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Preliminary Assessment of the Gulf of Alaska Sablefish Population based on the Japan-U.S. Cooperative Longline Survey, 1986

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PRELIMINARY ASSESSMENT OF THE GULF OF ALASKA SABLEFISH POPULATION BASED ON THE JAPAN-U.S. COOPERATIVE LONGLINE SURVEY, 1986

by

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ABSTRACT

The Japan-U.S. cooperative longline survey is a source of assessment information for the sablefish (Anoplopoma fimbria) fishery in the Gulf of Alaska. From the 1986 survey results, a relative population number (RPN), a relative population weight (RPW), a length composition, and a growth potential were computed for sablefish in the Gulf of Alaska. The statistical significance of annual changes in the RPN's from 1979 to 1986 also was evaluated. In 1986, the RPN was 1.7 million, the RPW was 4.3 million, and the growth potential was 12%. Sablefish abundance increased significantly from 1979 to 1986, an increase likely attributable to the recruitment of the relatively strong 1977 and 1980 year classes. The 1984 year class also may be stronger than average, based on the length composition for 1986.

CONTENTS

INTRODUCTION

Sablefish (Anoplopoma fimbria) have been harvested commercially for several decades along the Pacific coast of North America. Early in this century, U.S. and Canadian fishermen began harvesting sablefish in nearshore waters from California north to southeastern Alaska, but sablefish were not heavily exploited until Japanese longline vessels began fishing in U.S. waters in 1958. Japanese catches in U.S. and Canadian waters rose dramatically in the following two decades. Subsequent to passage of the Fishery Conservation and Management Act, foreign catches were reduced and the domestic allocation was increased. The domestic catch eventually increased nearly fivefold at the expense of the foreign fishery, and in 1985 the domestic fishery entirely displaced foreign vessels from directed fishing for sablefish in the Gulf of Alaska.

Prior to the reduction of the foreign fishery, information on sablefish abundance consisted of catch-per-unit-effort statistics calculated from catches reported by the Japanese longline fishery. In 1978, the Fisheries Agency of Japan and the U.S. National Marine Fisheries Service (NMFS) began a cooperative longline survey along the continental slope of Alaska to assess the abundance of sablefish and Pacific cod (Gadus macrocephalus). The cooperative survey, conducted annually, has provided 8 consecutive years (1979-86) of data for the Gulf of Alaska, 7 years (1980-86) of data for the Aleutian region, and 5 years (1982-86) of data for the eastern Bering Sea. The first year of the survey, 1978, was experimental.

In this report, the results from the Japan-U.S. cooperative longline survey in 1986 were used to compute a relative population

number (RPN), a relative population weight (RPW), a length composition, and a growth potential for sablefish in the Gulf of Alaska. In addition, the RPN's from 1979 to 1985 were calculated, and the statistical significance of annual changes in the RPN's from 1979 to 1986 was evaluated. The RPN's from the longline survey results from 1979 to 1985 were estimated previously by Sasaki (1986).

SURVEY METHODS

The Gulf of Alaska portion of the Japan-U.S. cooperative longline survey, conducted annually from about June to September 1979-86, covered five International North Pacific Fisheries Commission (INPFC) areas: Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern (Fig. 1). One of 47 stations total was sampled daily by longline in the Gulf of Alaska, each station ranging in depth from 100 to 1,000 m. The longline (16 km long) consisted of 160 hachis (the Japanese word for "skate" or length of longline); each hachi (100 m long) consisted of 45 hooks baited with squid. Soak time (time between setting and retrieval) varied from 3 hours at the beginning of the longline gear to 7 or 8 hours at its end. The depth at which the fish were caught was estimated by measuring the depth of water under the vessel with an echo sounder every fifth hachi. The fish caught were tallied by species and hachi as the longline was brought aboard, then were weighed, counted, and measured. Most sablefish were sexed, some were tagged and released, and others were sampled for otoliths and scales. Detailed survey methods are in Sasaki et al. (1983).

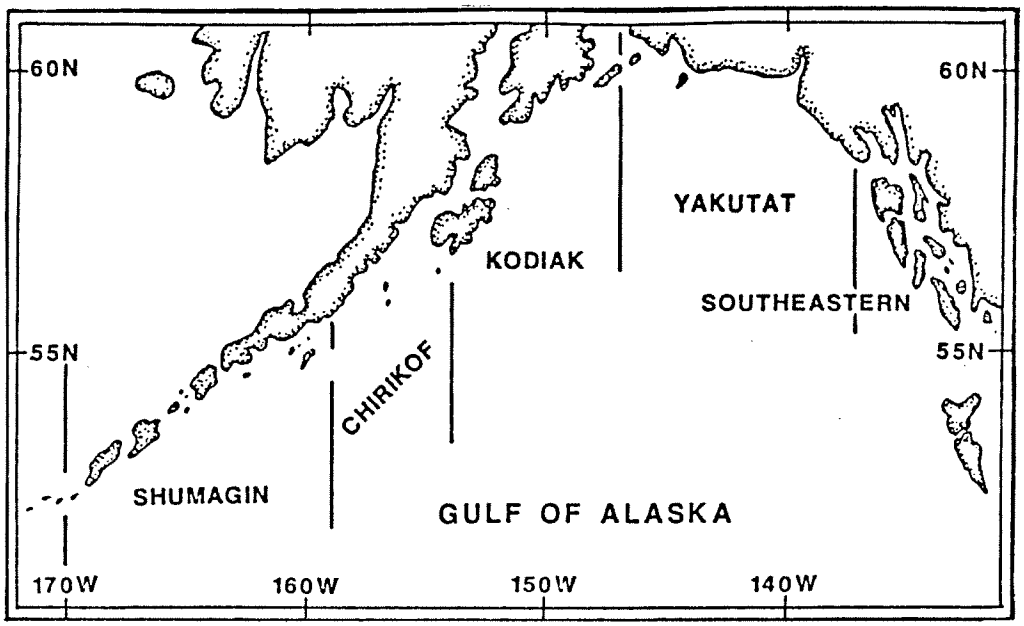

Figure 1.--International North Pacific Fisheries Commission statistical areas sampled for sablefish (Anoplopoma fimbria) during the Gulf of Alaska portion of the Japan-U.S. cooperative longline survey, 1979-86.

STATISTICAL METHODS

The catch data were stratified because of differences in the catch rate by depth. Assignment of the catch data to a stratum was based on the recorded depth of every fifth hachi or the interpolated depth of each of the intervening four hachis. The number of strata totaled nine, with the first stratum representing 101-200 m, the second representing 201-300 m, and so on. A catch per hachi value was calculated for each stratum of a station, and the resultant values within each INPFC area were averaged.

Relative population numbers from 1979 to 1986 were calculated from the catch per hachi values to index annual changes in sablefish abundance. As in Sasaki (1985), the average catch per hachi was multiplied by the areal size of each stratum and INPFC area to calculate an RPN for each stratum of an INPFC area. (The areal sizes do not, however, include Shelikof Strait, Cook Inlet, Prince William Sound, or the inside waters of southeastern Alaska.) The resultant RPN's were summed across strata to calculate an RPN for each INPFC area, and these RPN's were summed across INPFC areas to calculate an RPN for the Gulf of Alaska.

The bootstrap method (Efron 1982; Efron and Gong 1983) was applied to the cooperative survey data to determine whether annual changes in the RPN's were statistically significant. By this method, stations were randomly sampled with replacement within each area. A value, denoted RPN*, was computed from the catch per hachi values of the sampled stations by the RPN calculation method described above. Sampling with replacement and the computation of an RPN* were repeated 1,000 times. Ratios were calculated between the RPN*'s for each year. If more than

95% or less than 5% of the resultant 1,000 ratios were greater than 1, then the annual change in the RPN was considered statistically significant and the change in sablefish abundance was considered real. Conversely, if the percentage was between 5 and 95%, then it was concluded that sablefish abundance had not changed significantly.

Relative population weights were calculated to determine the relative biomass of sablefish by strata and INPFC area by the following method. An RPN weighted length frequency was calculated by allocating the RPN by area and strata to the elements of the length frequency distribution based on the relative size of the elements. (Lengths of tagged sablefish in the Shumagin, Chirikof, and Kodiak areas were not available for this analysis, but should not noticeably affect the results because tagged fish constituted only 5% of the sablefish catch.) The length-weight equation

$$W = 2.99 \times 10^{-6} \times L^{3.30}$$

(Sasaki 1985) was applied to the RPN weighted length frequencies to compute RPW weighted length frequencies which were then summed across length to calculate RPW's by stratum and INPFC area.

These RPW's by INPFC area were used to calculate the RPW's by North Pacific Fishery Management Council (NPFMC) management areas [i.e., Western, Central, and Eastern (which for management purposes is divided into two smaller areas, West Yakutat and East Yakutat-Southeastern)]. The RPW's for both INPFC areas and NPFMC areas were developed because of the management importance of knowing the relative biomass by both categories of areas. The Western NPFMC area is equivalent to the Shumagin INPFC area; the Central NPFMC area is equivalent to the Chirikof and Kodiak INPFC areas combined. The RPW for the Yakutat INPFC

area was allocated to the West and East Yakutat areas based on their areal size at the depths examined. The RPW for the East Yakutat area was then combined with the RPW for the Southeastern area.

Growth potential was estimated for 1987 from the results of the 1986 survey based on expected weight increases due to growth. Recruitment, fishing mortality, and natural mortality were not considered in the computation. The Walford expression of the von Bertalanffy growth model, based on the results of the 1984 cooperative longline survey for unsexed fish (C. Kastelle, Age Unit, Northwest and Alaska Fisheries Center, Seattle, personal communication, June 1986), was applied to the RPN weighted length frequencies to estimate the RPN weighted length frequencies for 1987:

$$L_{t+1} = 73.600\ (1 - e^{-0.2490}) + L_t e^{-0.2490}.$$

For $\underline{L}_t$ greater than $\underline{L}\infty$, $\underline{L}_t + 1$ was set equal to $\underline{L}_t$. The length-weight equation previously noted was applied to the RPN weighted length frequencies to estimate RPW weighted length frequencies, which were then summed across length to project RPW's by INPFC area for 1987. Growth potential was computed as the relative difference between the projected RPW for 1987 and the RPW for 1986.

RPN'S

The RPN's changed from 1985 to 1986, but the changes were not uniform across the INPFC areas in the Gulf of Alaska. The RPN increased in the Yakutat area, decreased in the Chirikof and Kodiak areas, and remained the same in the Shumagin and Southeastern areas (Fig. 2). The only significant change was the decrease in the Kodiak area (Table 1). For the entire Gulf of Alaska, the RPN also decreased significantly in

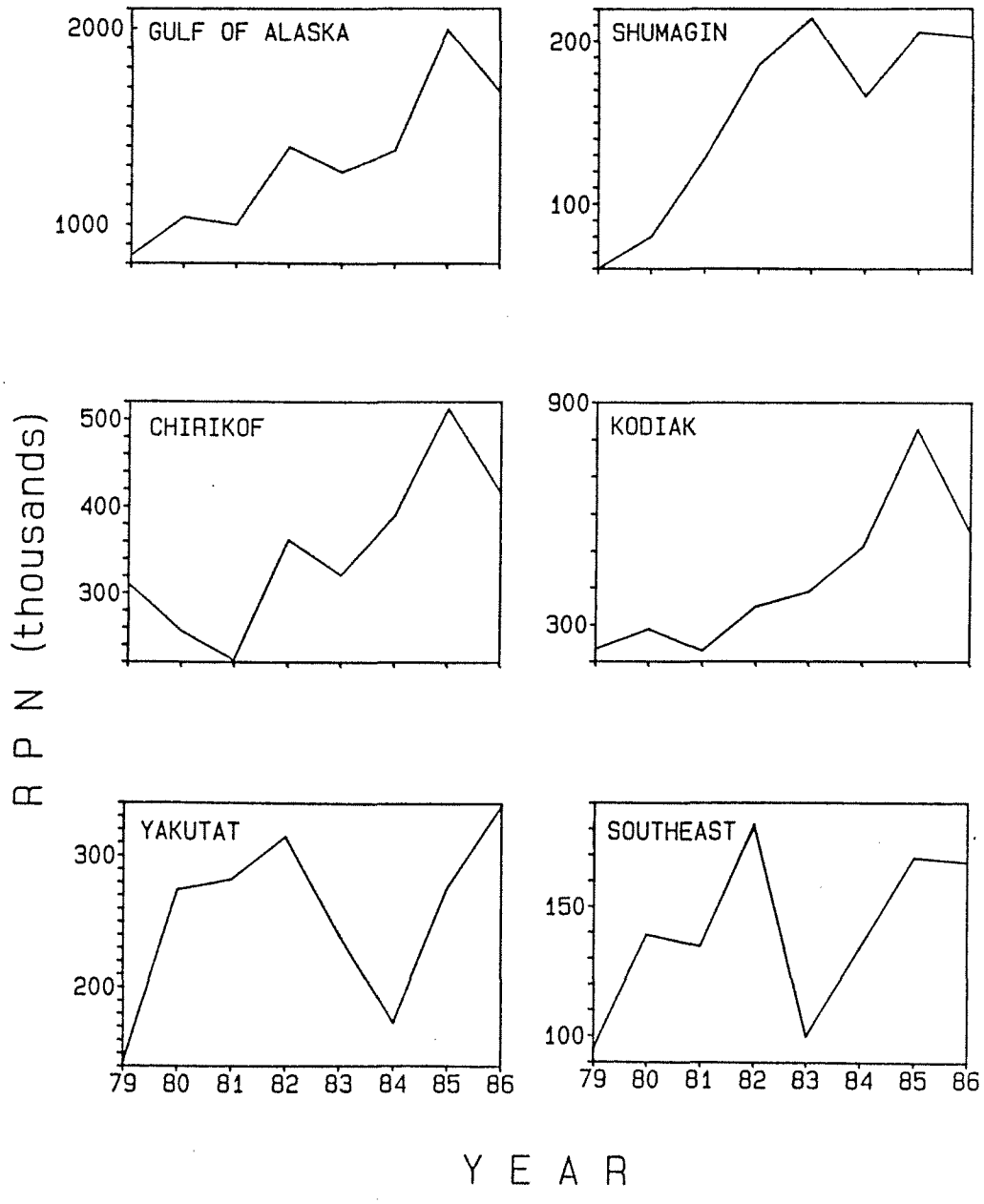

Figure 2.--Relative population numbers (RPN's) of sablefish (Anoplopoma fimbria) for the Gulf of Alaska and the Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern International North Pacific Fisheries Commission areas, 1979-86.

Table 1.--Statistical significance of annual changes in relative population numbers (RPN's) of sablefish (Anoplopoma fimbria) during the Japan-U.S. cooperative longline survey in the Gulf of Alaska, 1979-86. The symbols used are defined as follows: + signifies a significant increase in RPN; - signifies a significant decrease in RPN; 0 signifies no significant change. (For calculation of statistical significance by the bootstrap method (Efron 1982; Efron and Gong 1983), see Statistical Methods.)

	Statistical signficance													
	Year							Year						
Year	1980	1981	1982	1983	1984	1985	1986	1980	1981	1982	1983	1984	1985	1986
	Gulf of Alaska							Shumagin						
1979	+	0	+	+	+	+	+	0	+	+	+	+	+	+
1980		0	+	+	+	+	+		0	+	+	+	+	+
1981			+	+	+	+	+			+	+	+	+	+
1982				0	0	+	-				+	0	0	0
1983					0	+	+					-	0	0
1984						+	+						+	0
1985							-							0
	Chirikof							Kodiak						
1979	0	0	0	0	0	+	0	0	0	0	+	+	+	+
1980		0	0	0	+	+	+		0	0	0	+	+	+
1981			+	+	+	+	+			+	+	+	+	+
1982				0	0	0	0				0	0	+	+
1983					+	+	+					0	+	+
1984						0	0						+	0
1985							0							-

Table 1.--Continued.

	Statistical significance													
	Year							Year						
Year	1980	1981	1982	1983	1984	1985	1986	1980	1981	1982	1983	1984	1985	1986
	Yakutat							Southeastern						
1979	+	+	+	+	0	+	+	0	0	+	0	0	0	0
1980		0	0	0	0	0	0		0	0	0	0	0	0
1981			0	0	0	0	0			0	0	0	0	0
1982				0	-	0	0				-	0	0	0
1983					0	0	0					0	0	+
1984						+	+						0	0
1985							0							0

1986 compared to 1985; however, it remained significantly higher than the 1984 RPN, indicating that the increase in sablefish abundance from 1984 to 1986 was real (Table 1; Fig. 2). The upward trend in abundance has continued since the survey began: a 99% increase (from 0.8 to 1.7 million) in the RPN from 1979 to 1986. This increase also was statistically significant (Table 1), indicating that the upward trend was real and that sablefish abundance in the Gulf of Alaska has increased markedly since 1979. Much of the increase occurred in 1981-82 and 1984-86 when the RPN jumped about 40% and 22%, respectively. The strong 1977 (Sasaki 1982; McFarlane and Beamish 1983; Funk and Bracken 1984) and 1980 year classes (Sigler and Fujioka In prep.) probably were responsible for the 1981-82 and 1984-86 RPN increases, respectively.

The decrease in the RPN from 1985 to 1986 may have been due to an artificially high RPN in 1985, based on comparison of the RPN's at the 101-200 and 201-1,000 m depths. The RPN at 201-1,000 m increased steadily from 1979 to 1986 (Fig. 3). The RPN at 101-200 m paralleled the increase at 201-1,000 m, but diverged upward in 1985 and then downward in 1986. This divergence indicates that the RPN at the 101-200 m depth was overestimated in 1985. Overestimation of the RPN at this depth, and also at the 201-400 m depths, is possible because a large portion of these depths was not sampled. Because the distribution and abundance of sablefish at these depths were unknown, their RPN's were estimated from the catches at the sampled depths. If the abundance at the sampled depths was relatively low compared to the unsampled depths, then the RPN's at the unsampled depths were underestimated. On the other hand, if abundance at the sampled depths was relatively high compared to the unsampled depths, then the RPN's at the unsampled depths

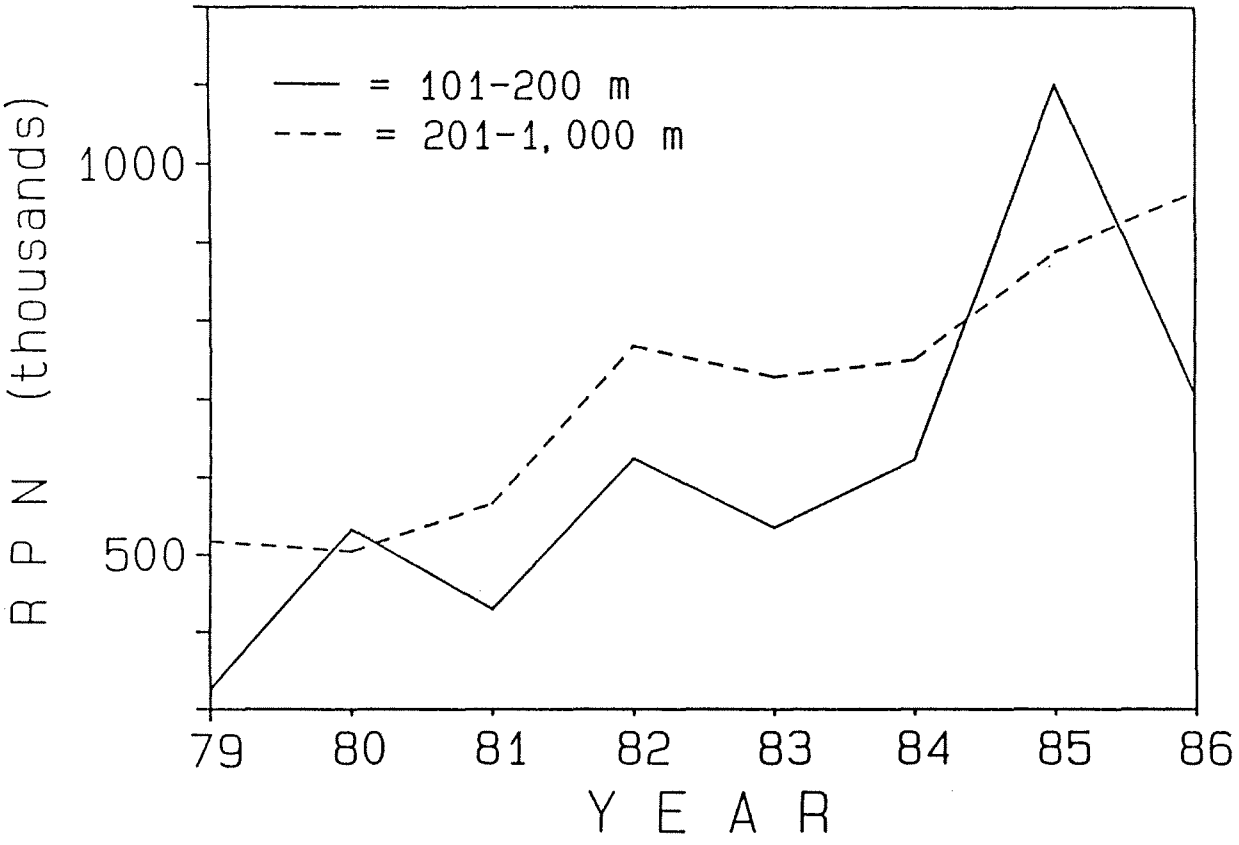

Figure 3.--Relative population numbers (RPN's) of sablefish (Anoplopoma fimbria) at depths of 101-200 m and 201-1,000 m in the Gulf of Alaska, 1979-86.

were overestimated. The drop in the RPN from 1985 to 1986, therefore, may be due to an overestimation of the 1985 RPN at the shallow depths. Because of the uncertainty in the RPN estimate, additional information on the distribution and abundance of sablefish in the unsampled area is needed to determine the validity of the RPN's and other population indices (RPW and length composition) at 101-400 m.

RPW'S

The largest RPW by INPFC area in 1986 was for the Kodiak area, closely followed by that for the Chirikof area (Table 2). These two areas constituted 30 and 28%, respectively, of the RPW for the entire Gulf of Alaska. The RPW for the Yakutat area ranked a distant third (19%) but was nearly twice as large as that for the Shumagin (12%) and Southeastern (11%) areas.

Three strata contributed a large portion of the RPW for the Gulf of Alaska at 101-1,000 m. The RPW's for the Chirikof area at 201-400 m and the Kodiak area at 101-200 m constituted 20 and 14%, respectively, of the RPW for the entire Gulf of Alaska in 1986 (Table 3). These three strata together have consistently contributed a high percentage (average, 29%) of the RPW's since 1979. The relative size of the RPW's has varied more from year to year for the Kodiak area at 101-200 m than for the Chirikof area at 201-400 m. Especially obvious in the Kodiak area at 101-200 m were the sharp increases in 1984 and 1985 and the drop in 1986.

The RPW for the NPFMC areas was largest in the Central NPFMC area. Of the RPW for the entire Gulf of Alaska, the Central NPFMC contributed

Table 2.--The 1986 relative population weights (RPW's) of sablefish (*Anoplopoma fimbria*) by International North Pacific Fisheries Commission (INPFC) statistical area and depth.

Depth (m)	RPW's by INPFC area				
	Shumagin	Chirikof	Kodiak	Yakutat	Southeast
101-200	181,470	171,351	591,138	365,796	86,884
201-400	160,590	850,027	404,283	186,128	215,205
401-600	107,214	73,763	143,010	112,886	73,322
601-800	54,109	62,345	108,288	91,723	57,147
801-1,000	9,303	53,982	46,367	61,465	55,121
All depths	512,686	1,211,468	1,293,086	817,998	487,679

Table 3.--Relative population weights (RPW's) of sablefish (Anoplopoma fimbria) for the Chirikof area at 201-400 m and the Kodiak area at 101-200 m, each expressed as a percentage of the RPW for the Gulf of Alaska at 101-1,000 m.

	RPW's	
Year	Chirikof	Kodiak
1979	19	6
1980	16	11
1981	13	7
1982	16	10
1983	16	11
1984	16	18
1985	15	27
1986	20	14

58% at the 101-1,000 m depths and 60% at 201-1,000 m (Table 4). However, the 401-1,000 m depths in the Central NPFMC area constituted less than half (44%) of the RPW for the entire Gulf. Yet the RPW at 401-1,000 m was larger than the combined total of the second (East Yakutat-Southeastern) and third (West Yakutat) largest RPW's. Clearly, in 1986 the Central NPFMC area was the major contributor to the RPW, regardless of depth.

LENGTH COMPOSITIONS

The length compositions generally were similar for all areas, but there were a few exceptions (Figs. 4-7). At 101-1,000 m, the Yakutat and Kodiak areas had more small fish and the Chirikof and Southeastern areas had more large fish (Fig. 4). The Southeastern area also had more large fish at 101-200 m (Fig. 5), possibly because sampling in this strata was limited to only two of the nine stations. At 201-400 m, the Southeastern area had relatively more large fish, whereas the Yakutat area had relatively more small fish, as indicated by a mode centered at 50 cm fork length (FL) (Fig. 6).

The most obvious differences among length compositions were by depth. Sablefish smaller than 57 cm FL were much more common in the Gulf of Alaska at 101-200 m than at 201-400 m or 401-1,000 m (Fig. 8), constituting 30% of the RPW at 101-200 m, but only 5% and 4% of the RPW at 201-400 and 401-1,000 m, respectively. Thus, fishing in shallow areas will result in catches of smaller fish on average than will fishing in deep areas.

Table 4.--The 1986 relative population weights (RPW's) of sablefish (Anoplopoma fimbria) by North Pacific Fishery Management Council (NPFMC) management area and depth expressed as a percentage of the relative population weights for the Gulf of Alaska by the same depth.

Depth (m)	RPW's by NPFMC area			
	Western	Central	West Yakutat	East Yakutat-Southeastern
101-1,000	12	58	12	18
201-1,000	11	60	12	17
401-1,000	15	44	20	21

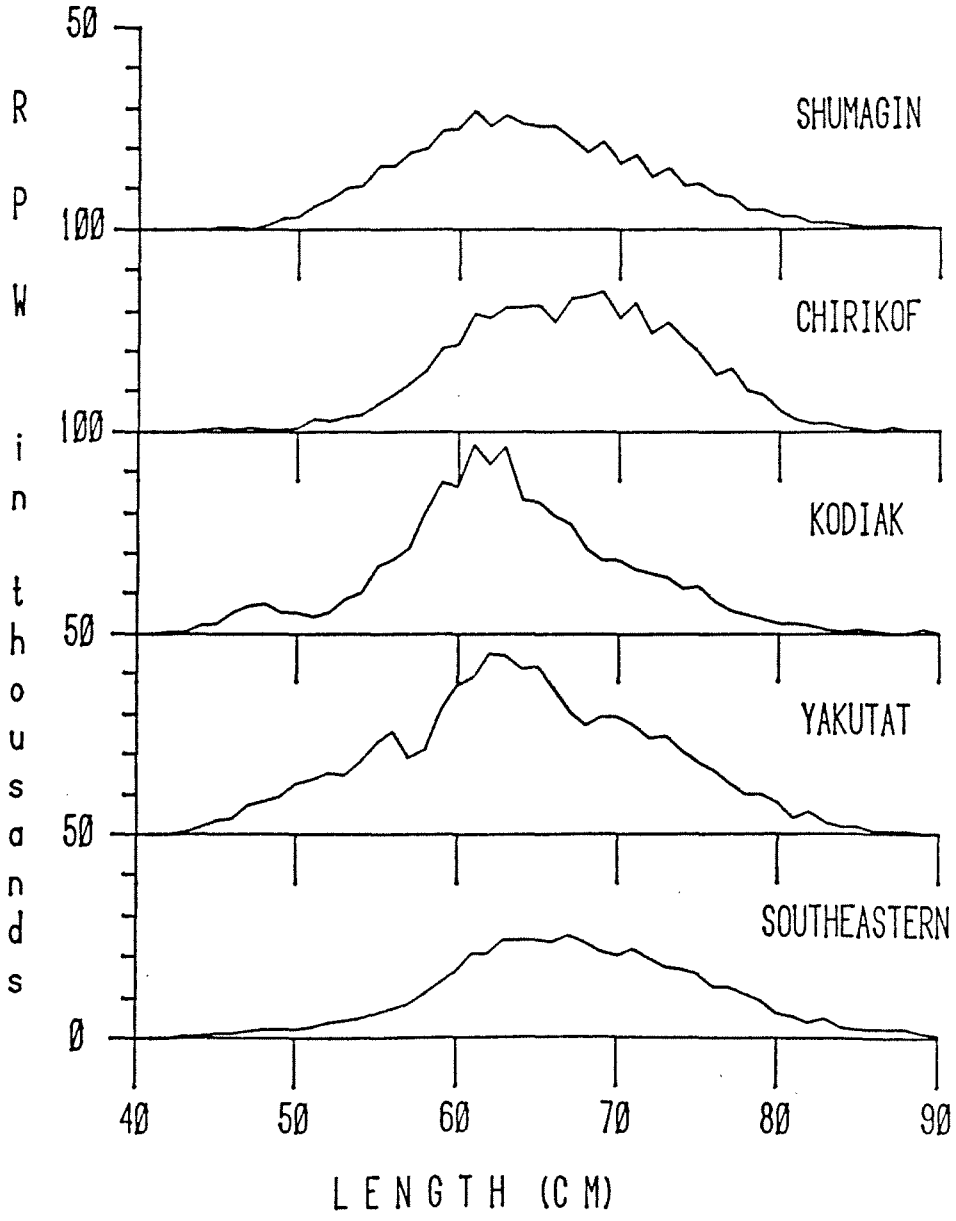

Figure 4.--Relative population weight (RPW) weighted length frequencies of sablefish (Anoplopoma fimbria) at depths of 101-1,000 m in the Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern International North Pacific Fisheries Commission areas in 1986.

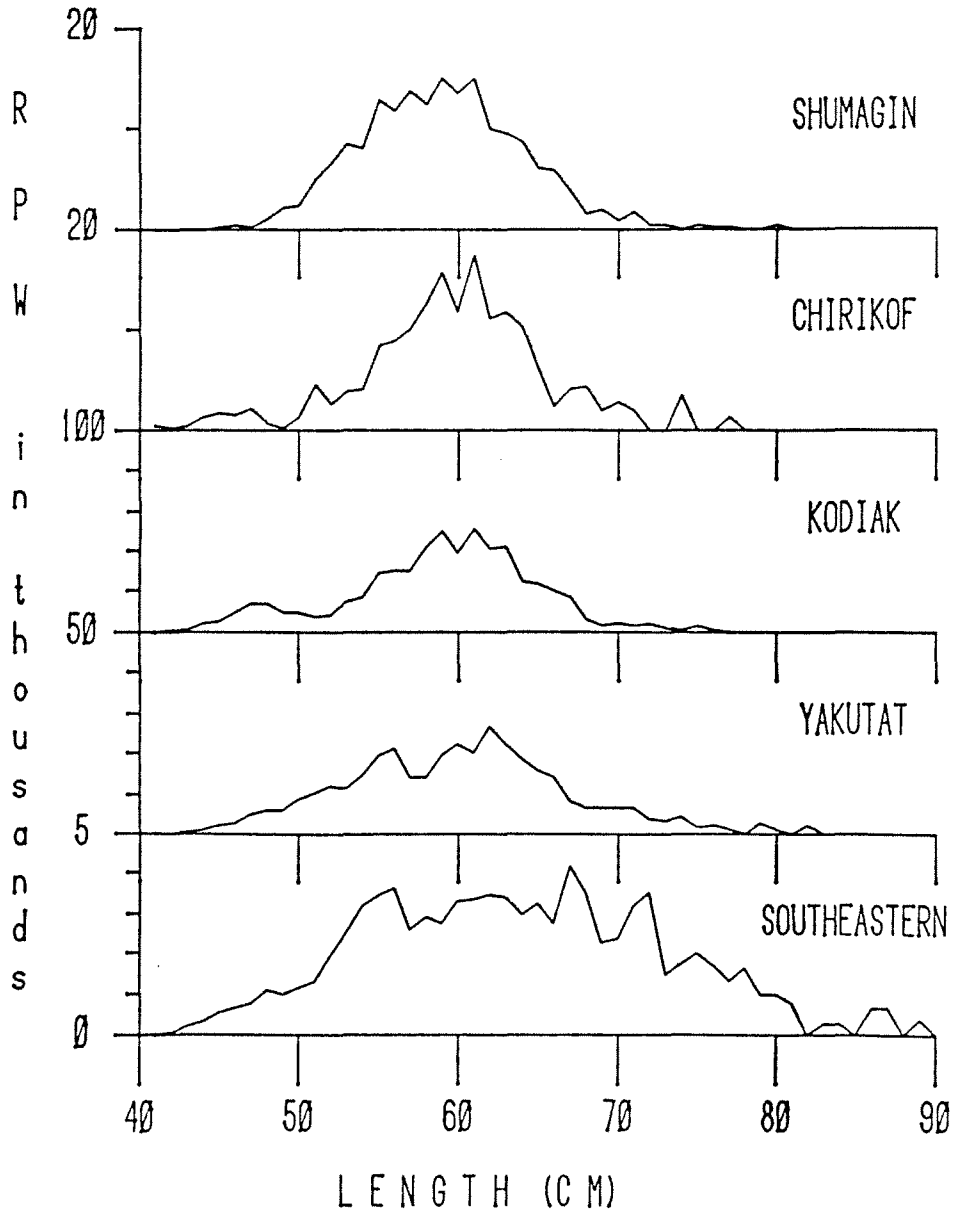

Figure 5.--Relative population weight (RPW) weighted length frequencies of sablefish (Anoplopoma fimbria) at the 101-200 m depth in the Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern International North Pacific Fisheries Commission areas in 1986.

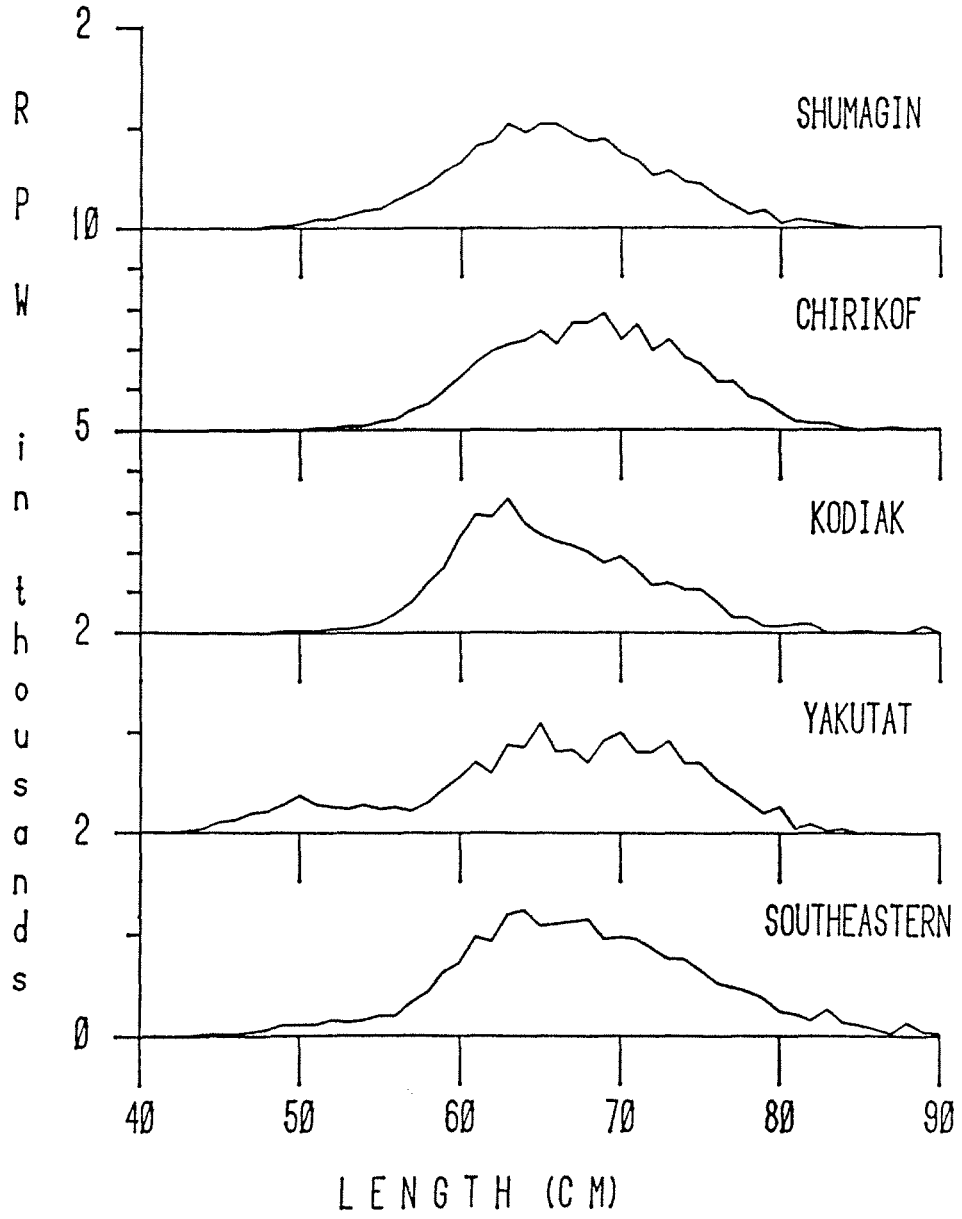

Figure 6.--Relative population weight (RPW) weighted length frequencies of sablefish (Anoplopoma fimbria) at depths of 201-400 m in the Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern International North Pacific Fisheries Commission areas in 1986.

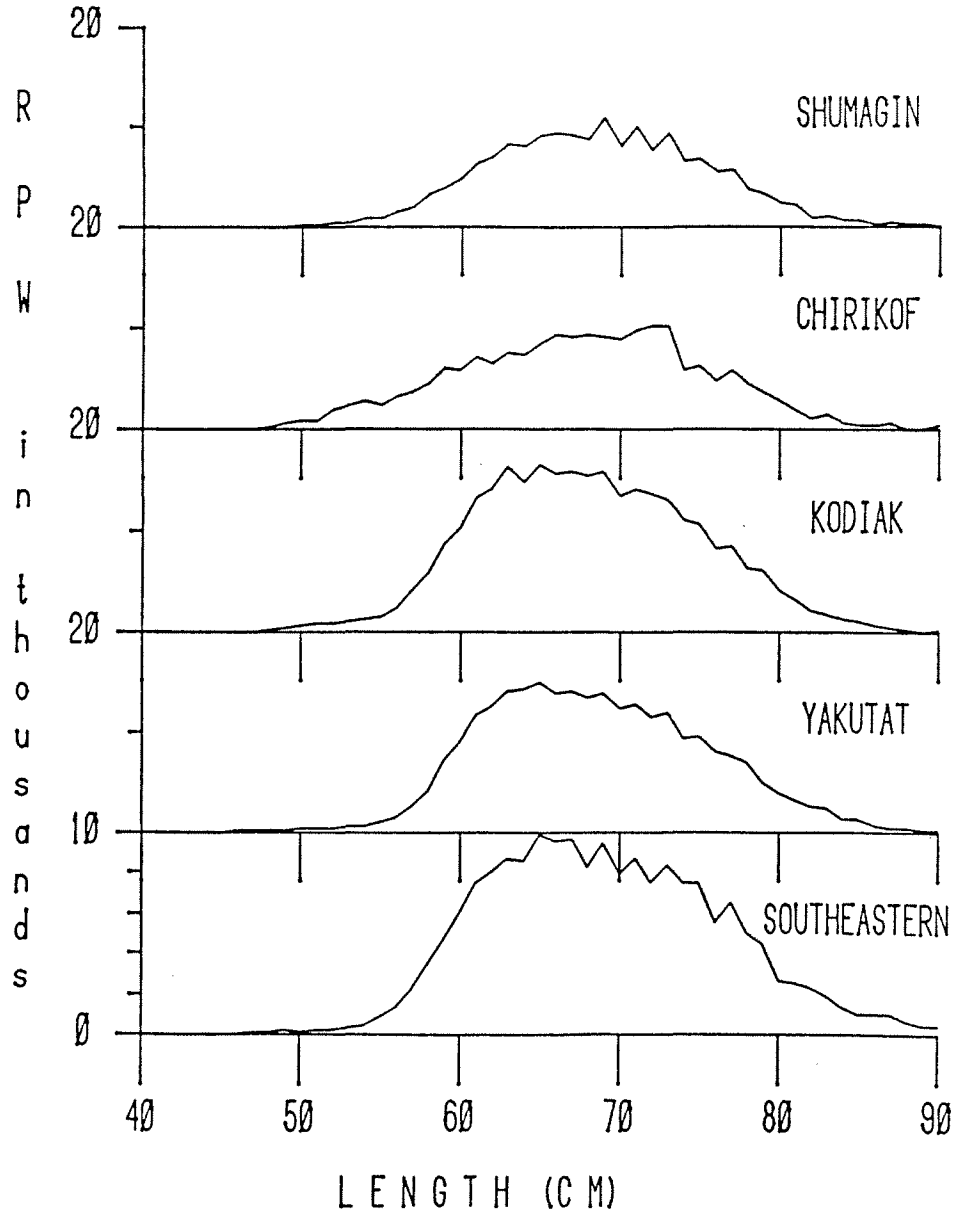

Figure 7.--Relative population weight (RPW) weighted length frequencies of sablefish (Anoplopoma fimbria) at depths of 401-1,000 m in the Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern International North Pacific Fisheries Commission areas in 1986.

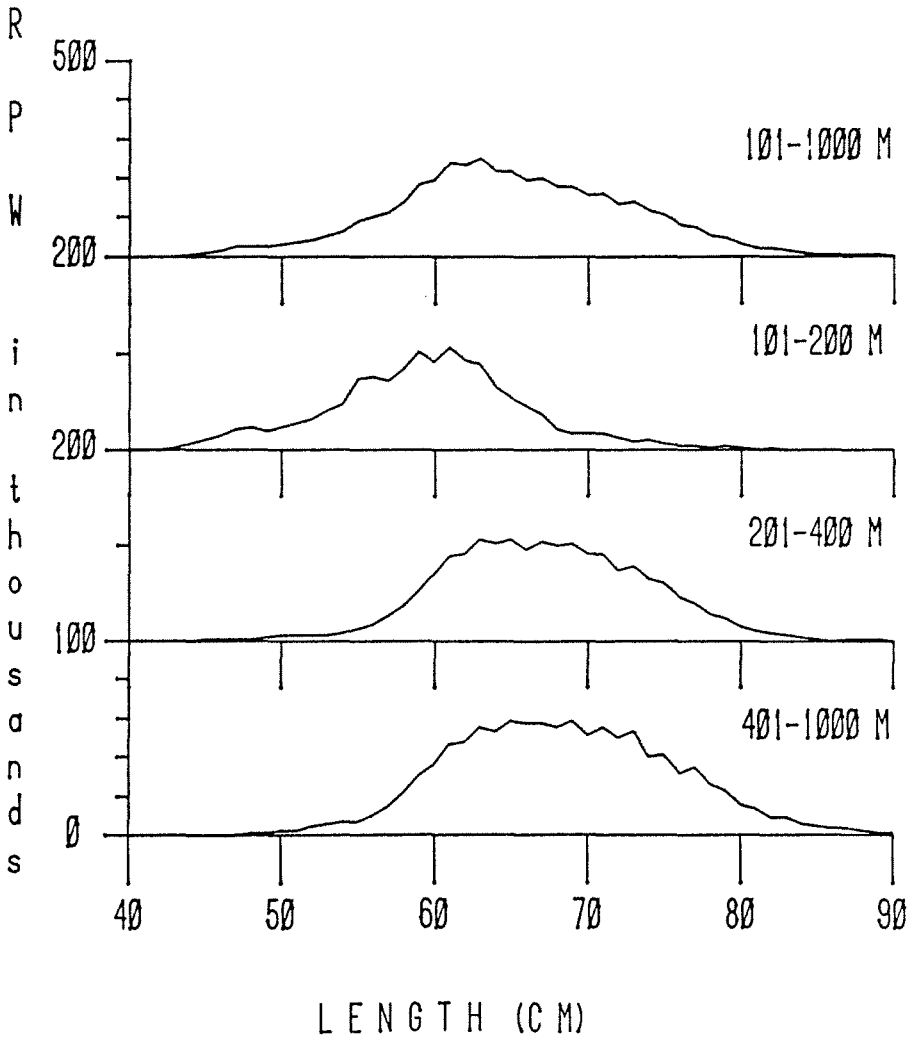

Figure 8.--Relative population weight (RPW) weighted length frequencies of sablefish (Anoplopoma fimbria) at depths of 101-1,000 and 101-200, 201-400, and 401-1,000 m in the Gulf of Alaska in 1986.

GROWTH POTENTIAL

Growth potential, expressed as the percentage increase in the projected RPW for 1987 compared to the RPW for 1986, is mostly dependent on the relative numbers of sablefish juveniles, which grow rapidly, compared to adults, which grow slowly. Growth potential is greatest at 101-200 m and less at 201-1,000 m (Table 5). At 101-200 m, growth potential is relatively low for the Southeastern area compared to the other areas because of the bias toward large fish in the Southeastern area. In the Gulf of Alaska, markedly more small fish were at 101-200 m than at either 201-400 m or 401-1,000 m (Fig. 8), and this bias toward small fish in the shallow depth is reflected in the higher growth potential compared to the other depths (Table 5).

TRENDS IN SABLEFISH ABUNDANCE

Sablefish abundance in 1987, as measured by the RPN, probably will be similar to that in 1986. This statement is based on two observations. First, there is no indication from the RPN weighted length frequency distributions derived from the longline survey results that any strong year classes will recruit to the fishery by 1987 (Sigler 1986). Second, recent increases in sablefish abundance were sudden and sharp (Fig. 2) and probably attributable to the recruitment of relatively strong year classes. These sharp increases indicate that most sablefish of a given year class recruit to the survey gear in the same year. Because another strong year class probably will not recruit to the fishery in 1987, sablefish abundance in the Gulf in 1987 likely will be similar to the 1986 level.

Table 5.--Growth potential of sablefish (Anoplopoma fimbria) for 1987 based on the percentage increase in the projected relative population weight (RPW) for 1987 compared to the RPW for 1986.

Depth (m)	Growth potential (%)					
	Shumagin	Chirikof	Kodiak	Yakutat	Southeast-ern	Gulf of Alaska
101-200	20	19	21	19	15	20
201-400	10	7	10	12	9	9
401-1,000	7	9	8	7	7	8
101-1,000	11	9	15	14	9	12

Another year class recruiting to the fishery in about 1989 may be stronger than average. The mode at about 45-50 cm FL in the Chirikof and Kodiak areas at 101-200 m (Fig. 5) indicates that the 1984 year class is stronger than average. Length frequency data from a NMFS trawl survey in the eastern Bering Sea in 1986 also showed a dominant mode of sablefish on the shelf at 44-47 cm FL, and this mode was attributed to a fairly strong 1984 year class (McDevitt In prep.). Because the strength of the 1977 year class was similar in the eastern Bering Sea and Gulf of Alaska (Umeda et al. 1983), the dominant mode of the 1984 year class in the eastern Bering Sea in 1986 supports the evidence that this year class is stronger than average in the Gulf of Alaska. Further evidence for this possibility is the high numbers of sablefish 30-40 cm FL in the inside waters of southeastern Alaska in 1985. Confirmation of the importance of the 1984 year class, however, should await the results of the 1987 longline survey.

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