SECTION 7 PELAGIC SHELF ROCKFISH

SAFE Report

by

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SUMMARY OF MAJOR CHANGES IN THE PELAGIC SHELF ROCKFISH ASSESSMENT

Because a Gulf of Alaska trawl survey was not conducted in 2002, most of this year's Pelagic Shelf Rockfish assessment is identical to last year' assessment. The same values of current exploitable biomass, ABC, ABC geographic apportionment, and overfishing are recommended for 2003 as were recommended for 2002. These values are summarized as follows:

1. An average of the 1996, 1999, and 2001 surveys was used to compute the estimate of current exploitable biomass for the assemblage, 62,489 mt.

2. ABC for dusky rockfish was computed similar to previous years, in which an F=M=0.09 strategy was used. This F is more conservative than the maximum allowable for a tier 4 species such as dusky rockfish because trawl survey biomass estimates and abundance trends for this species are very uncertain. Multiplying the current exploitable biomass for dusky rockfish, 56,336 mt, by an M of 0.09 yields an ABC of 5,070 mt for this species in 2003. ABC for widow and yellowtail rockfish was computed based upon the maximum allowable F for tier 5 species, 0.75 x M. Multiplying the current exploitable biomass for widow and yellowtail rockfish, 6,153, by 0.75 times an M of 0.09 yields an ABC of 415 mt. Total recommended Gulfwide ABC for the assemblage in 2003 is the addition of these two ABC values: 5,485 mt.

3. Recommended geographic apportionment of this ABC was calculated using the same procedure as in previous years, in which a 4:6:9 weighting of biomass in the three most recent trawl surveys was used to compute distribution of biomass by area. The recommended apportionments for 2003 are: Western area, 512 mt; Central area, 3,475 mt, and Eastern area, 1,498 mt.

4. Based on the tier 4 status for dusky rockfish and the tier 5 status for widow and yellowtail rockfish, the overfishing level was computed to be 7,662 mt for dusky rockfish and 554 mt for widow and yellowtail rockfish, which totals 8,216 mt for the entire assemblage.

The only substantive change for this assessment relative to the November 2001 assessment is the inclusion of Appendix A, which discusses preliminary results of an age-structured model for dusky rockfish.

Minor changes or additions to the report include updating the commercial and survey catch tables, presenting dusky rockfish length frequency and age distributions for the 2001 commercial fishery, and adding a section for ecosystem considerations.

INTRODUCTION

The pelagic shelf rockfish assemblage in the Gulf of Alaska is comprised of three species: dusky rockfish (*Sebastes ciliatus*), yellowtail rockfish (*S. flavidus*), and widow rockfish (*S. entomelas*). This assemblage is one of three management groups for *Sebastes* in the Gulf which were implemented in 1988 by the North Pacific Fishery Management Council (NPFMC). Pelagic shelf rockfish can be defined as those species of *Sebastes* that inhabit waters of the continental shelf of the Gulf of Alaska, and that typically exhibit a midwater, schooling behavior. Gulfwide, dusky rockfish is the most important species in the assemblage, whereas yellowtail and widow rockfish are generally considered minor species in Alaska waters.

Dusky rockfish has one of the most northerly distributions of all rockfish species in the Pacific. It ranges from southern British Columbia north to the Bering Sea and west to Hokkaido Is., Japan, but appears to be abundant only in the Gulf of Alaska. No studies have been done to determine if the Gulf of Alaska population is one stock, or if subpopulations occur.

The taxonomy of dusky rockfish is unclear, and biochemical studies (Seeb 1986 and footnote[1]) and morphometric studies[2] indicate that two distinct species of dusky rockfish likely occur in the Gulf of Alaska: an inshore, shallow water, dark-colored variety; and a lighter-colored variety found in deeper water offshore. No actual reclassification of dusky rockfish has yet been made, but a publication is currently in preparation that will propose the formal separation of the two varieties into distinct species[3]. In this report, nearly all the discussion on dusky rockfish will concern the offshore, light-colored variety, since most information is available from offshore trawl surveys and the offshore commercial fishery.

Until 1998, black rockfish (*S. melanops*) and blue rockfish (*S. mystinus*) were also included in the assemblage. However, in April 1998, a NPFMC Gulf of Alaska Fishery Management Plan amendment went into effect that removed these two species from the federal management plan and transferred their jurisdiction to the state of Alaska. Because of their removal from the assemblage, black and blue rockfish are no longer be covered in this report.

7.2 FISHERY

7.2.1 Catch History

Fishery catch statistics for pelagic shelf rockfish in the Gulf of Alaska are only available for the years 1988-2002 (Table 7-1a). Previous to 1988, these fish were classified into another, larger management group ("other rockfish"), and it is generally not possible to separate out catches of the pelagic shelf species. Generally, annual catches increased from 1988 to 1992, and have fluctuated in the years following. This pattern is largely explained by management actions that have affected rockfish during this period. In the years before 1991, TAC's were relatively large for more desirable slope rockfish species such as Pacific ocean perch, and there was less reason for fishermen to target a lower valued fish such as dusky rockfish. However, as TAC's

[1]Seeb, L.W. 2000. Molecular markers distinguish light and dark forms of the dusky rockfish (*S. ciliatus*) in the Gulf of Alaska. Presentation at the 11th Western Groundfish Conference, Sitka, Alaska, April 25-28, 2000.

[2]Orr, J.W., and J. Blackburn. 2000. Morphology and systematics of dusky rockfish: the *Sebastes ciliatus* problem. Presentation at the 11th Western Groundfish Conference, Sitka, Alaska, April 25-28, 2000.

[3]J. Orr, National Marine Fisheries Service, Alaska Fisheries Science Center, RACE Division, 7600 Sand Point Way NE, BIN C15700, Seattle, WA 98115-0070. Pers. commun. October 2000.

for slope rockfish became more restrictive in the early 1990's, there was a greater economic incentive for taking dusky rockfish. As a result, catches of the pelagic shelf assemblage increased, reaching 3,605 mt Gulfwide in 1992. In following years, in-season management regulations have usually prevented any further increase in the dusky rockfish fishery, and have sometimes caused a decrease in catch. For example, in 1997-1998 and 2000-2002, the pelagic shelf rockfish trawl fishery in the Central area was closed with a substantial amount of unharvested TAC remaining, either to ensure that catches did not exceed the TAC, or to prevent excessive bycatch of Pacific ocean perch or Pacific halibut.

It should be mentioned that the catches in Table 7-1a include black and blue rockfish for the years 1988-97, when these species were members of the pelagic shelf assemblage. A significant black rockfish jig fishery existed in the Gulf of Alaska starting in 1991, but precise catches of black rockfish for these years are not available. Clausen and Heifetz (1997) provided approximations of the Gulfwide annual catches of black rockfish for the years 1991-97. The approximation for 1997 was later revised in the 1998 SAFE report (Clausen and Heifetz 1998). These approximations can be subtracted from the Gulfwide totals in Table 7-1a to yield the following estimates of pelagic shelf rockfish catch for the three species that now comprise the assemblage:

Year	1991	1992	1993	1994	1995	1996	1997
Catch (mt)	1,773	3,163	3,041	2,610	2,342	1,834	2,280

Catches of pelagic shelf rockfish from research cruises since 1977 are listed in Table 7-1b.

7.2.2 Description of the Fishery

Pelagic shelf rockfish (excluding its former members black and blue rockfish) have been caught almost exclusively with bottom trawls. Species composition data for the present species in the assemblage are shown below for the fishery in the years 1991-2001, based on data from the domestic observer program:

	Percent of assemblage catch			
Year	Light dusky	Dark dusky	Yellowtail	Widow
1991	93.5	0.2	5.1	1.2
1992	98.9	0.3	trace	0.8
1993	98.1	trace	0.5	1.4
1994	98.3	1.2	0.1	0.4
1995	99.2	trace	trace	0.8
1996	99.7	trace	trace	0.3
1997	99.9	trace	trace	0.1
1998	99.9	trace	trace	trace
1999	97.4	2.6	trace	trace
2000	99.2	0.6	0.1	0.2
2001	99.7	0.3	trace	trace

Although the vast majority of these catches come from bottom trawls, a small portion of the data may also come from longline vessels that carried observers, which could account for some of the yellowtail and dark dusky rockfish listed. Clearly, with the possible exception of 1991, nearly all the catch consists of "light" dusky rockfish.

The trawl fishery for light dusky rockfish in the Gulf of Alaska in recent years has occurred mostly in July, because management regulations do not allow rockfish trawling in the Gulf until the first week in July. The same trawlers that target Pacific ocean perch and northern rockfish also target light dusky rockfish. Typically, these vessels fill the quota first for Pacific ocean perch, and after this fishery is closed, move on to catch dusky and northern rockfish. Catches of light dusky rockfish are concentrated at a number of relatively shallow, offshore banks of the outer continental shelf, especially the "W" grounds west of Yakutat, Portlock Bank northeast of Kodiak Is, and around Albatross Bank south of Kodiak Is. Highest catch-per-unit-effort in the commercial fishery is generally at depths of 100-149 m (Reuter 1999). During the period 1988-95, almost all the catch of light dusky rockfish (>95%) was taken by large factory trawlers that processed the fish at sea. This changed starting in 1996, when smaller shore-based trawlers also began taking a sizeable portion of the catch in the Central area for delivery to processing plants in Kodiak. These shore-based trawlers have accounted for the following percentages of the trawl catch in the Central area in the years 1996-2002[4]:

1996	1997	1998	1999	2000	2001	2002
27.1	18.1	25.0	45.2	74.4	58.0	49.7

7.2.3 Bycatch

The only analysis of bycatch in rockfish fisheries of the Gulf of Alaska is that of Ackley and Heifetz (2001). They examined data from the observer program for the years 1994-96. For hauls targeting pelagic shelf rockfish, the major bycatch species were northern rockfish and fish in the "other slope rockfish" management category, followed by Pacific ocean perch. Similarly, dusky rockfish was the major bycatch species for hauls targeting northern rockfish. These conclusions are supported by another study (Reuter 1999), in which catch data from the observer program showed dusky rockfish were most commonly associated with northern rockfish, Pacific ocean perch, and harlequin rockfish (the latter is one of the "other slope rockfish" species). There is no information on the bycatch of pelagic shelf rockfish in non-rockfish fisheries, but it is presumed to be small.

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

7.2.4 Discards

Fishery discard rates for pelagic shelf rockfish have been relatively low, as shown in the following table[5]:

Year	Discard rate (%)
1991	10.2
1992	5.9
1993	10.8
1994	9.4
1995	6.3
1996	10.9
1997	6.4
1998	4.8
1999	9.3
2000	3.8
2001	4.3
2002	4.7

In contrast, discard rates in the fisheries for slope rockfish in the Gulf of Alaska have generally been much higher (see section 6.2.4 of the slope rockfish report in this document).

7.3 DATA

7.3.1 Fishery Data

In addition to the catch data listed in Table 7-1a, length frequency data for dusky rockfish in the commercial fishery are also available for the years 1991-2001 (Figure 7-1). The reader is cautioned that for each year, these data are the raw length frequencies for all dusky rockfish measured by observers; because there was no attempt to collect or analyze these data systematically, some biases may be expected, especially for 1995 and 1996 when sample sizes were relatively small. Generally, however, these lengths were taken from hauls in which dusky rockfish was either the target or a dominant species, and they provide an indication of the trends in size composition for the fishery. Size of fish taken by the fishery generally appears to have increased after 1992; in particular, the mode increased from 42 cm in 1991-92 to 44-47 cm in 1993-97. The mode then decreased to 42 cm in 1998, and rose back to 45 cm in 1999-2001. Fish smaller than 40 cm are seen in moderate numbers in certain years (1991-92 and 1996-98), but it is unknown if this is an artifact of observer sampling patterns, or if it shows true influxes of younger fish.

Age samples for light dusky rockfish have been collected by observers only in the 1999, 2000, and 2001 commercial fisheries. The 1999 and 2000 samples have not yet been aged, but aging was recently completed for the 2001 samples (Figure 7-2). Similar to the fishery length data discussed in the preceding paragraph, the data in Figure 7-2 depicts the simple raw age distribution of the samples, and we did not attempt any further analysis to estimate a more comprehensive age composition. However, the samples were randomly collected from fish in over 100 hauls that had large catches of light dusky rockfish, so the raw distribution is probably representative of what the true age composition of the fishery would be. The fish ranged in age from 6 to 47 years. A mode was present at ages 13-15, which corresponds to the 1986-88 year classes.

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

7.3.2 Survey Data

7.3.2.1 Survey Biomass Estimates

Comprehensive trawl surveys were conducted on a triennial basis in the Gulf of Alaska in 1984, 1987, 1990, 1993, 1996, and 1999, and these surveys became biennial in 2001. The surveys provide estimates of biomass for pelagic shelf rockfish (Table 7-2). It is important to note that the 2001survey, in contrast to the previous surveys, did not cover the eastern Gulf of Alaska (the Yakutat and Southeastern statistical areas). Although the eastern Gulf was not sampled in 2001, in Table 7-2 we have included substitute estimates of 2001 biomass in this region for pelagic shelf rockfish. These substitutes were computed by averaging the biomass for each species in each area for the three previous surveys in 1993, 1996, and 1999 (see section 7.4.2 in this report). The estimates for the 1984 through 1996 surveys showed that dusky rockfish comprised virtually all the biomass of the assemblage. In 1999, dusky rockfish again predominated, but a relatively large biomass of yellowtail rockfish was also seen in the Southeastern area. This yellowtail rockfish biomass can be mostly attributed to one relatively large catch in Dixon Entrance near the U.S./Canada boundary. Dusky rockfish were separated into "light" or "dark" varieties only in the three most recent surveys in 1996, 1999, and 2001. Each of these surveys has shown that light dusky rockfish overwhelmingly predominate and that dark dusky rockfish are caught in only small quantities. Presumably, the dusky rockfish biomass in previous surveys also consisted of nearly all light dusky rockfish. On a geographic basis, the Kodiak statistical area has shown the highest biomass of dusky rockfish in all years of the survey except 1984. For the Gulfwide surveys before 2001, biomass estimates for the assemblage were consistently lowest in the Southeastern area, with the exception of 1999.

Comparative biomass estimates for the seven triennial surveys show wide fluctuations in the abundance of dusky rockfish (Table 7-2; Figure 7-3). Total biomass increased substantially between 1984 and 1987, dropped by over 50% in 1990, rebounded in 1993 and 1996, and decreased again in 1999 and in the areas that were sampled in 2001. Large confidence intervals are associated with all these biomass estimates, and are an indication of the generally patchy and highly aggregated distribution of this species. None of the changes in biomass appear to be statistically significant. Whether these fluctuations indicate true changes in abundance, temporal changes in the availability of dusky rockfish to the survey gear, or are an artifact of the imprecision of the survey for this species, is unknown. However, because of the apparently light fishing pressure on dusky rockfish during most of these years (catches have usually been much less than the ABC), and their relatively low rate of natural mortality (see section 7.4.1, "Assessment Parameters"), large and abrupt changes in abundance such as those shown by the trawl surveys seem unlikely.

7.3.2.2 Survey Size Compositions

Survey population size compositions suggest that recruitment of dusky rockfish is a relatively infrequent event, as only one survey, 1993, showed evidence of substantial recruitment (see Clausen and Heifetz 1989 for 1987 results and Figure 7-4 for 1990, 1993, 1996, 1999, and 2001 results). Size compositions of dusky rockfish from both the 1987 and 1990 surveys showed virtually no fish <35 cm. Mean population length increased from 39.8 cm in 1987 to 43.1 cm in 1990, apparently the result of growth. In 1993, however, a large number of small fish (~27-35 cm long) appeared which formed a sizeable percentage of the population, and this recruitment decreased the mean length to 38.3 cm. It is interesting to note, however, that no corresponding numbers of small fish are seen in the fishery length frequency data for this year (see Figure 7-1). In the 1996 and 1999 surveys, the length frequency distribution was similar to that of 1990, with very few small fish, and both years had a mean population length of 43.9 cm. The 2001 size composition, although not directly comparable to previous years because the eastern Gulf of Alaska was not sampled, shows modest recruitment of fish <40 cm.

7.3.2.3 Survey Age Compositions

Gulfwide age composition data for dusky rockfish are available for the 1984, 1987, 1990, 1993, 1996, and 1999 surveys (Figure 7-5), and, similar to the length data, these age data also indicate that recruitment is highly variable. For each survey, ages were determined using the "break-and-burn" method of aging otoliths, and a Gulfwide age-length key was developed. The key was then used to estimate age composition of the dusky rockfish population in the Gulf of Alaska. The 1976 year class appeared to be abundant in the 1984 survey. This year class is also prominent in the 1987 and 1990 age compositions. In 1987, just 4 year classes (1975, 1976, 1977, and 1980) comprised over 75% of the estimated population, and mean age was 10.3 years. The 1990 results showed no significant recruitment of young fish and appeared to merely reflect growth of the population that existed in 1987; mean age was 13.9 years. The 1993 age composition showed a very prominent 1986 year class. This year class is clearly associated with the large influx of small fish that was noted previously in the 1993 size compositions, and its presence likely explains much of the increase in dusky rockfish biomass that year. The existence of a strong 1986 year class was further confirmed by the 1996 age composition, in which this year class was again the most important. The 1996 results showed little evidence of recruitment of young fish <10 years old; accordingly, mean age of the population increased from 12.0 years in 1993 to 14.7 years in 1996. In 1999, fish <10 years old again comprised only a small part of the population, and fish aged 12, which would correspond to the 1987 year class, were very prominent. Because rockfish are difficult to age, especially as the fish grow older, one possibility is that some of the fish aged 12 in 1999 were actually age 13 (members of the 1986 year class), which would agree more with the 1993 and 1996 age results. Finally, it should be noted that the 2001 fishery age distributions discussed previously in section 7.3.1 generally agreed with the recent survey age compositions, as they both showed prominent 1986 or 1987 year classes.

7.3.3.1 Length at Age

Clausen and Heifetz (1999) presented revised estimates of the von Bertalanffy growth parameters for combined sexes of dusky rockfish. These were based on age samples from 1,245 fish in the 1984, 1987, 1990, and 1993 triennial surveys. The revised parameters are: $L_{inf} = 45.9$ cm; $K = 0.24$; and $t_o = 1.18$. A manuscript has also been prepared that presents these results in more detail (Malecha and Heifetz 2000).

7.3.3.2 Weight at Length

The best length-weight information for light dusky rockfish comes from the 1996 triennial survey, in which motion-compensated electronic scales were used to weigh a relatively large sample of individual fish for this species. For combined sexes, using the formula $W = aL^b$, where W is weight in grams and L is fork length in mm, $a = 3.28 \times 10^{-5}$ and $b = 2.90$ (Martin 1997).

7.4 ANALYTIC APPROACH

Due to the lack of biological information for dusky rockfish, past assessments have used a biomass-based approach based on trawl survey data to calculate ABC's for pelagic shelf rockfish. We continue to use this approach in the present assessment. However, we began work in 2001 on using an age-structured model for dusky rockfish, and initial results of this model are discussed in Appendix A at the end of this chapter.

7.4.1 Assessment Parameters: Natural Mortality, Maximum Age, Age of Recruitment, and Age and Size at Maturity

Information on mortality rates and maximum age for the three species of pelagic shelf rockfish is shown in Table 7-3. These data are based on the currently accepted "break-and-burn" method of aging otoliths. The method used to determine the natural mortality rate for dusky rockfish was described in Clausen and Heifetz (1991). The dusky rockfish natural mortality rate of 0.09 is an indication that dusky rockfish is a faster growing and shorter lived species than most other rockfish. For example, mortality rates for slope rockfish species are all <0.09, with the exception of redstripe rockfish (see Table 6-12 of the slope rockfish report in this document). The maximum age of 59 years for dusky rockfish in Table 7-3 represents the age of just a single specimen and is 8 years older than the next oldest fish that has been aged. Therefore, it may be an outlier whose validity should be viewed with some caution.

There is no published information on age or size of recruitment for any of the pelagic shelf species in Alaska. In SAFE reports before 1999, we used a very rough estimate of 7 years as the age of recruitment for dusky rockfish. However, in Clausen and Heifetz 1999 we revised this estimate to 10 years. This was based on a visual examination of the length frequency distributions for the commercial fishery, which indicated that length of 50% recruitment probably corresponds to about 40 cm. This length translates to an age of approximately 10 years, which we believe is a more reasonable estimate of age at 50% recruitment than the 7 years that we had used previously. A more precise estimate of the age at 50% recruitment will be computed in the future when an age-structured model is applied to dusky rockfish.

Size at 50% maturity for a relatively small sample (n=64) of female light dusky rockfish in the Kodiak area has been estimated to be 42.8 cm fork length (Clausen and Heifetz 1997). Age data for these fish were analyzed using a logistic function, which provided an estimated age at 50% maturity of 11.3 years[6].

7.4.2 Current Exploitable Biomass

In the last eight SAFE reports (Clausen and Heifetz 1994, 1995, 1996, 1997, 1998, 1999, 2000, and 2001), current exploitable biomass for pelagic shelf rockfish was computed by averaging the Gulfwide assemblage biomass in the most recent three trawl surveys (i.e., averaging the 1987, 1990, and 1993 surveys for the 1994 and 1995 reports, averaging the 1990, 1993, and 1996 surveys for the 1996, 1997, and 1998 reports, averaging the 1993, 1996, and 1999 surveys for the 1999 and 2000 reports, and averaging the 1996, 1999, and 2001 surveys for the 2001 report). This averaging technique was used because of the uncertainty of the biomass estimates (discussed previously in section 7.3.2.1, “Survey Biomass Estimates”) and the resultant desire to avoid placing too much emphasis on the results of an individual survey. We recommend continuing this procedure in this report.

The 2001 survey, however, presents a problem in these calculations because the eastern Gulf of Alaska was not sampled that year. To use 2001 data in the computation of exploitable biomass, an estimate of biomass is needed for pelagic shelf rockfish in the eastern Gulf in 2001. Similar to last year’s SAFE report, we have decided to use a simple approach of averaging the three most recent biomass estimates for the eastern Gulf from the 1993, 1996, and 1999 surveys to compute biomass estimates for this region in 2001. (See last year’s report (Clausen and Heifetz 2001) for details on the reasoning behind this approach.) These averages are listed in Table 7-2 for the eastern Gulf in 2001.

[6]C. Lunsford, National Marine Fisheries Service, Alaska Fisheries Science Center, Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801. Pers. commun. August 1999.

Therefore, the Gulfwide assemblage biomass estimates for three most recent surveys in 1996, 1999, and 2001 are 75,843 mt, 64,694 mt,, and 46,929 mt respectively (Table 7-2). Averaging these values yields a current exploitable biomass of 62,489 mt for pelagic shelf rockfish. Because no new trawl survey information is available for 2002, this value is the same as last year's estimate. This estimate can be broken down into 56,336 mt for dusky rockfish (both light and dark forms) and 6,153 mt for widow and yellowtail rockfish.

7.4.3 Reference Fishing Mortality Rates and Yields for Dusky Rockfish

A spawning biomass-per-recruit analysis was applied to dusky rockfish to determine several reference values of fishing mortality (F) and corresponding yields. The computed values of F include $F_{30\%}$, $F_{35\%}$, and $F_{40\%}$. Required parameters for this analysis include an estimate of natural mortality (M), von Bertalanffy growth parameters K, t_o, and W_{inf}, and ages of maturity and recruitment. The estimates of M, K, and t_o used were those listed in section 7.3.3.1, "Length at Age" and 7.4.1, "Assessment Parameters". W_{inf} was calculated using a length-weight regression to convert L_{inf} in the "Assessment Parameters" section to a weight value. Age at 50% maturity for females was estimated at 11.3 years as listed in "Assessment Parameters" section. Recruitment was assumed to be "knife-edge", and age of recruitment was estimated at 10 years as discussed in the "Assessment Parameters" section. Yields were calculated using an exploitable biomass of 56,336 mt for dusky rockfish from section 7.4.2, "Current Exploitable Biomass". The computed reference values of F and another reference value, F=M, are listed in the following table, along with their corresponding yields.

	$F_{30\%}$	$F_{35\%}$	$F_{40\%}$	F=M
Reference value	0.169	0.136	0.110	0.090
Yield (mt)	9,521	7,662	6,197	5,070

7.5 ACCEPTABLE BIOLOGICAL CATCH

In previous stock assessments, acceptable biological catch (ABC) of pelagic shelf rockfish was estimated using the most conservative of the reference values listed above, F=M (Clausen and Heifetz 1991, 1992, 1993, 1994, and 1995). In this strategy, which was originally based on the NPFMC's old (pre-1996) definitions for overfishing and ABC, the annual exploitation rate for the assemblage was set equal to the rate of natural mortality for dusky rockfish, 0.09. New definitions for overfishing and ABC were established in 1996, and these were revised in 1999. As described below in section 7.6, "Overfishing Definition", dusky rockfish falls into tier 4 of the current definitions, in which the fishing rate that determines ABC is required to be less than or equal to $F_{40\%}$. This new definition theoretically allows a somewhat higher ABC than the old (pre-1996) definition, as shown by the yields in the preceding section (compare the yield for $F_{40\%}$, 6,197 mt, with that for F=M, 5,070 mt). However, because of the uncertainty of the biomass estimates for dusky rockfish that was previously discussed in section 7.3.2.1, and the resultant lack of knowledge about the real trend in stock abundance for these fish, we opted to stay with the more conservative F=M approach in the last six assessments (Clausen and Heifetz 1996, 1997, 1998, 1999, 2000, and 2001). We recommend again using F=M for computing the 2003 ABC. Thus, multiplying the current estimate of exploitable biomass for dusky rockfish (56,336 mt; see previous section 7.4.2) by an M of 0.09 yields an ABC of 5,070 mt in 2003 for this species in the Gulf of Alaska.

Before last year's SAFE report, widow and yellowtail rockfish were always lumped with dusky rockfish in the ABC computations. Exploitable biomass of widow and yellowtail rockfish was multiplied by 0.09 to determine ABC, identical to the procedure used for dusky rockfish. In effect, this meant that all three species were treated as "tier 4" species. According to the 1999 overfishing definitions, however, widow and yellowtail rockfish should be assigned to tier 5, because $F_{35\%}$ and $F_{40\%}$ are unknown for these species in Alaska. In tier 5, F_{ABC} is defined to be <=0.75 x M . To correct this error of treating widow and yellowtail

rockfish as tier 4 species, in last year's SAFE report we recommended that ABC for these two fish be computed separately from dusky rockfish, and that the tier 5 formula be applied to widow and yellowtail rockfish. If we assume an M of 0.09 for the two species (the same M as used for dusky rockfish), F_{ABC} is then 0.75 x M, which equals 0.0675. Multiplying this value of F by the current exploitable biomass for widow and yellowtail rockfish (6,153 mt; see previous section 7.4.2) yields an ABC of 415 mt for 2003.

Therefore, our recommended overall ABC in 2003 for the pelagic shelf rockfish assemblage in the Gulf of Alaska is 5,070 mt + 415 mt = 5,485 mt. This same ABC was recommended for 2002 in last year's assessment.

In all previous years, annual allocation of the Gulfwide ABC for pelagic shelf rockfish amongst the three regulatory areas in the Gulf has been based on the geographic distribution of pelagic shelf rockfish biomass in the trawl surveys. Since the 1996 SAFE report, this distribution has been computed as a weighted average of the percent biomass distribution for each area in the three most recent trawl surveys. In the computations, each successive survey is given a progressively heavier weighting using factors of 4, 6, and 9, respectively. This 4:6:9 weighting scheme was originally recommended by the Gulf of Alaska Groundfish Plan Team, and had already been used for Pacific ocean perch in the 1996 fishery (for a rationale, see section 6.7.1 of the slope rockfish report in this document). The Plan Team believed that for consistency among the rockfish assessments, the same weighting should be applied to pelagic shelf rockfish. The Plan Team's scheme was adopted for the 1997 fishery, and we have continued to follow it. Therefore, based on a 4:6:9 weighting of the 1996, 1999, and 2001 trawl surveys, the percent distribution of pelagic shelf rockfish biomass in the Gulf of Alaska is: Western area, 9.33%; Central area, 63.36%, and Eastern area, 27.30%. Applying these percentages to the overall recommended ABC of 5,485 mt yields the following apportionments for the Gulf in 2002: Western area, 512 mt; Central area, 3,475 mt; and Eastern area, 1,498 mt.

7.6 OVERFISHING DEFINITION

In 1990, the NPFMC adopted a policy to prevent overfishing by requiring that fishing mortality for any stock should not exceed a prescribed maximum rate. For any given stock, a specific rate of overfishing (F_{OFL}) was defined based on the amount of population dynamics information available for the stock. In June 1996, the NPFMC approved a revised series of overfishing definitions, and these definitions were further revised in January 1999. The 1999 definitions specify that for a species such as dusky rockfish, where estimates of biomass, $F_{35\%}$, and $F_{40\%}$ are the only parameters known (i.e., tier 4 in the definitions), F_{OFL} is defined to be the $F_{35\%}$ level. The definitions also state that the fishing rate that determines ABC (F_{ABC}) should be less than or equal to $F_{40\%}$. As shown previously in the "Reference Fishing Mortality Rates and Yields" section, $F_{35\%}$ is computed to be 0.136, and $F_{40\%}$ is 0.110. These rates correspond to Gulfwide yields of 7,662 mt for overfishing and 6,197 mt for ABC, respectively. Thus, the ABC recommendation of 5,070 mt in this report for dusky rockfish in the Gulf of Alaska is consistent with the NPFMC definition because it is less than the maximum allowable ABC of 6,197 mt.

As described in Section 7.5, widow and yellowtail rockfish fall into tier 5 of the overfishing definitions, in which estimates of biomass and natural rate of mortality (M) are the only parameters known. (M is not really known for these species in Alaska, but the M for dusky rockfish, 0.09, appears to be a reasonable approximation of M for the two species.) For tier 5 species, F_{OFL} is defined to equal M, and F_{ABC} is <= 0.75 x M. These rates equate to 0.09 and 0.0675, respectively, and correspond to Gulfwide yields of 554 mt and 415 mt.

The total level of overfishing for the assemblage in the Gulf of Alaska equals the overfishing level of 7,662 mt for dusky rockfish plus the overfishing level of 554 mt for widow and yellowtail rockfish, which totals 8,216 mt.

7.7 HARVEST SCENARIOS TO SATISFY REQUIREMENTS OF NPFMC's AMENDMENT 56, NEPA, AND MSFCMA

To satisfy requirements of the NPFMC's Amendment 56, the National Environmental Policy Act (NEPA), and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), all stock assessments have been asked to provide a set of seven harvest scenarios for future years. For species that are assessed using an age/length-structured model (tiers 1, 2, or 3 in the overfishing definitions), these scenarios can take the form of multi-year projections. For species such as pelagic shelf rockfish that are not modeled (tier 4 or higher), such projections are not possible, but yields for just the year 2003 can be computed for scenarios 1-5 as follows:

(Note: all the computed yields are based on an exploitable biomass of 62,489 mt in 2003.)

Scenario 1: F equals the maximum permissible F_{ABC} as specified in the ABC/OFL definitions. For tier 4 species such as dusky rockfish, the maximum permissible F_{ABC} is $F_{40\%}$. $F_{40\%}$ equals 0.110, and the corresponding yield is 6,197 mt. For tier 5 species such as widow and yellowtail rockfish, the maximum permissible F_{ABC} is 0.75 x M, and the corresponding yield is 415 mt. Total yield for the assemblage would be 6,197 mt + 415 mt = 6,612 mt.

Scenario 2: F equals the stock assessment author's recommended F_{ABC}. In this assessment, the recommended F_{ABC} for dusky rockfish is F=M=0.09, and the recommended F_{ABC} for widow and yellowtail rockfish is F = 0.75 x M. Corresponding yields are 5,070 mt and 415 mt, respectively, which equals a total of 5,485 mt for the entire assemblage.

Scenario 3: F equals the 5-year average F from 1997 to 2001. Using the catch data for these years in Table 7-1 (excluding estimated catches of black and blue rockfish in 1997) and annual exploitable biomass estimates for the assemblage, the average F for 1996 to 2001 is 0.055719, and the corresponding yield is 3,482 mt.

Scenario 4: F equals 50% of the maximum permissible F_{ABC} as specified in the ABC/OFL definitions. For dusky rockfish, 50% of $F_{40\%}$ (the maximum permissible F_{ABC}) is 0.055, and the corresponding yield is 3,098 mt. For widow and yellowtail rockfish, 50% of 0.75 x M (the maximum permissible F_{ABC}) is 0.0338, and the corresponding yield is 208 mt. Total yield for the entire assemblage under this scenario is 3,098 mt + 208 mt = 3,306 mt .

Scenario 5: F equals 0. Corresponding yield is 0.

7.8 OTHER CONSIDERATIONS

7.8.1 Management Problems Involving Dark Dusky Rockfish

Although black and blue rockfish have been removed from the pelagic shelf assemblage, one management problem that remains is the taxonomic uncertainty of dusky rockfish. The inshore habitat of dark dusky rockfish is one that this variety shares with black and blue rockfish. This suggests that from a biological perspective, it may be more logical for dark dusky rockfish to be grouped with the latter two species, rather

than in the pelagic shelf assemblage. Moreover, information from ADF&G indicates that in past years a sizeable portion (perhaps 25%) of the fish reported as "black rockfish" in the Kenai Peninsula jig fishery may have actually been dark dusky rockfish.[7] Dark dusky rockfish and black rockfish often co-occur in nearshore kelp beds of the Gulf of Alaska, and they are superficially similar in appearance, especially in body color, which leads to misidentification. As already mentioned, however, no definitive taxonomic studies have been completed that would separate the light and dark varieties of dusky rockfish into distinct species. Until results of such studies are available, we recommend for the interim that both forms of dusky rockfish remain in the pelagic shelf assemblage. In the future, if dark dusky rockfish is found to be a valid species, it may be appropriate to consider its removal from the assemblage and transfer to state jurisdiction, similar to what has been done for black and blue rockfish.

7.9 ECOSYSTEM CONSIDERATIONS

In general, a determination of ecosystem considerations for pelagic shelf rockfish is hampered by the lack of biological and habitat information for dusky rockfish. A summary of the ecosystem considerations presented in this section is listed in Table 7-4.

7.9.1 Ecosystem Effects on the Stock

Prey availability/abundance trends: similar to many other rockfish species, stock condition of dusky rockfish appears to be greatly influenced by periodic abundant year classes. Availability of suitable zooplankton prey items in sufficient quantity for larval or post-larval dusky rockfish may be an important determining factor of year class strength. Unfortunately, there is no information on the food habits of larval or post-larval rockfish to help determine possible relationships between prey availability and year class strength; moreover, field-collected larval dusky rockfish at present cannot even be visually identified to species. Adult dusky rockfish consume mostly euphausiids (Yang 1990). Euphausiids are also a major item in the diet of walleye pollock, Pacific ocean perch, and northern rockfish. Changes in the abundance of these three species could lead to a corollary change in the availability of euphausiids, which would then have an impact on dusky rockfish.

Predator population trends: there is no documentation of predation on dusky rockfish. Larger fish such as Pacific halibut that are known to prey on other rockfish may also prey on adult dusky rockfish, but such predation probably does not have a substantial impact on stock condition. Predator effects would likely be more important on larval, post-larval, and small juvenile dusky rockfish, but information on these life stages and their predators is nil.

Changes in physical environment: strong year classes corresponding to the period 1976-77 have been reported for many species of groundfish in the Gulf of Alaska, including walleye pollock, Pacific ocean perch, northern rockfish, sablefish, and Pacific cod. As discussed in Section 7.3.2.3, age data for dusky rockfish indicates that the 1976 and/or 1977 year classes were also usually strong for this species. Therefore, it appears that environmental conditions may have changed during this period in such a way that survival of young-of-the-year fish increased for many groundfish species, including dusky rockfish. The environmental mechanism for this increased survival of dusky rockfish, however, remains unknown. Pacific ocean perch and dusky rockfish both appeared to have strong 1986 year classes, and this may be another year when environmental conditions were especially favorable for rockfish species.

[7] W. Bechtol, Alaska Department of Fish and Game, 3298 Douglas St., Homer, AK 99603. Pers. commun. August 1995.

7.9.2 Fishery Effects on the Ecosystem

Fishery-specific contribution to bycatch of HAPC biota: there is limited habitat information on adult dusky rockfish, especially regarding the habitat of the major fishing grounds for this species in the Gulf of Alaska. Nearly all the catch of dusky rockfish, however, is taken by bottom trawls, so the fishery potentially could affect HAPC biota such as corals or sponges if it occurred in localities inhabited by those biota. Corals and sponges are usually found on hard, rocky substrates, and there is some evidence that dusky rockfish may be found in such habitats. On submersible dives on the outer continental shelf of the eastern Gulf of Alaska, light dusky rockfish were observed in association with rocky habitats and in areas with extensive sponge beds, where the fish were observed resting in large vase-type sponges.[8] Also, dusky rockfish often co-occur and are caught with northern rockfish in the commercial fishery and in trawl surveys (Reuter 1999), and there is information to suggest that northern rockfish are associated with a rocky or rough bottom habitat (Clausen and Heifetz 2002). Based on this indirect evidence, it can be surmised that dusky rockfish are likely also associated with a rocky substrate. An analysis of bycatch of HAPC biota in commercial fisheries in the Gulf of Alaska in 1997-99 indicated that the dusky rockfish trawl fishery ranked fourth (after the deepwater flatfish, walleye pollock, and Pacific ocean perch bottom trawl fisheries) among all fisheries in the amount of corals taken as bycatch and sixth in the amount of sponges taken (National Marine Fisheries Service 2001). Little is known, however, about the extent of these HAPC biota and whether the bycatch is detrimental.

Fishery-specific concentration of target catch in space and time relative to predator needs in space and time (if known) and relative to spawning components: the dusky rockfish trawl fishery in the Gulf of Alaska starts in July and usually lasts only a few weeks. As mentioned previously in section 7.2.2, the fishery is concentrated at a number of offshore banks on the outer continental shelf. There is no published information on time of year of insemination or parturition (larval release), but insemination is likely in the fall or winter, and anecdotal observations indicate parturition is mostly in the spring. Hence, reproductive activities are probably not directly affected by the commercial fishery.

Fishery-specific effects on amount of large size target fish: a comparison between Figure 7-1 (length frequency in the commercial fishery) and Figure 7-4 (size composition in the trawl surveys) suggests that although the fishery does not catch many small fish <40 cm length, neither does it particularly target on very large fish.

Fishery contribution to discards and offal production: fishery discard rates of pelagic shelf rockfish have been quite low in recent years, as they have averaged only about 6% in the period 1997-2002. The discard amount of species other than pelagic shelf rockfish in the dusky rockfish fishery is unknown.

Fishery-specific effects on age-at-maturity and fecundity of the target fishery: unknown, but based on the size of 50% maturity of female dusky rockfish reported in this document (42.8 cm), the fishery length frequency distributions in Figure 7-1 suggest that in some years the fishery may be catching a sizeable number of immature fish.

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

7.9.3 Data Gaps and Research Priorities

There is no information on larval, post-larval, or early stage juvenile dusky rockfish. Larval dusky rockfish cannot even be identified in plankton samples except by using genetic techniques, which are very high in cost

[8] V.M. O'Connell, Alaska Dept. of Fish and Game, 304 Lake St., Sitka, AK 99835. Pers. commun. July 1997.

and manpower. Habitat requirements for larval, post-larval, and early stage juvenile dusky rockfish are completely unknown. Habitat requirements for later stage juvenile and adult fish are anecdotal or conjectural. Research needs to be done on the bottom habitat of the major fishing grounds, on what HAPC biota are found on these grounds, and on what impact bottom trawling has on these biota.

7.10 SUMMARY

A summary table of the natural mortality rate (M), biomass, exploitation rates, OFL, and recommended ABC for pelagic shelf rockfish is presented below:

M	current exploitable biomass (mt)	F_{OFL}	maximum allowable F_{ABC}	recommended F_{ABC}	OFL (mt)	recommended ABC (mt)
			Dusky rockfish			
0.090	56,336	0.136	0.110	0.090	7,662	5,070
			Widow and yellowtail rockfish			
0.090	6,153	0.090	0.068	0.068	554	415
			Entire pelagic shelf rockfish assemblage			
0.090	62,498	-	-	-	8,216	5,485

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Table 7-1a.--Commercial catch[a] (mt) of fish in the pelagic shelf rockfish assemblage in the Gulf of Alaska, with Gulfwide values of acceptable biological catch (ABC) and total allowable catch (TAC), 1988-2002. Updated through October 5, 2002.

Year	Category	Regulatory Area[b]					Gulfwide Total	Gulfwide ABC	Gulfwide TAC
		Western	Central	Eastern	West Yakutat[c]	Southeast Outside[d]			
1988	Foreign	0	0	0	-	-	0		
	U.S.	400	517	168	-	-	1,085		
	JV	Tr	1	0	-	-	1		
	Total	400	518	168	-	-	1,086	3,300	3,300
1989	U.S.	113	888	737	-	-	1,738	6,600	3,300
1990	U.S.	165	955	527	-	-	1,647	8,200	8,200
1991	U.S.	215	1,191	936	-	-	2,342	4,800	4,800
1992	U.S.	105	2,622	887	-	-	3,605	6,886	6,886
1993	U.S.	238	2,061	894	-	-	3,193	6,740	6,740
1994	U.S.	290	1,702	997	-	-	2,989	6,890	6,890
1995	U.S.	108	2,247	536	471	64	2,891	5,190	5,190
1996	U.S.	182	1,849	265	190	75	2,296	5,190	5,190
1997	U.S.	96	1,959	574	536	38	2,629	5,140	5,140
1998	U.S.	60	2,477	576	553	22	3,113	4,880	4,880
1999	U.S.	130	3,835	694	672	22	4,659	4,880	4,880
2000	U.S.	190	3,074	467	445	22	3,731	5,980	5,980
2001	U.S.	121	2,436	451	439	12	3,008	5,980	5,980
2002	U.S.	181	2,670	452	448	4	3,303	5,490	5,490

[a]Catches for 1988-97 include black rockfish and blue rockfish, which were members of the assemblage during those years.
[b]Catches for West Yakutat and Southeast Outside areas are not available for years before 1996. Eastern area is comprised of the West Yakutat and Southeast Outside areas combined.
[c]West Yakutat area is comprised of statistical areas 640 and 649.
[d]Southeast Outside area is comprised of statistical areas 650 and 659.

Notes: There were no foreign or joint venture catches after 1988. Catches in 1988 are landed catches only. Catches in 1989-91 also include fish reported in weekly production reports as discarded by fishermen or processors. Catches in 1992-2002 also include discarded fish, as determined through a "blend" of weekly production reports and information from the domestic observer program.

Definition of terms: JV = joint venture production; U.S. = domestic annual production; Tr = trace catches.

Sources: Catch: 1988, Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW 5th. Avenue, Portland, OR 97201; 1989-2002, National Marine Fisheries Service, Alaska Region, P.O. Box 21668, Juneau, AK 99802-1668. ABC and TAC: 1988-2001, Clausen and Heifetz (2001); 2002, North Pacific Fishery Management Council News and Notes, Vol. 6-01, December 2001. 605 W. 4th. Avenue, Suite 306, Anchorage, AK 99501-2252.

Table 7-1b.--Catch (mt) of pelagic shelf rockfish taken during research cruises in the Gulf of Alaska, 1977-2001. (Catches before 2002 do not include longline surveys; tr=trace)

Year	Catch
1977	0.4
1978	0.5
1979	0.9
1980	0.2
1981	7.4
1982	1.0
1983	0.5
1984	6.5
1985	6.8
1986	0.3
1987	34.4
1988	0.0
1989	0.1
1990	4.8
1991	0.0
1992	tr
1993	6.8
1994	0.0
1995	0.0
1996	7.4
1997	0.0
1998	2.5
1999	6.7
2000	0.0
2001	2.7
2002	tr

Table 7-2.--Biomass estimates (mt) for species in the pelagic shelf rockfish assemblage in the Gulf of Alaska, based on results of the 1984, 1987, 1990, 1993, 1996, 1999, and 2001 trawl surveys.

	Statistical Area					
Species	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern	Total
			1984			
Dusky rockfish	3,843	7,462	4,329	15,126	307	31,068
Yellowtail rockfish	0	0	0	17	454	471
Total, all species	3,843	7,462	4,329	15,143	761	31,539
			1987			
Dusky rockfish	12,011	4,036	46,005	18,346	1,097	81,494
Widow rockfish	0	0	0	51	96	147
Total, all species	12,011	4,036	46,005	18,397	1,193	81,641
			1990			
Dusky rockfish	2,963	1,233	16,779	5,808	953	27,735
Widow rockfish	0	0	0	285	0	285
Total, all species	2,963	1,233	16,779	6,093	953	28,020
			1993			
Dusky rockfish	11,450	12,880	23,780	7,481	1,626	57,217
Total, all species	11,450	12,880	23,780	7,481	1,626	57,217
			1996			
Light dusky rockfish	3,553	19,217	36,037	14,193	1,480	74,480
Dark dusky rockfish	152	139	59	0	0	350
Widow rockfish	0	10	0	0	919	929
Yellowtail rockfish	0	0	20	0	65	85
Total, all species	3,704	19,366	36,116	14,193	2,464	75,843
			1999			
Light dusky rockfish	2,538	9,157	33,729	2,097	2,108	49,628
Dark dusky rockfish	2,130	31	49	0	0	2,211
Widow rockfish	0	0	69	0	115	184
Yellowtail rockfish	0	0	0	162	12,509	12,671
Total, all species	4,668	9,188	33,847	2,259	14,732	64,694
			2001			
Light dusky rockfish	5,587	2,062	24,594	7,924[a]	1,738[a]	41,905[a]
Dark dusky rockfish	383	15	36	0[a]	0[a]	434[a]
Widow rockfish	0	0	0	0[a]	345[a]	345[a]
Yellowtail rockfish	0	0	0	54[a]	4,192[a]	4,245[a]
Total, all species	5,970	2,077	24,630	7,978[a]	6,275[a]	46,929[a]

[a]Note: The Yakutat and Southeastern areas were not sampled in the 2001 survey. Estimates of biomass for these two areas in 2001 were obtained by averaging the corresponding area biomasses in the 1993, 1996, and 1999 surveys.

Table 7-3.--Instantaneous rate of mortality and maximum age for pelagic shelf rockfish, based on the break-and-burn method of aging otoliths. Area indicates location of study: Gulf of Alaska (GOA) or British Columbia (BC).

Species	Mortality rate	Maximum age	Area	Reference
Dusky rockfish	0.09[a]	59	GOA	1
		51	GOA	2
Yellowtail rockfish	0.06-0.14[b]	64	BC	3, 4
Widow rockfish	0.05[b]	59	BC	4

[a]Instantaneous rate of natural mortality (M).
[b]Instantaneous rate of total mortality (Z).

References: 1) Clausen and Heifetz (1996); 2) Clausen and Heifetz (2001); 3) Archibald et al. (1981); 4) Chilton and Beamish (1982).

Table 7-4.-- Analysis of ecosystem considerations for pelagic shelf rockfish and the dusky rockfish fishery.

Indicator	*Observation*	*Interpretation*	*Evaluation*
ECOSYSTEM EFFECTS ON STOCK			
Prey availability or abundance trends	important for larval and post-larval survival, but no information known	may help to determine year class strength	possible concern if some information available
Predator population trends	unknown		little concern for adults
Changes in habitat quality	variable	variable recruitment	possible concern
FISHERY EFFECTS ON ECOSYSTEM			
Fishery contribution to bycatch			
Prohibited species	unknown		
Forage (including herring, Atka mackerel, cod, and pollock)	unknown		
HAPC biota (seapens/whips, corals, sponges, anemones)	fishery may affect hard-bottom biota, i.e., corals, sponges	could harm the ecosystem by reducing shelter for some species	possible concern
Marine mammals and birds	probably few taken		little concern
Sensitive non-target species	unknown		
Fishery concentration in space and time	little overlap between fishery and reproductive activities	fishery does not hinder reproduction	little concern
Fishery effects on amount of large size target fish	no evidence for targeting large fish	large fish and small fish are both in population	little concern
Fishery contribution to discards and offal production	discard rates small for pelagic shelf rockfish	little unnatural input of food into the ecosystem	little concern
Fishery effects on age-at-maturity and fecundity	**fishery may be catching some immature fish**	**could reduce spawning potential and yield**	possible concern

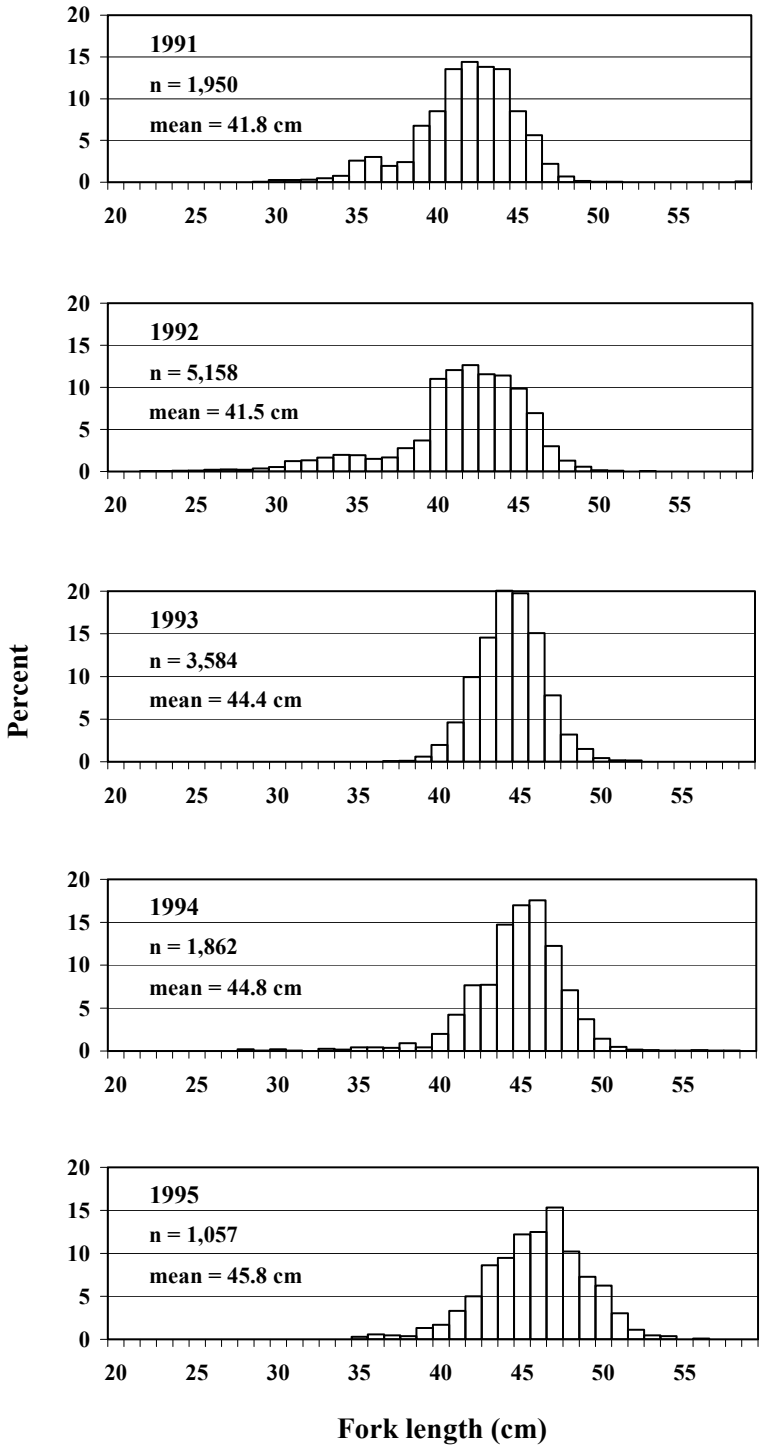

Figure 7-1.--Raw length frequency distribution of dusky rockfish measured by observers in the Gulf of Alaska commercial fishery, 1991-2001 (continued on next two pages).

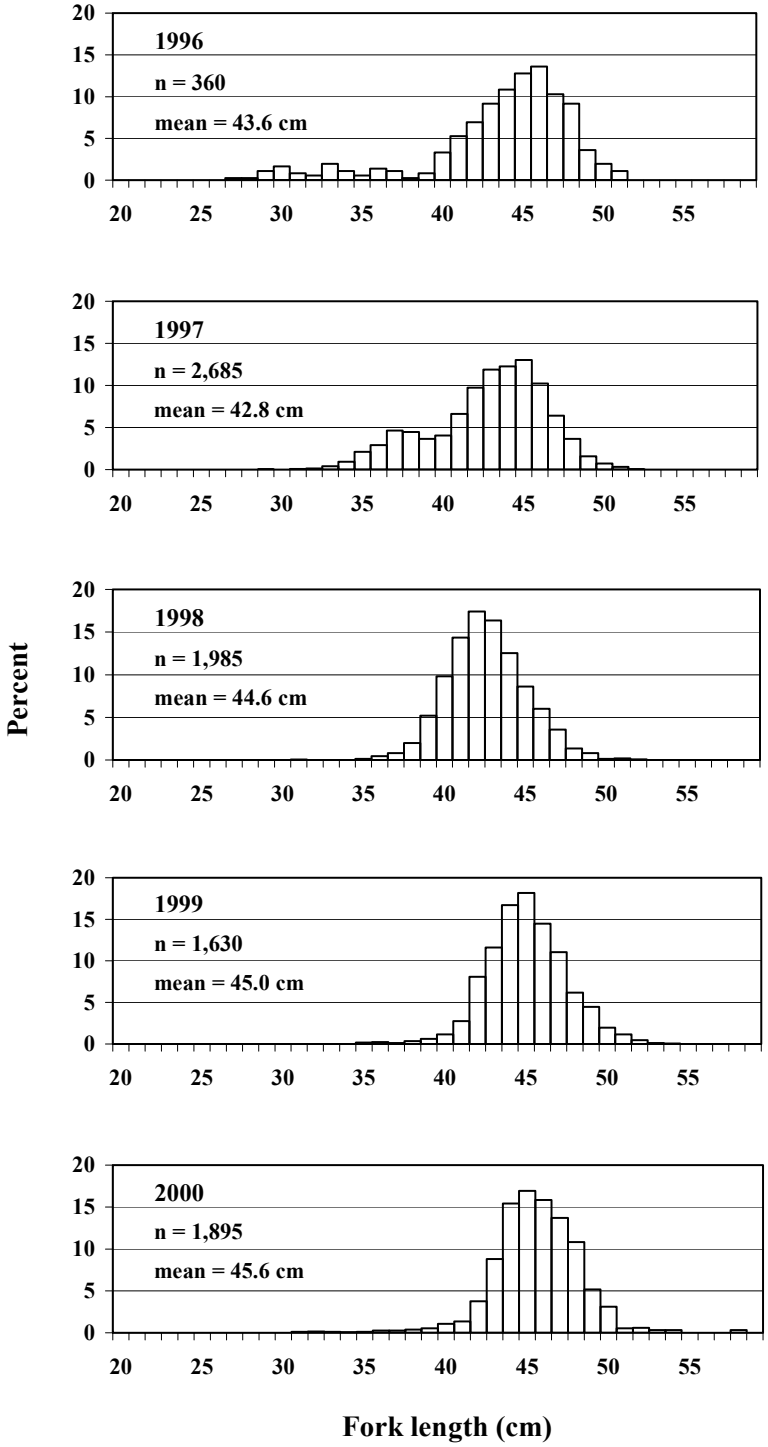

Figure 7-1.--(continued).

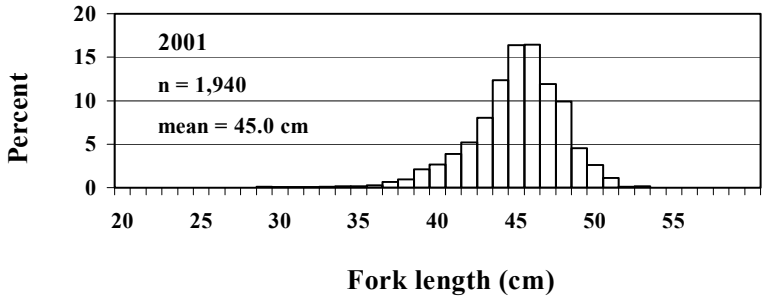

Figure 7-1.--(continued).

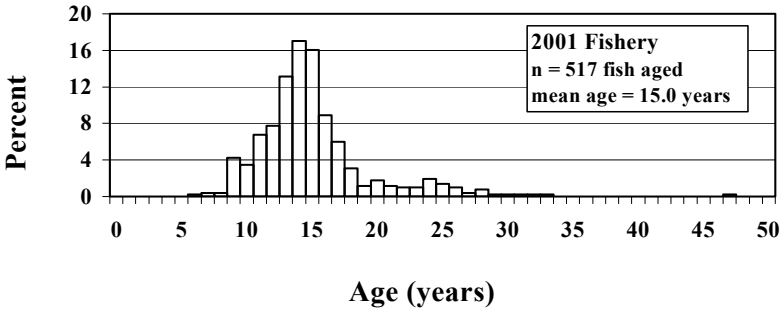

Figure 7-2.--Raw age distribution of light dusky rockfish sampled in the 2001 Gulf of Alaska commercial fishery.

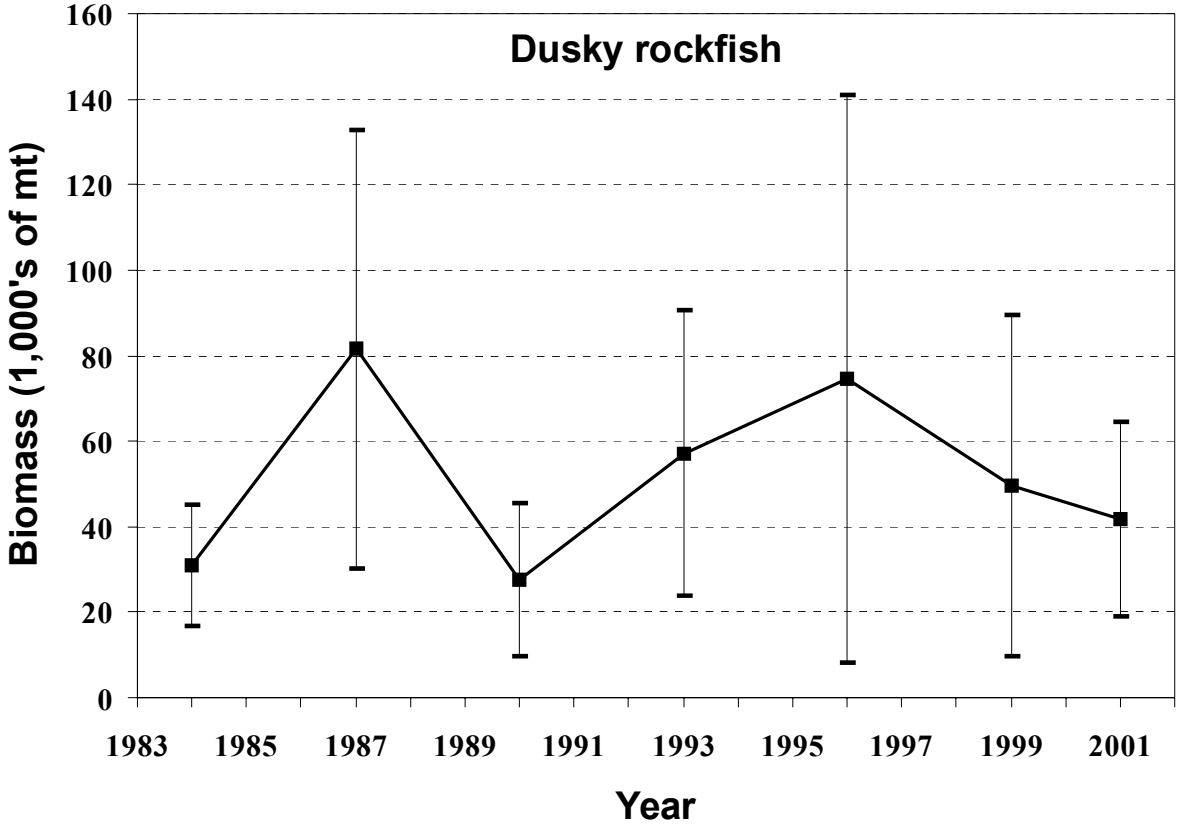

Figure 7-3.--Estimated biomass of dusky rockfish in the Gulf of Alaska based on results of the 1984, 1987, 1990, 1996, 1999, and 2001 trawl surveys. The vertical bars show the 95% confidence limits associated with each estimate. The eastern Gulf of Alaska was not sampled in the 2001 survey, but substitute estimates of biomass and variance for this region in 2001 were calculated and included in the above graph. See Section 7.4.2 of this report for an explanation of the substitute biomass calculations. To determine 95% confidence intervals for 2001, variance for the eastern Gulf of Alaska was computed using this formula: (variance of 1993, 1996, and 1999 biomass estimates in this region) x (1 + 1/3).

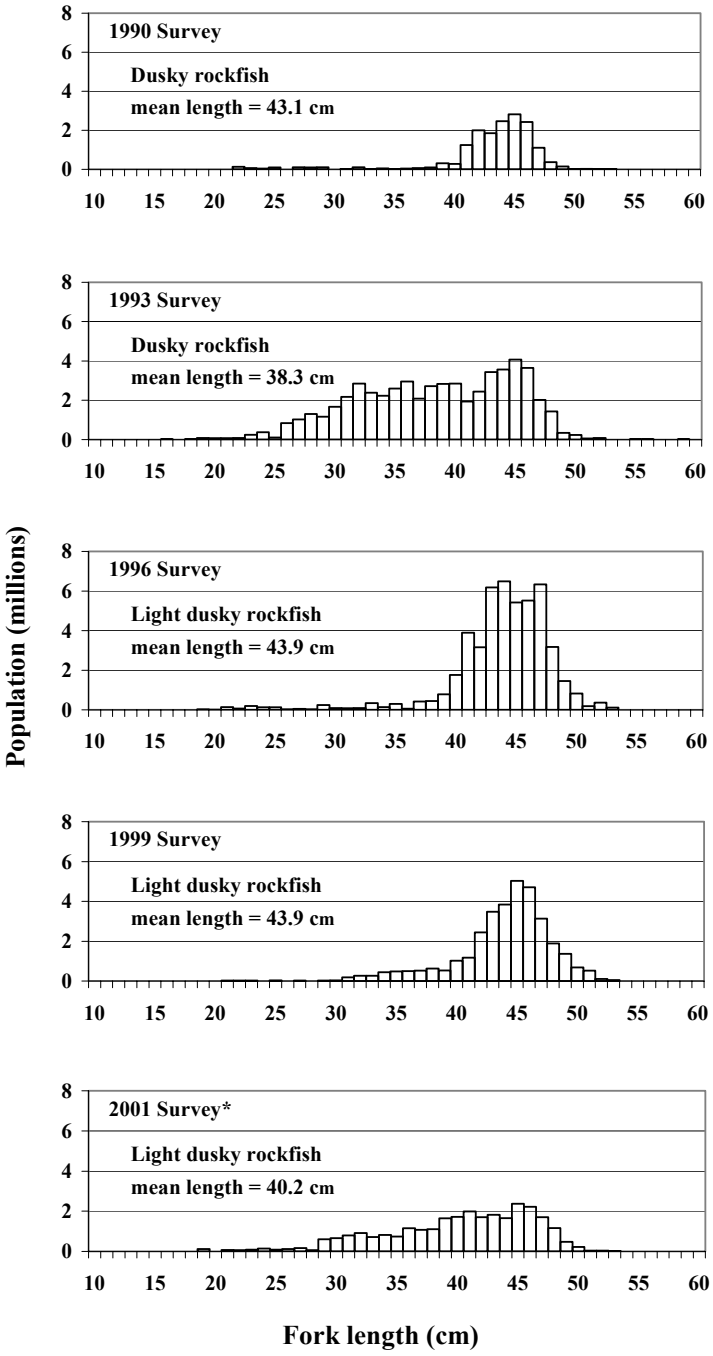

Figure 7-4.--Length frequency distribution of the estimated population of dusky rockfish in the Gulf of Alaska, based on the 1990, 1993, 1996, 1999, and 2001 trawl surveys. The 1996, 1999, and 2001 distribution only includes data for the light-colored variety of dusky rockfish; in the 1990 and 1993 distribution, variety of dusky rockfish is unknown, but nearly all (>99%) are thought to be the light variety. *The eastern Gulf of Alaska was not sampled in the 2001 survey.

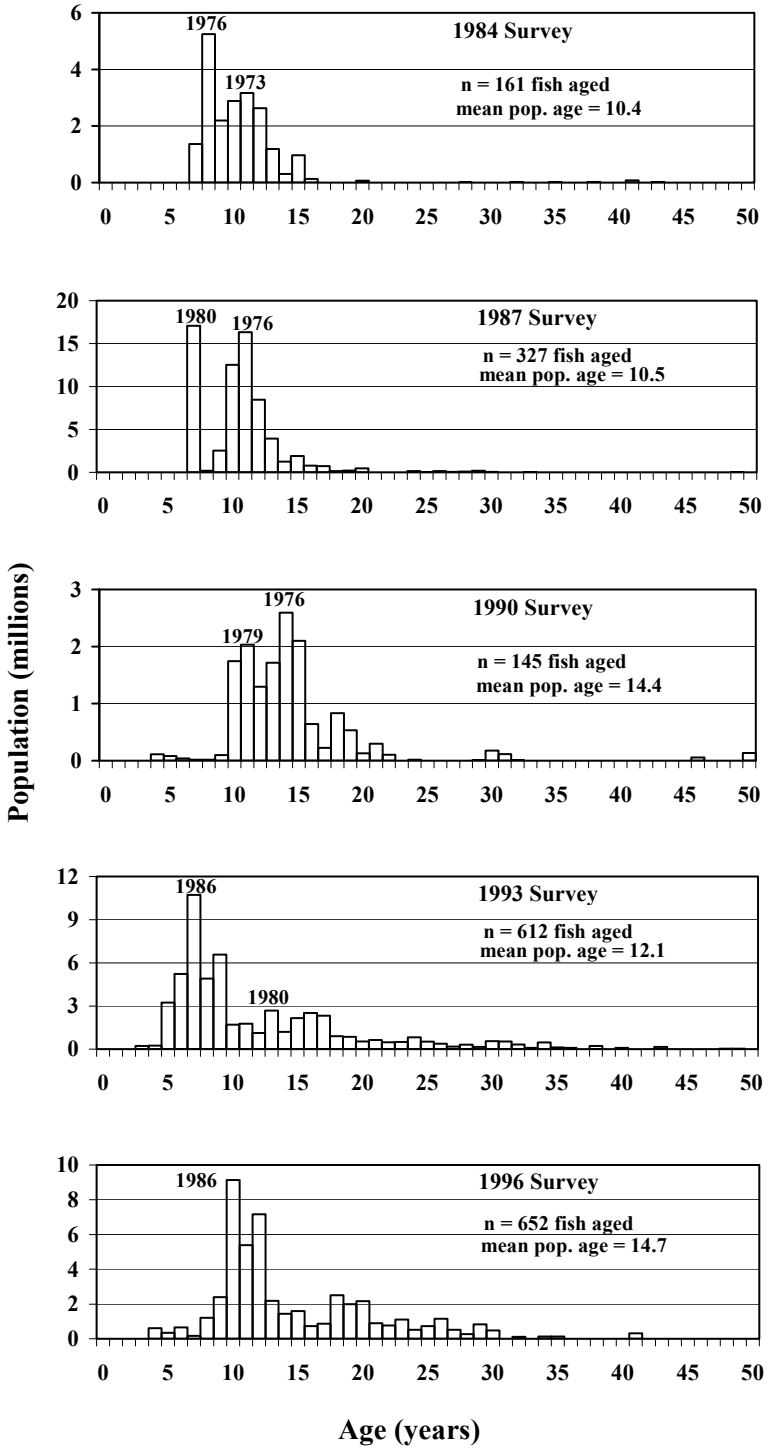

Figure 7-5.--Age composition of the estimated population of dusky rockfish in the Gulf of Alaska, based on the 1984, 1987, 1990, 1993, 1996, and 1999 trawl surveys. The numbers next to prominent bars identify possibly strong year classes. (Figure continued on next page.)

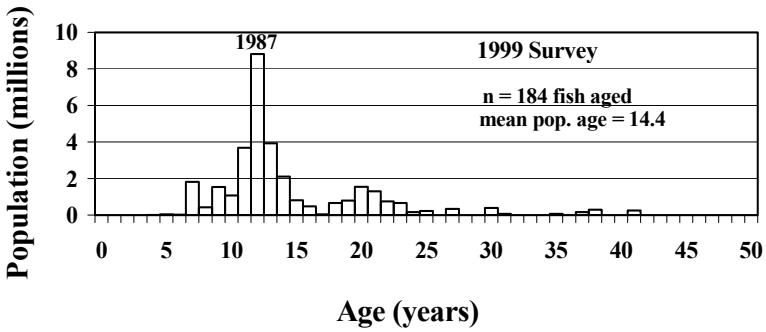

Figure 7-5--(continued).

Chapter 7, Appendix A.

Dusky Rockfish Age-Structured Model

by
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Overview

For dusky rockfish (*Sebastes ciliatus*), we explored the use of a generic rockfish model template developed in a modeling workshop held at the Auke Bay Laboratory in February 2001[9]. The model was constructed with AD Model Builder software. The template is a simple age-structured model with allowance for size composition data that is adaptable to several rockfish species. Several alternate model configurations were explored. Here we present the base model which set the likelihood emphasis factors equal to 1(except for catch, which was set equal to 100) and restricted the prior on the coefficient of variation of catchability q. Restricting the prior forces the model to estimate a q close to 1. While we expect substantial refinements to the model will be made next year, the base model presented here represents a working model that provides reasonable fits to the data while incorporating all of the available dusky rockfish data through 2002.

Base Model Structure

The rockfish model template is a modification of the northern rockfish model used in 1999 (Courtney et al. 1999). The model's starting point is 1977 and contains all available data. The data sets used in the dusky rockfish model included total fishery catch for the years 1977-2002, size compositions from the fishery for 1990-2002, survey age compositions for 1984, 87, 90, 93, 96 and 99, survey size compositions for 1984, 87, 90, 93, 96, 99, and 2001, fishery age composition for 2001, and survey biomass estimates for 1984, 87, 90, 93, 96, 99, and 2001. Life-history parameters including natural mortality (m), proportion mature at age, and weight at age were taken from the 2001 Pelagic Shelf Rockfish SAFE Document (Clausen and Heifetz, 2001). Size compositions were organized into twenty-nine length bins (15-46+cm) and age data into 29 age bins with a recruitment age of 3 years (3-31+ years). The size-age transition matrix came from a lognormal fit to the von Bertalanffy growth curve to length and age data collected from triennial trawl surveys with parameter estimates from Malecha and Heifetz (2000). The age error transition matrix was constructed by assuming the same age determination error found for northern rockfish (Courtney et al. 1999).

Base Model Results

Our base model was run with all data components given a likelihood weight of 1. The only exception was that the likelihood weight for catch was set at 100 because we assume our estimates of catch are accurate. Figure 1 summarizes the results from the base model. For this base model the fit to survey biomass was questionable for the more recent surveys. Model fits to survey age compositions (Figure 2) attempt to track a fairly strong year class from 1984-1990 that weakens in the observed ages in the 1993 survey. Survey size distributions (Figure 3) and fishery size distributions (Figure 4) appear to increase in length and contract in range over time. We believe some of this change over time may be due to the separation of dark dusky rockfish from light dusky rockfish in later years. Beginning in 1996, dark dusky and light dusky rockfish were treated as separate species in the survey data collection procedures. Low numbers of dark dusky rockfish are generally caught in the survey but there are likely larger numbers of dark dusky represented in the fishery length data. In the future we hope to explore the uncertainty in the fits of age and length data for both the survey and the fishery and possibly increase the likelihood values for these which should improve the model fits.

We compared the base model results to results from a model run using the likelihood values taken from the northern rockfish age-structured model used for the northern rockfish assessment in 2001. The northern

[9] Rockfish Modeling Workshop, NMFS Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK. February, 2001.

rockfish model is nearly identical to the rockfish template model developed in 2001[10]. A comparison of model results is summarized in the following:

Model 1 - base model, all emphasis weights equal 1 and prior on q restricted near 1
Model 2 - Likelihood weights set equal to northern rockfish template model and prior on q restricted to near 1

	Model	
Likelihood Component	1 Base Model	2 Northern Template
	-ln likelihood	
Catch	0.31	1.39
Survey Biomass Index	13.3	12.07
Fishery Age Comp	8.58	2.71
Survey Age Comp	92.4	42.37
Fishery Size Comp	96.7	120.61
Total (unweighted)	211.4	179.17
Survey *q*	0.997	0.994
Current female spawning biomass (mt)	30,684	32,445
$F_{40\%}$	0.111	0.099
ABC (mt)	6,555	6,517

Results from Models 1 and 2 are similar. The difference in unweighted likelihoods is mostly due to a better fit in survey age compositions when using the likelihoods from the northern rockfish template. This is probably because of the higher likelihood weights placed on fishery age and survey age in the northern model. Both models resulted in similar ABC recommendations which are slightly higher than the actual ABC recommendation of 5,070 mt for 2003 (see previous section 7.5 in this report). The larger ABC projected by the model is not unexpected. Due to the uncertainty surrounding the survey biomass estimates, the current ABC recommendation is based on a conservative F=M strategy (which is less than the maximum allowable F for a tier 4 species such as dusky rockfish) and also on the exploitable biomass of only the last three surveys. The 1999 and 2001 biomass estimates are substantially lower than the previous survey estimate in 1996. The model attempts to fit all the survey information and therefore does not weight the 1999 and 2001 survey estimates as heavily as the current methodology for determining ABC.

For 2003, the base model will be explored further and model sensitivity to the likelihood weights will be explored. We hope to investigate the relationship between natural mortality *m* and catchability *q* and will attempt to allow the model to freely estimate *q*. The effects of the likelihoods will be explored using more in-depth analysis such as Monte Carlo Markov Chain (MCMC) modeling and simulations comparing the effects of one likelihood on other parameters in the model. For the 2003 Plan Team Meetings we hope to present a dusky rockfish ABC derived from the rockfish template model presented here.

[10]D. Courtney, National Marine Fishery Service, Alaska Fishery Science Center, Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801. Pers. observation, October 2002.

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Clausen, D. M., and J. Heifetz. 2001. Pelagic shelf rockfish. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 7-1 - 7-25. North Pacific Fishery Management Council, 605 W. 4th. Avenue, Suite 306, Anchorage, AK 99501-2252.

Courtney, D. L., J. Heifetz, M. F. Sigler, and D. M. Clausen. 1999. An age structured model of northern rockfish, *Sebastes polyspinis*, recruitment and biomass in the Gulf of Alaska. In Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska as projected for 2000, p. 361-404. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Malecha, P.W., and J. Heifetz. 2000. Growth and mortality of rockfish (Scorpaenidae) from Alaska waters. Unpubl. manuscr., 39 p. Available from the Auke Bay Laboratory, NMFS, NOAA, 11305 Glacier Hwy, Juneau, AK 99801.

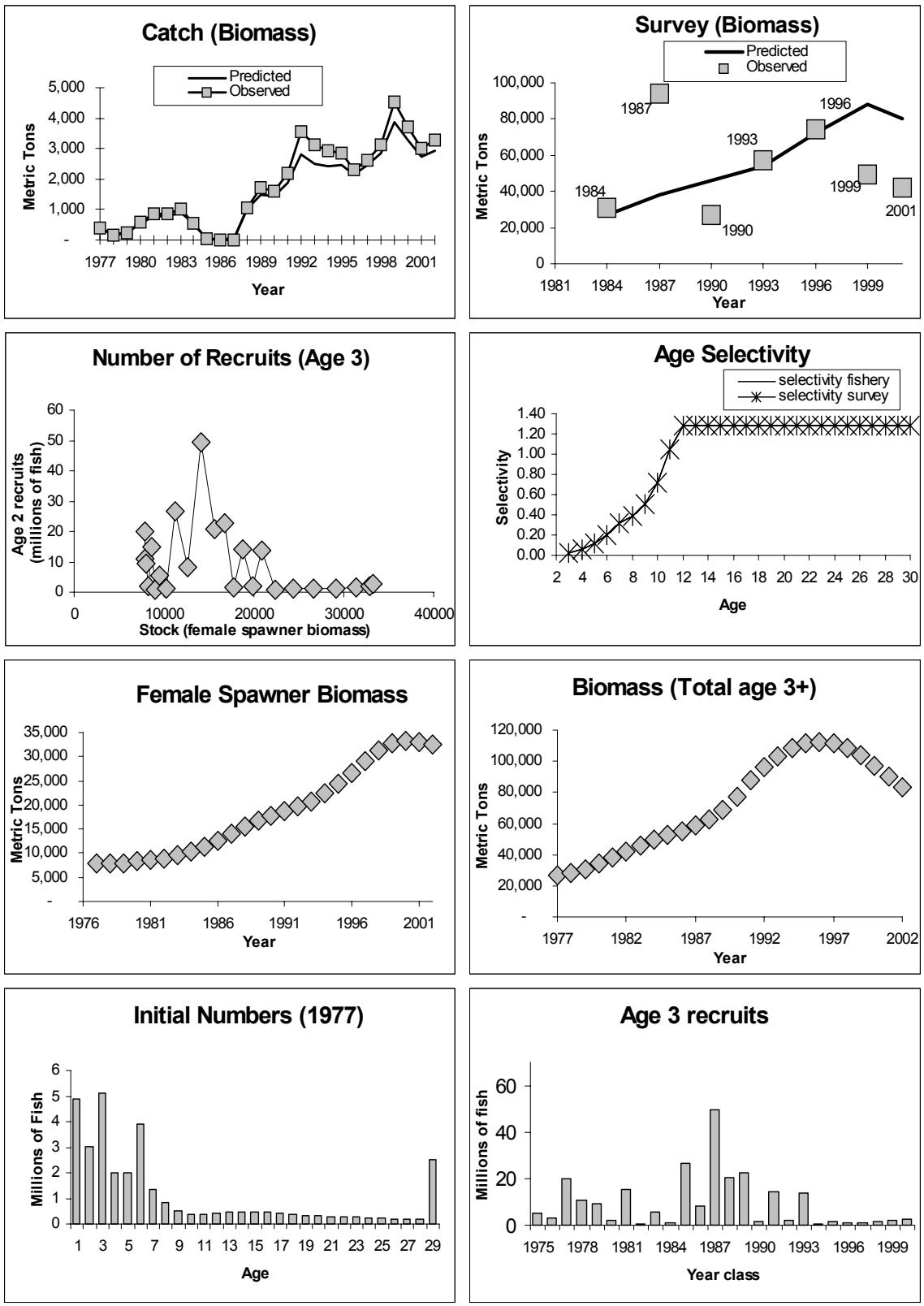

Figure 9. Dusky rockfish age-structured model output data for base model.

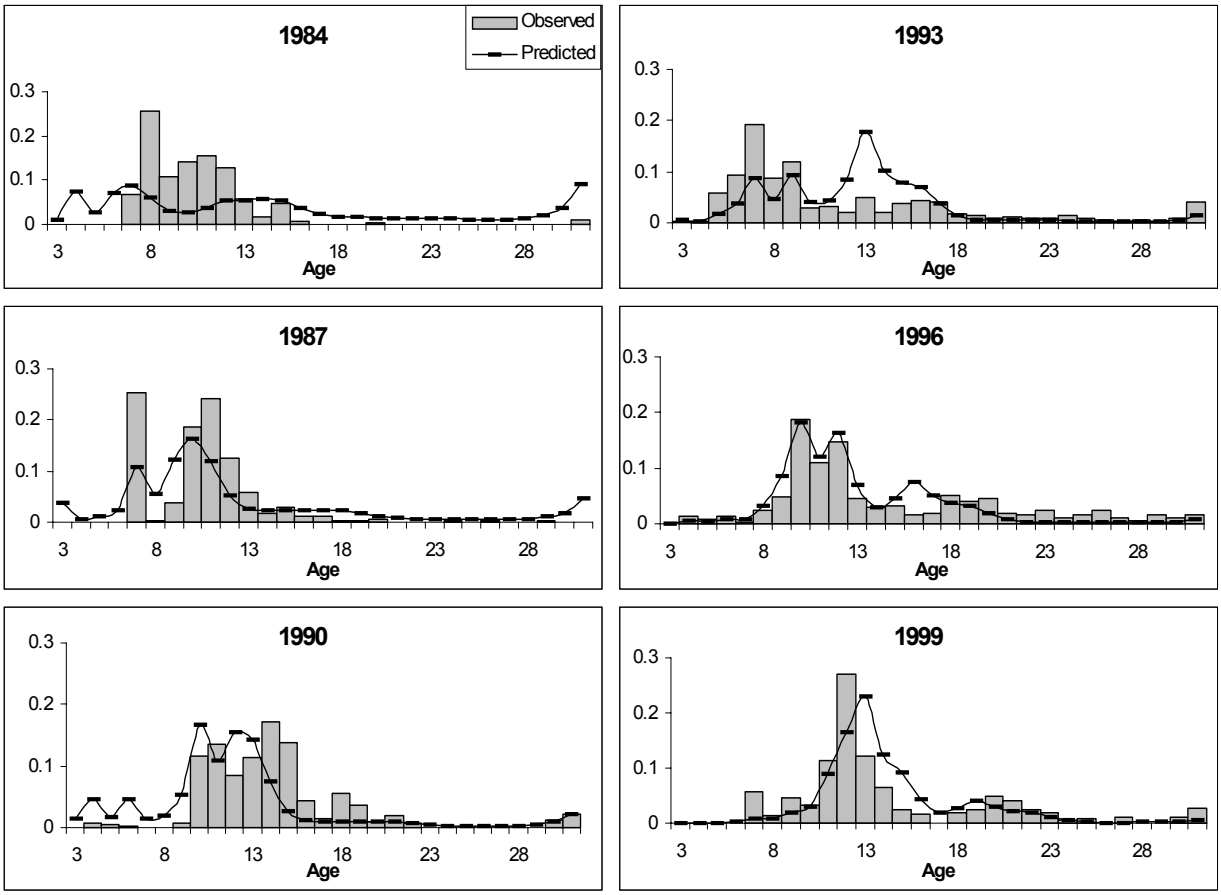

Figure 10. Predicted proportions at age (lines) relative to observed values (bars) for triennial survey data for dusky rockfish age-structured base model.

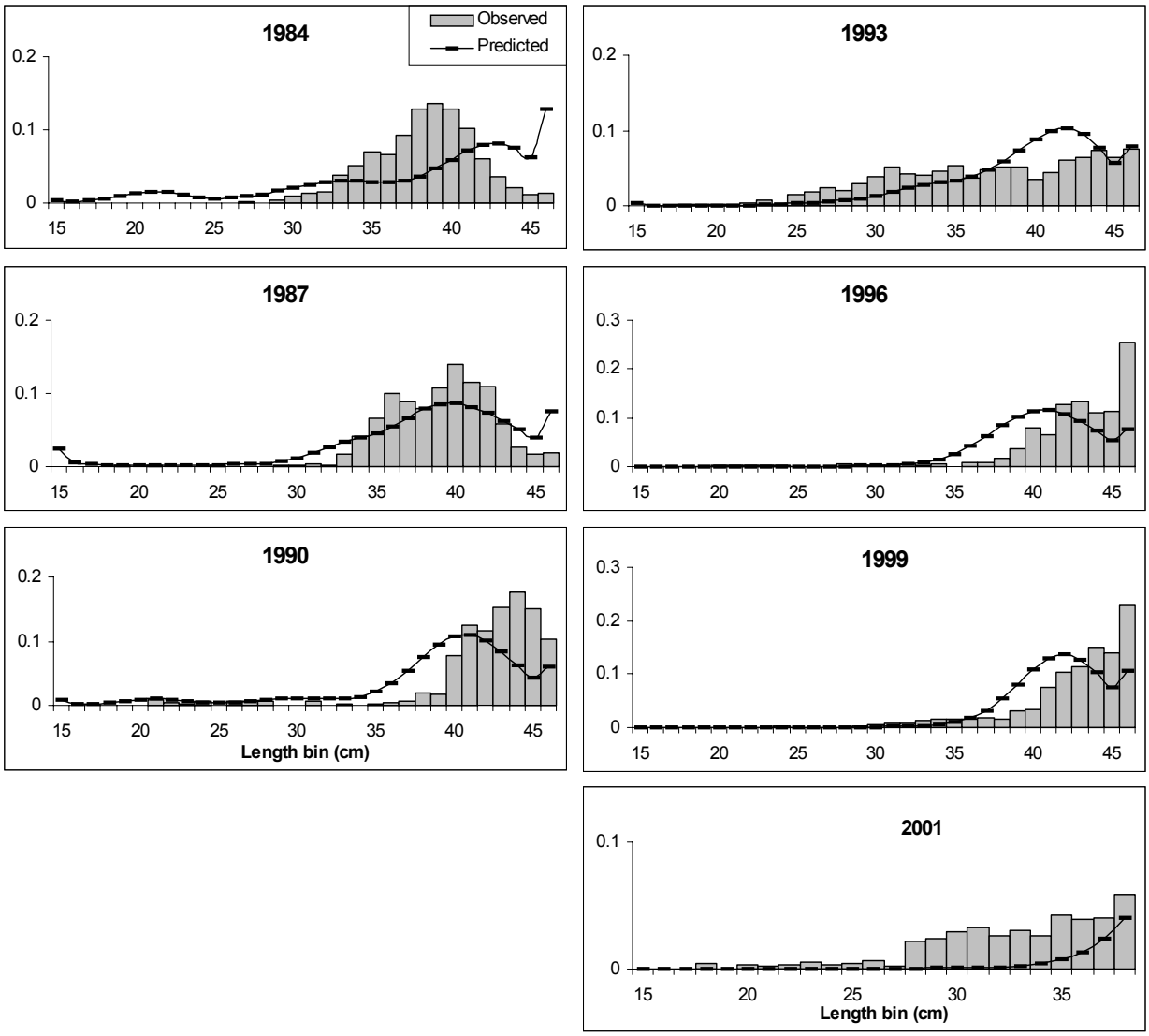

Figure 11. Predicted proportions at size (line) relative to observed proportions (bar) for triennial survey data for dusky rockfish age-structured base model.

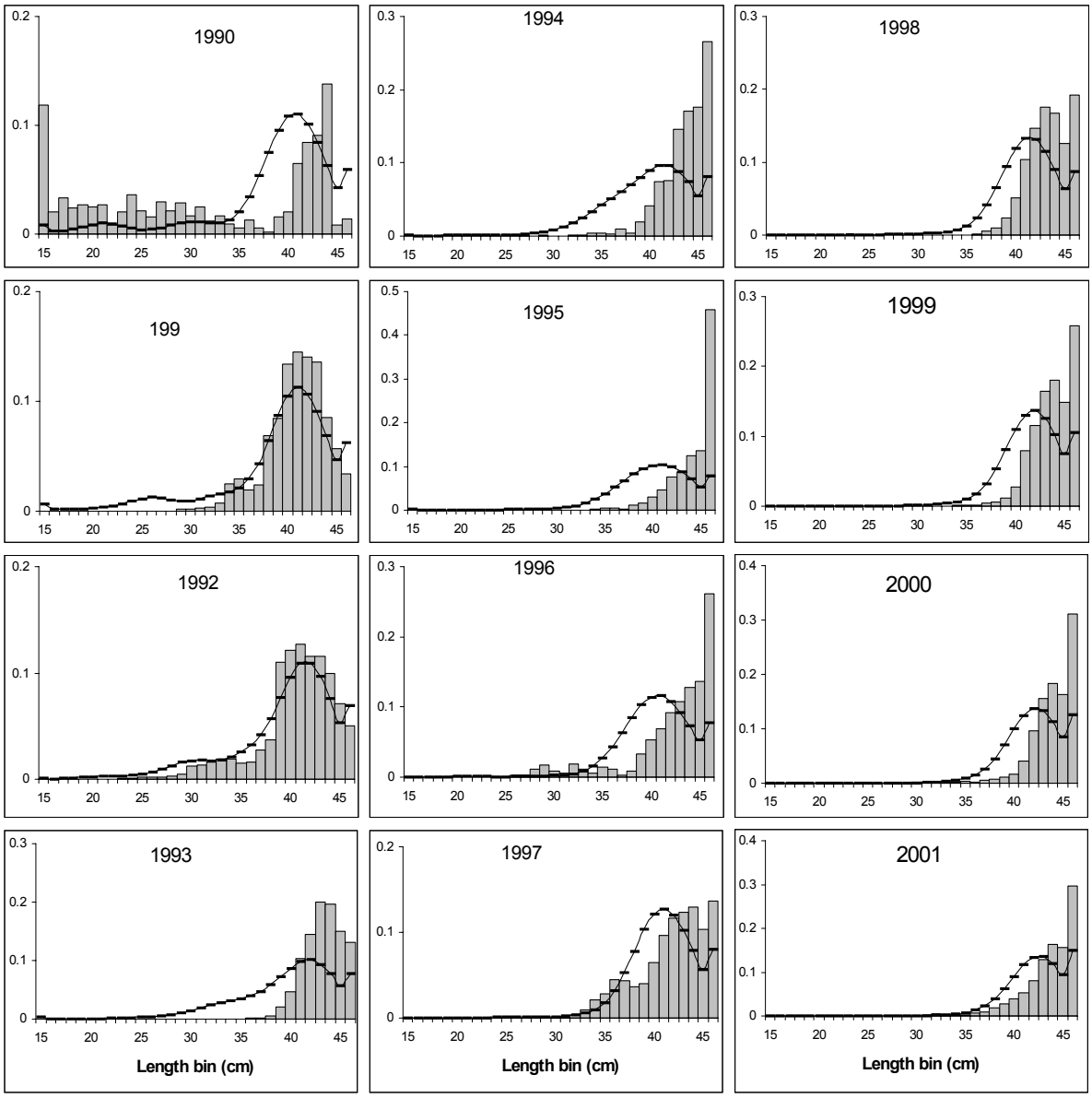

Figure 12. Predicted proportions at size (lines) relative to observed proportions (bars) for fishery data for dusky rockfish age-structured base model.