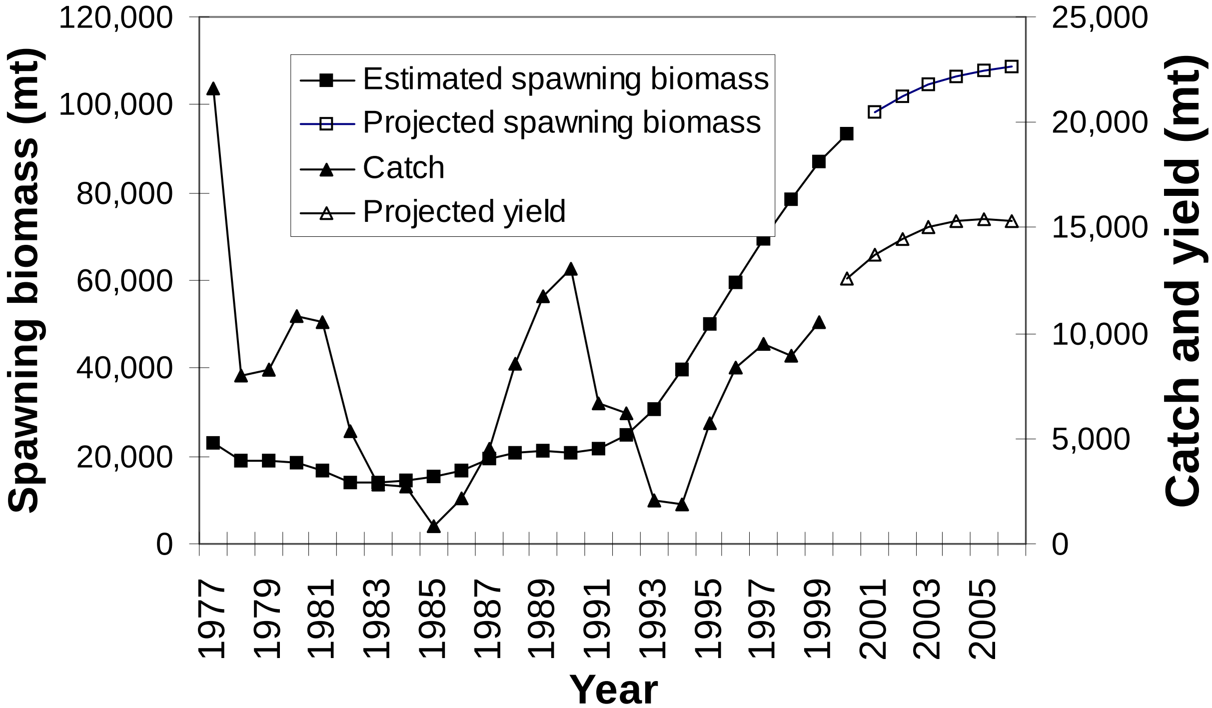


Figure 6-10.--Recent trend and short-term projection of spawning biomass and yield of Pacific ocean perch in the Gulf of Alaska based on tier 3 computations.