NOAA Technical Memorandum NMFS F/NWC-134

Relative Abundance of Sablefish in Southeastern Alaska, Based on Trap Indexing Surveys, 1978-85

by
David M. Clausen
and
Jeffrey T. Fujioka

May 1988

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

/

RELATIVE ABUNDANCE OF SABLEFISH IN SOUTHEASTERN ALASKA, BASED ON TRAP INDEXING SURVEYS, 1978-85

by

David M. Clausen and Jeffrey T. Fujioka

Auke Bay Laboratory
Northwest and Alaska Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
P. O. Box 210155
Auke Bay, Alaska 99821

May 1988

ii

This document is available to the public through:

National Technical Information **Service**
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

ABSTRACT

Annual indexing surveys of sablefish (*Anoplopoma fimbria*) abundance were conducted in outside waters of southeastern Alaska in 1978-85. Four indexing sites were fished annually with standardized trap gear. Decreasing catch rates in 1979-82 indicated-a general decline in sablefish abundance, especially in larger (>67 cm fork length (FL)) fish. Increasing catch rates after 1982, particularly in 1983 and 1985, showed that sablefish stock condition was apparently improving. Most of this increase appeared to be caused by the 1977 year class. Length frequency distributions of sablefish showed that mean FL's decreased in 1979-82, then increased thereafter. Sablefish catch rates were consistently low at the shallowest (274-m) depth stratum fished and variable in deeper waters. Sex ratios were nearly 1:1 in five survey years, and males predominated in the other three survey years. Catch rates were higher in most years at the southern sites, Capes Addington and Muzon, than at the northern sites, Capes Cross and Ommaney.

The methods used in the indexing surveys were evaluated. A bait experiment indicated different batches of bait herring used in the surveys had little effect on sablefish catch rates. Visit comparisons, (i.e., fishing two indexing sites about 1 month after they were originally fished in the indexing surveys) showed that catch rates were consistent and repeatable for a given year at each indexing site and, thus, increased confidence in the validity of survey results. A comparison between catches in conical traps with two designs of entry tunnels demonstrated that relatively small differences in tunnel design can greatly affect catch rates. Relative abundance of sablefish in Chatham Strait, where some of the experimental work was conducted, appeared to be higher than in outside waters.

CONTENTS

INTRODUCTION

Sablefish (Anoplopoma fimbria) historically have been an important groundfish resource in the Gulf of Alaska, especially in southeastern Alaska where a domestic commercial sablefish fishery using longline gear has-existed since the early 1900's. Catches averaged 889 metric tons (t) round weight in 1958-74, mostly in inshore waters of Chatham Strait (Funk and Bracken 1984). Japanese long-lining vessels in the mid-1960's began intensively harvesting sablefish in the outside waters of southeastern Alaska and soon were eclipsing the relatively small domestic fishery. Japanese longline catches in the southeastern statistical area of the International North Pacific Fisheries Commission annually averaged 6,391 t in 1968-77 and peaked at 9,301 t in 1972 (McDevitt 1986). This foreign fishery was curtailed by U.S. quotas in 1977 and then was ended in 1978 when foreign long-lining was prohibited in waters of southeastern Alaska, east of 140°W longitude.

Domestic catches of sablefish in outside waters of southeastern Alaska generally have increased since 1975 (Table 1). Total U.S. catches in outside waters increased rapidly in 1977-79 as the competing foreign fleets were excluded. Catches decreased in 1980-81 because of unfavorable market conditions, followed by increases each year since 1981. However, catch quotas have kept the annual harvests to a much lower level than those during the unrestricted Japanese fishery of the early 1970's. Most catches have been taken in the area between Cape Spencer and Helm Point (Fig. 1); 71% of all sablefish caught by U.S. fishermen in outside waters of southeastern Alaska in 1977-84 came from this area (Table 1). The ex-vessel value of the catch in southeastern

Table 1.--Domestic catches of sablefish (Anoplopoma fimbria) (metric tons round weight) in southeastern Alaska waters, east of 140°W longitude, 1975-85 (Alaska Department of Fish and Game unpubl. data).

	Outside waters				
Year	South of Helm Pt.[a/]	Helm Pt. to Cape Spencer	Cape Spencer to 140°W Long.	Total	Inside waters
1975	168.9	217.6	165.9	552.4	1,001.9
1976	167.5	260.1	7.7	435.3	703.4
1977	19.4	602.8	133.3	755.5	412.4
1978	64.2	829.7	124.1	1,018.0	649.0
1979	380.4	1,383.2	561.6	2,325.2	916.9
1980	307.7	1,237.5	173.8	1,719.0	599.2
1981	232.8	1,012.8	79.5	1,325.1	494.2
1982	505.9	829.0	489.0	1,823.9	701.7
1983	168.5	1,747.1	390.3	2,305.9	801.6
1984	123.6	2,282.5	309.8	2,715.9	987.9
1985[b/]	-	-	-	2,962.5	1,580.1

a/ Includes waters of Dixon Entrance.
Catches not available for individual areas.

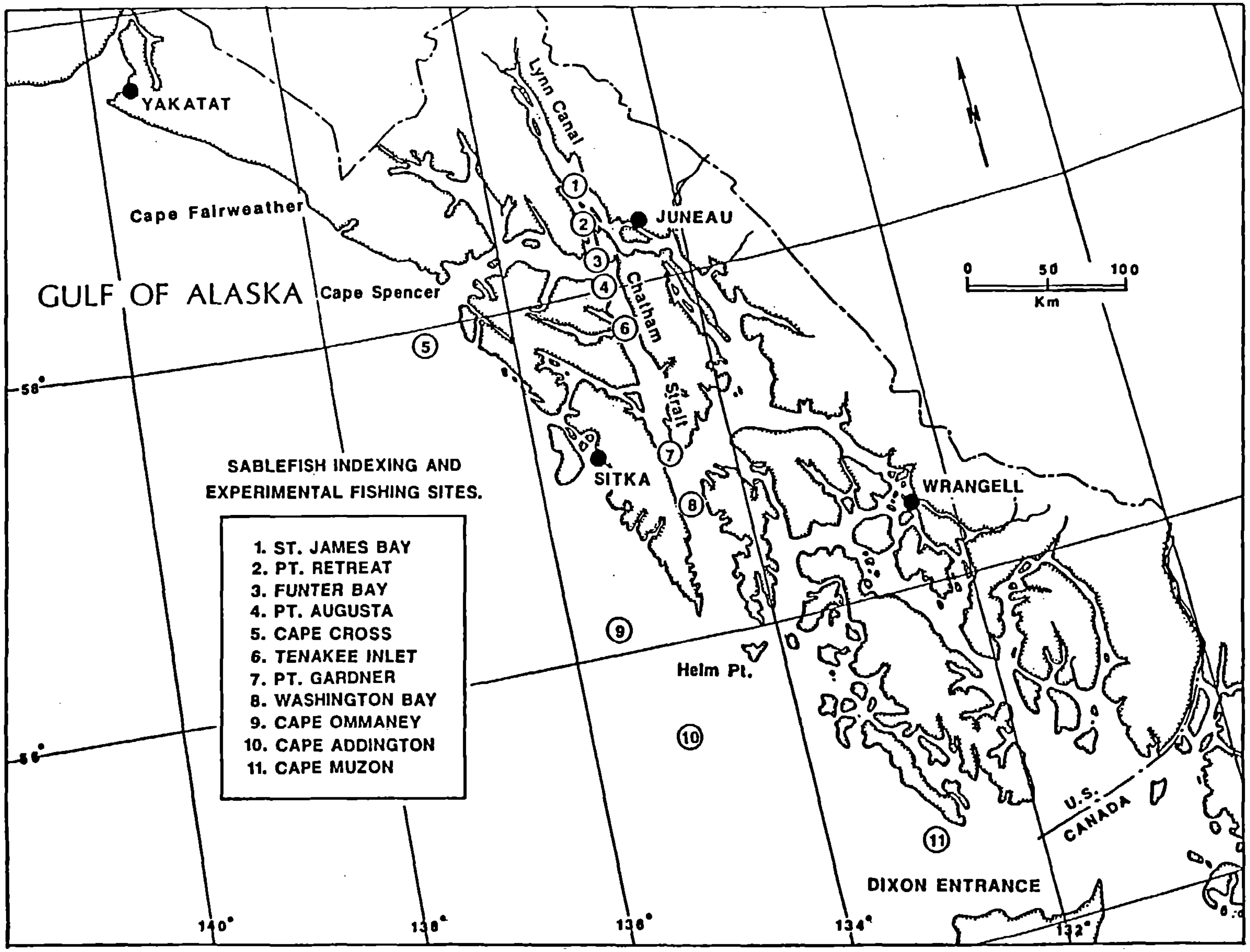

Figure 1.--Locations of sablefish (Anoplopoma fimbria) fishing areas listed in Table 1 and of sablefish indexing and experimental fishing sites, southeastern Alaska, 1978-85.

Alaska outside waters in 1985 was estimated at $4.4 million (Alaska Department of Fish and Game 1985), making sablefish the most valuable groundfish species in this region.

Formerly, fishery managers used catch and effort statistics from the Japanese longline fleet to monitor the condition of sablefish stocks off southeastern Alaska. These data were no longer available after 1977 when Japanese fishing ended in this area, and similar data have not been available from the domestic fleet. To overcome this loss of the Japanese database, the Northwest and Alaska Fisheries Center (NWAFC) has conducted annual indexing surveys of sablefish abundance in outside waters of southeastern Alaska since 1978. The surveys were conducted by the NWAFC Resource Assessment and Conservation Engineering (RACE) Division in 1978-81. The methods and results of these surveys are summarized in Zenger (1981). Since 1982, the surveys have been the responsibility of the NWAFC Auke Bay Laboratory (ABL), which also' conducted experimental studies in conjunction with the indexing surveys in 1983-84 to evaluate and improve the indexing techniques.

In this report, an updated overview of the sablefish indexing surveys in the outside waters of southeastern Alaska is provided. Results from ABL's 1982-85 surveys are presented along with the previously reported RACE results in 1978-81. Results of experimental studies on sablefish indexing techniques also are discussed.

SURVEY SITES AND METHODS

The NOAA research vessel John N. Cobb was used to annually survey four indexing sites, usually in June or July, in 1978-85 in outside waters of southeastern Alaska. Progressing from north to south, these sites were located off Capes Cross, Ommaney, Addington, and Muzon (Fig. 1). The Cape Muzon site was not surveyed in 1978.

Bottom trawling has been used in other areas of the Gulf of Alaska to generate area-swept biomass estimates of sablefish populations (Brown 1986). This method is impractical in the continental slope waters of southeastern Alaska inhabited by sablefish because rough bottom terrain precludes trawling in most locations. Thus, the sablefish survey methods in southeastern Alaska are based upon the abundance indexing technique, which consists of annually fishing baited traps at selected sites off the southeastern Alaska coast. This method provides information on trends in catch rates from year to year. The annual trends at these indexing sites are considered indicative of trends in abundance for the entire populationof sablefish in the outside waters of southeastern Alaska.

Traps were used for the surveys because catch data from this type of gear can be standardized more easily than that of longlines, the predominate gear in the commercial fishery. Standardization ensured that all catch rates, regardless of locations or years fished, were directly comparable and not biased by differences in fishing procedures. In contrast, data from longline catches are difficult to standardize because of hook saturation (i.e., when fish abundance is high or other species are competing for hooks, catches will be limited by the number of hooks available), bait loss from hooks, and the difficulty of standardizing fishing time of all hooks along the longline. Traps, however, do not have catch saturation or bait loss problems because 1) the volume of the traps is large enough that saturation did not occur at most levels of sablefish abundance and 2) the bait is within jars positioned inside the traps. Traps also can be fished for a precisely standardized time period. Thus, traps were selected as the most appropriate gear for indexing sablefish in southeastern Alaska.

Two designs of sablefish traps were fished in the surveys: rectangular and conical traps. Rectangular traps were used in 1978-82 in the first five indexing surveys. The dimensions of these traps were 0.86 x 0.86 x 2.44 m, and a single entry tunnel was located at one end (Hipkins 1974). Rectangular and conical traps were fished in the 1983 survey as part of a gear comparison test. The conical traps were in the shape of a truncated cone; diameter of the bottom ring was 1.37 m, and of the top ring, 0.85 m, and the height was 0.71 m. A single tunnel was located on the side of the trap. The gear test showed no significant difference in catch rates of sablefish between rectangular and conical traps and that conical traps were much easier to use (Clausen and Fujioka 1985). Based on these conclusions, only conical traps were fished in the 1984-85 surveys,

At the Capes Cross, Ommaney, and Addington sites, 50 sablefish traps were fished on the bottom each day. Each trap was baited with about 0.9 kg of chopped Pacific herring (_Clupea harengus pallasi_) in a perforated bait jar. Traps were set in five separate strings of 10 traps each; a string was composed of a 1,006-m groundline, and 10 attached traps were spaced equidistantly along the line (for diagram, see Zenger (1981)). At each site, strings were set at specific locations as close as possible to five depth contours: 274, 412, 549, 686, and 823 m (150, 225, 300, 375, and 450 fm). These depth contours corresponded to the depth range most commonly fished in the commercial fishery for sablefish in southeastern Alaska. Although sablefish are known to also inhabit greater depths (McFarlane and Beamish 1983a), time and gear constraints did not allow us to fish deeper than 823 m.

At the Cape Muzon site, the fishing scheme was slightly different because the five depth contours were not present. At this site, 40 traps (four strings of 10 traps each) were fished per day, and all strings were fished at the 412-m depth contour.

The traps were fished a standardized 24-hour period that constituted a set. Previous studies showed catches of sablefish in traps decreased with increasing fishing times (Hughes et al. 1970). For our surveys, 24 hours was chosen as the minimum practical time the traps could be fished, based on limitations of the crew's working day. The traps were usually set in the morning or early afternoon and hauled 24 hours later. In case the traps could not be retrieved because of stormy weather, each trap was fitted with a timed-release closing device (a magnesium-alloy link) that corroded and broke after 24 hours (?2 hours) in seawater and closed the entry tunnel of the trap (Zenger 1981).

Repetitive sets of the gear were made at each indexing site (Table 2). These replicates were necessary to obtain better annual indexing values for each site because daily sablefish catches in a string of traps were often highly variable. Five sets were made at each depth location at the Capes Cross, Ommaney, and Addington sites in 1979-81, and four sets were made at Cape Muzon in 1979-82. The numbers of sets were selected arbitrarily as the maximum that could be fished at four sites within the time allotted to the surveys. Poor weather in

Table 2.--Sumnary of sites fished in sablefish (Anoplopoma fimbria) indexing surveys, outside waters of southeastern Alaska 1978-1985.

Site	Dates fished	Strings of traps fished/day (No.)	Sets (No.)	Traps fished (No.)
		1978		
Cape Cross	7-13 Jul	5	5	250
Cape Ommaney	24-29 Jun	5	5	250
Cape Addington	10-16 Jun	5	5	250
		1979		
Cape Cross	23-29 Jun	5	5	250
Cape Ommaney	13-19 Jun	5	5	250
Cape Addington	3-10 Jun	5	5	250
Cape Muzon	7-15 Jul	4	4	160
		1980		
Cape Cross	24-29 Jun	5	5	250
Cape Ommaney	16-20 Jun	5	5	250
Cape Addington	6-14 Jun	5	5	250
Cape Muzon	6-10 Jul	4	4	160
		1981		
Cape Cross	20-25 Jun	5	5	250
Cape Ommaney	10-16 Jun	5	5	250
Cape Addington	2-8 Jun	5	5	250
Cape Muzon	7-12 Jul	4	4	160
		1982		
Cape Cross	4-6 Jun	5	3	150
Cape Ommaney	11-13 Jun	5	3	150
Cape Addington	31 May/15-17 Jun	5	4	200
Cape Muzon	20-24 Jun	4	4	149

Table 2.--Continued.

Site	Dates fished	Strings of traps fished/day (No.)	Sets (No.)	Traps fished (No.)
		1983		
Cape Cross[a]	7-9 Jun	5	3	149
Cape Ommaney[a]	2-6 Jun	5	3	149
Cape Addington	28-30 May	5	3	149
Cape Muzon	21-23 May	4	3	119
Cape Cross[b]	24-25 Jun	5	2	100
Cape Ommaney[b]	29-30 Jun	5	2	99
		1984		
Cape Cross[a]	5-8 Jun	5	3	150
Cape Ommaney[a]	9-16 Jun	5	3	145
Cape Addington	17-20 Jun	5	3	149
Cape Muzon	22-30 Jun	4	3	118
Cape Cross[b]	2-5 Jul	5	3	149
Cape Ommaney[b]	24-26 Jul	5	2	100
		1985		
Cape Cross	2-7 Jul	5	3	150
Cape Ommaney	9-13 Jul	5	3	150
Cape Addington	14-21 Jul	5	3	150
Cape Muzon	22-25 Jul	4	3	112

a/ Visit I
b/ Visit II

1982 allowed only three sets to be made at Capes Cross and Omnaney, and four sets at Cape Addington. Subsequent analyses showed that deleting the fourth and fifth sets from the data resulted in only a negligible change in indexing values (Fig. 2). Therefore, three sets of the gear were fished at each site after 1982.

Data collected annually at each site included the following:

1. Number of sablefish and incidental fish caught in each trap;
2. Measurements of all sablefish to the nearest centimeter fork length (FL) for length frequency distributions; and
3. Sex ratio and otoliths from a random subsample of sablefish at each. depth contour. (The otoliths were later used to determine age composition of the fish.)

All sablefish not sacrificed for sex determination and otolith extraction were tagged and released for migration studies. Preliminary results from the tagging studies are reported in Dark (1983) and Fujioka and Sigler (1984), and results from the ageing studies will be reported later.

Annual catch rates of sablefish were determined in terms of both weight and numbers. Estimates of the total kilograms of sablefish caught annually at each indexing site were computed using the measured FL's of the fish and a length-weight regression equation (Zenger 1981) for combined sexes of sablefish in southeastern Alaska. The estimates were then divided by the number of traps fished at a site, to calculate kilograms of sablefish caught per trap. For the analysis by numbers, sablefish were divided into three size categories according to value in the commercial fishery. These categories were as follows:

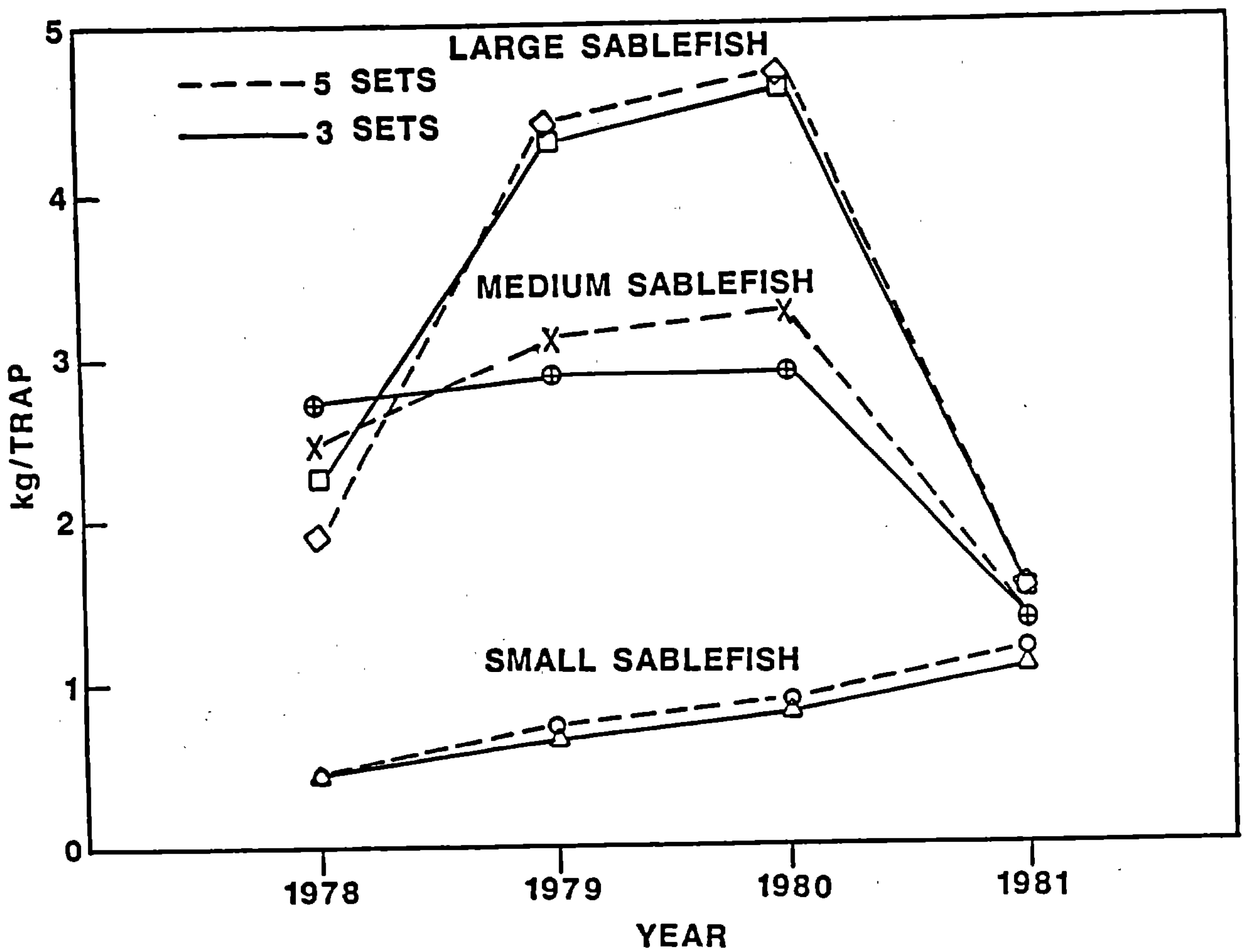

Figure 2.--Comparison of sablefish (Anoplopoma fimbria) catch rates for three sets versus five sets of gear at Capes Cross, Ommaney, and Addington indexing sites,- outside waters of southeastern Alaska, 1978-81. (Sablefish size categories are small = <57 cm FL, medium = 57-66 cm FL, and large =>167 cm FL.)

1. Small sablefish, <57 cm FL (<3 lb dressed weight, of relatively low commercial value);
2. Medium sablefish, 57-66 cm FL (3-5 lb dressed weight, of moderate value to commercial fishermen); and
3. Large sablefish, 167 cm FL (>5 lb dressed weight, highest in value to fishermen).

Mean numbers of small, medium, and large sablefish annually caught per trap were calculated for each site.

Annual indexing values for sablefish were computed by averaging the kilograms per trap data for each of the four sites. This computation was not done in 1978 when only three of the sites were fished. Differences in catches of sablefish by depth also were examned by combining data from the Capes Cross, Omnaney, and Addington sites for each of the five depth strata fished. Cape Muzon, where on y one depth' stratum was fished, was not included in this analysis.

EXPERIMENTAL Studies

Three experimental studies on indexing survey methods were conducted in 1983 and 1984, in addition to the actual surveys. The purpose of these experiments was to examine factors that could bias indexing survey results. The experiments included 1) a bait quality comparison between two batches of bait herring, 2) a visit comparison (i.e., fishing two indexing sites about 1 month after they were originally fished in the indexing surveys), and 3) a comparison between catches in conical traps with two designs of entry tunnels. Because results of these experiments have a bearing on interpretation of the indexing survey results, the methods, results, and discussion of each of these experiments will be presented first, followed by the indexing survey results.

Bait Quality Experiment

A basic assumption of the trap indexing surveys was that different batches of bait have not affected catch rates. Efforts were made each year to purchase the highest quality of bait herring available. However, during the 1982 survey, it was noticed that one batch of bait appeared to be of lower quality. This bait, which was discolored and mushy when thawed and had a slightly rancid odor, had been used to bait about one-half the traps fished in the 1982 survey, Because this bait may have affected catch rates, thereby biasing 1982 survey results, we conducted a bait quality experiment.

Methods

The experiment was conducted in April 1983 at three sites in the inside waters of southeastern Alaska. One site was located in Lynn Canal off St. James Bay, and two sites were located in Chatham Strait, one off Point Retreat and the other off Funter Bay (Fig. 1). At each site, four strings (40 traps) were fished per set, similar to the indexing surveys in outside waters. Five sets were made at Funter Bay, three sets at Point Retreat, and two at St. James Bay (Table 3).

Catches of sablefish using two different batches of bait herring were compared in the experiment. One batch was from the same lot used in the 1982 survey and appeared to be of lower quality. This bait had been frozen for at least 16 months prior to the experiment. The other batch was herring that we caught locally and quick froze to ensure high quality. This latter batch was frozen for 8 months before it was used.

Table 3.--Summary of sites fished during sablefish studies in Chatham Strait and Lynn Canal in the inside waters of southeastern Alaska, 1981-84.

Study	Site	Dates fished	Depth (m)	Strings of traps fished/set (No.)	Sets (No.)	Traps (No.)
ADF&G*	Pt. Augusta	19-22 May 1981	408-664	4	4	160
	Washington Bay	25-28 May 1981	512-695	4	4	160
Sablefish tagging	Funter Bay	27-30 Jun 1981	564-694	4	4	140
Bait quality	Funter Bay	9-11/19-20 Apr 1983	600-690	4	5	140
	Pt. Retreat	13-15 Apr 1983	490-619	4	3	105
	St. James Bay	17-18 Apr 1983	287-375	4	2	70
Tunnel design comparison	Pt. Retreat	17-21 May 1984	490-620	5	2	100
	Funter Bay	26-28 May 1984	538-672	6	2	120
	Pt. Gardner	29-31 May 1984	604-661	6	2	111
	Tenakee	11-22 Jul 1984	509-580	6	10	580

*Alaska Department of Fish and Game.

For each string (i.e., 10 traps), bait from the two batches was alternated from trap to trap; thus, for each string, five traps had lower quality bait, and five traps had higher quality bait. The traps were presumably spaced far enough apart to prevent differences in odor from affecting catches in the adjoining traps. Personal observations over the years caused us to believe this assumption was correct, but limited vessel time did not allow us to test the validity of this assumption. Numbers of sablefish caught by each type of bait were recorded.

A paired t-test was used to compare the numbers of sablefish caught with the two batches of bait. Mean number of sablefish caught per trap in each string was calculated for each batch of bait. These two mean values per string comprised the paired data for the test. The significance value of the t-test was determined using a randomization test (Edgington 1980) because the catches of sablefish in the traps did not appear to have a normal distribution.

Results and Discussion

Traps baited with the higher quality herring caught more sablefish than did those baited with lower quality herring. Overall, 881 sablefish were caught with higher quality bait and 706 with lower quality bait, a ratio of 1.25 to 1. The 95% confidence interval of this ratio was 0.99 to 1.49, while a l-tailed randomization test was significant at 2.5%. The lower quality herring apparently was not as effective as the higher quality herring in attracting sablefish into the traps.

Based on these results, the lower quality bait may have caused a reduction in sablefish catch rates during the 1982 indexing survey.

Ideally, a correction factor calculated from the experimental results could be applied to the 1982 survey to adjust upward the number of sablefish caught in traps with the lower quality bait and, thus, reduce the biases caused by the lower quality bait. However, the 1982 survey results could not be adjusted because the lower quality bait was not noted until after the start of the survey and instances in which the bait was used had not been recorded.

The 1982 survey results still appeared valid, however, even without correction. Difference in catch rates between baits, although statistically significant, was relatively small, with the higher quality bait catching only 25% more sablefish. Moreover, only about one-half the traps fished in the 1982 survey were baited with the lower quality herring. If a correction factor of 1.25 (the ratio from results of the bait quality experiment) was applied to the number of sablefish caught in these. traps, mean catch rates would change by a factor of only about 1.12. Increasing the mean catch rates of small, medium, and large sablefish at each indexing site in 1982 by 1.12 would not appreciably affect overall trends in sablefish abundance in the survey. Even in a worst-case scenario, where a correction factor of 1.49 (i.e., the upper end of the ratio's confidence interval) was used, catches would increase by only 1.24. Uncorrected catch rates in the 1982 survey were, therefore, used in all subsequent analyses.

Results of the bait quality experiment also indicated that differences in bait quality probably have not biased survey results in other years. Except for 1982, bait quality in the survey appeared to be consistently good from year to year, with no differences noticeable. If any undetected differences were occuring in these years, affects on the survey's catch rates presumably would have been less than those observed in the bait experiments. Therefore, based on the experiment, it is unlikely that minor differences in bait quality in years other than 1982 affected standardization of the surveys.

Visit Comparisons

Fishing a site only once in the indexing survey, with sets over a period of several consecutive days, may not adequately reflect the seasonal abundance of sablefish at that site. If local sablefish abundance at a site varies greatly from week to week or month to month, the present sampling scheme in the surveys would not provide valid indexing values. To investigate this problem, we fished two sites twice, once during and once after the trap indexing surveys. Each period of fishing at these sites is called a "visit" in the remainder of this report.

Methods

Visit comparisons were made at two sites, Capes Cross and Ommaney, in 1983 and 1984. In both years, three sets were made at each site during the regular indexing surveys (visit I). Each site was then fished again, about 14 to 38 days after the regular indexing surveys (visit II). During visit II, two sets were made at each site in 1983, and two sets were made at Cape Ommaney and three sets at Cape Cross in 1984 (Table 2).

Visit comparisons were also used to evaluate the effect of commercial fishing pressure on survey catch rates at the two sites in 1984. When the Capes Cross and Ommaney sites were fished during visit I in 1984, several commercial longline vessels were intensively fishing for sablefish in the immediate vicinity. These fishing operations could have caused a short-term depletion of the local sablefish population and biased survey results. When the sites were fished again in visit II, the commercial fishery had ended.

Paired t-tests were used to analyze results of the visit comparisons. For each visit, mean number of small, medium, and large sablefish caught per trap at a site was calculated for each of the five depth locations fished. The five mean values for each size category of fish in visit I at a site and-the corresponding five mean values in visit II at a site comprised the paired data. Thus, a total of 12 paired t-tests were made, 3 for each visit comparison in 1983 and 3 for each comparison in 1984.

Results and Discussion

Catch rates of each size category of sablefish were similar in each visit at the Capes Cross and Ommaney indexing sites in 1983 and 1984 (Table 4). Each of the 12 paired t-tests showed no significant difference between catches in visit I compared with visit II at the $P = 0.05$ level.

Table 4. --Number of small (<57 cm FL), medium (57-66 cm FL), and large (>67 cm FL) sablefish (*Anoplopoma fimbria*) caught per trap in each visit to the Capes Cross and Ommaney indexing sites, 1983-84.

Site	Visit	Sablefish caught/trap (No.)		
		Small	Medium	Large
		1983		
Cape Cross	I	0.62	0.66	0.14
	II	0.50	0.74	0.45
Cape Ommaney	I	0.87	0.68	0.27
	II	0.34	0.48	0.33
		1984		
Cape Cross	I	0.53	0.70	0.43
	II	0.42	0.82	0.48
Cape Ommaney	I	0.39	0.56	0.42
	II	0.49	0.64	0.34

Results of the visit comparisons indicated that temporal variations in the number of sablefish at each site were small, at least during the 2- to 5-week period between visits. Because numbers of sablefish caught in each visit were so similar, catch rates in any survey year appeared to be consistent and repeatable at each site. Apparently, fishing a site once for three sets provides a valid seasonal indexing of sablefish abundance at each site fished.

The 1984 visit comparisons also showed that commercial fishing around the Capes Cross and Ommaney indexing sites apparently did not affect survey results. Catch rates of sablefish in the first visits to the sites during the commercial fishery were nearly identical to catch rates in the second visits after the commercial fishery ended.

Tunnel Design in Conical Traps

Conical traps purchased in 1984 had entry tunnels that differed somewhat from those of the conical traps used in 1983. Tunnels of the 1983 traps led straight back into the interior, and the netting on the top and bottom of the tunnels was taut. Tunnels of the 1984 traps projected at an angle downwards into the interior, and the top drooped loosely instead of being taut, because its netting had more meshes than did the netting on the bottom. Otherwise, the two types of tunnels were designed similarly and were constructed of 5.1-cm nylon stretched mesh netting. Although the difference in tunnel design of the 1983 and 1984 traps appeared relatively minor, effect of the difference on catch rates was unknown. To ensure continued standardization of the indexing surveys, catch rates of the two types of conical traps were compared in 1984.

Methods

The two types of conical traps were fished at sites off Point Retreat, Funter Bay, and Point Gardner in Chatham Strait in May 1984 (Fig. 1; Table 3) and also were fished during the regular indexing survey in June and July 1984 at the four established sites, including visit II to Cape Cross (Table 2). At each site, the two types of traps were alternated along the groundlines so that a string was composed of five traps per tunnel design. Number of sablefish caught in each type of trap was recorded.

After both types of traps were fished at the above sites, the tunnels of the 1984 traps were modified to make them similar to the 1983 traps. Modification was done by raising the tunnels until they did not project downwards and by pulling the netting on top taut. These modified traps. and the 1983 traps were fished at Tenakee Inlet in July 1984 (Fig. 1; Table 3) and at Cape Ommaney in visit II (Table 2). The two types of traps were alternated along the groundlines, as at the previous sites.

Ratio estimators (Cochran 1963; Clausen and Fujioka 1985) and corresponding 95% confidence intervals were used to statistically compare sablefish catches in the two types of conical traps. A ratio estimator was defined as total number of sablefish caught in one type of trap divided by total number of sablefish caught in the other type of trap. A ratio estimator and confidence interval were computed based on pooled data from all strings of traps at sites where unmodified 1984 traps were fished. A separate ratio estimator and confidence interval were computed for pooled catch data at Tenakee Inlet and Cape Ommaney (visit II) where modified traps were fished.

Results and Discussion

The 1983 conical traps with taut tunnels were much more effective in catching sablefish than were the 1984 traps with drooping tunnels. The 1983 traps outfished the 1984 traps by 2.17:1. Ratio estimator analysis showed this difference to be highly significant. The 1.0 value (where total catch of sablefish in both types of traps would be equal) was far outside the 95% confidence interval of R (Table 5). Thus, the seemingly slight difference in tunnel design was shown to have a marked effect on catch rates.

Catches in the 1984 traps greatly increased when the tunnels were made identical to those in the 1983 traps. Sablefish catches in both types of traps were similar after the modifications; 1983 traps outfished modified 1984 traps by only 1.11:1. This difference was not statistically significant because the 1.0 value was within the 95% confidence interval of 5 (Table 5).

Table 5.--Ratio estimators and associated confidence intervals used to compare catches of sablefish (Anolopoma fimbria) in two types of conical traps, southeastern Alaska computed ratio estimator (number of sablefish caught in one type of trap divided by number of sablefish caught in the other type of trap), Var (R) = variance of R, and R = the underlying true ratio estimated by R.

Comparison	$\hat{R}$	Var ($\hat{R}$)	95% Confidence interval of R
1984 Traps (drooping tunnels) vs. 1983 traps (taut tunnels)	0.46	0.0016	$0.38 \leq R < 0.54$
Modified 1984 traps (taut tunnels) vs. 1983 traps (taut tunnels)	0.90	0.0049	$0.76 \leq R \leq 1.04$

These comparisons demonstrated that subtle differences in tunnel design can greatly affect catch rates of sablefish in conical traps.

Drooping tunnels were apparently the direct cause of low catches in the 1984 traps, as shown by the comparison made after the tunnels were modified. Taut trap tunnels are now standard features in all sablefish indexing surveys to ensure comparability of results.

Low catches in the unmodified 1984 traps introduced a bias into the 1984 survey results. To correct this bias, correction factors were computed at each site for the catches of sablefish in the 1984 traps. Each correction factor was calculated from data independent of the site itself and was based on the ratio of sablefish catches between 1983 and 1984 traps at all other sites. Correction factors were unnecessary for catch rates of sablefish from the Tenakee and Cape Ommaney (visit II) sites where modified 1984 traps were fished. Corrected data for 1984 are used in the remainder of this report.

SURVEY RESULTS AND DISCUSSION

Trends in Catch Rates and Size Composition

Overall catch rates of sablefish by weight at all indexing survey sites combined varied markedly (Fig. 3). Catch rates were stable in 1979-80 but decreased considerably in 1981. This decrease continued in 1982, when catch rates fell to only 3.9 kg/trap, the lowest in any survey year. Catch rates increased sharply in 1983, followed by a decrease in 1984 and another sharp increase in 1985.

Catch rates at individual sites generally followed the same trend as the combined data (Fig. 4). Catch rates in 1978 were relatively low at the three sites fished, and catch rates in 1979 and 1980 were variable at the sites. In 1981, similar to the combined data, catch rates decreased sharply at all sites. This decrease continued in 1982,

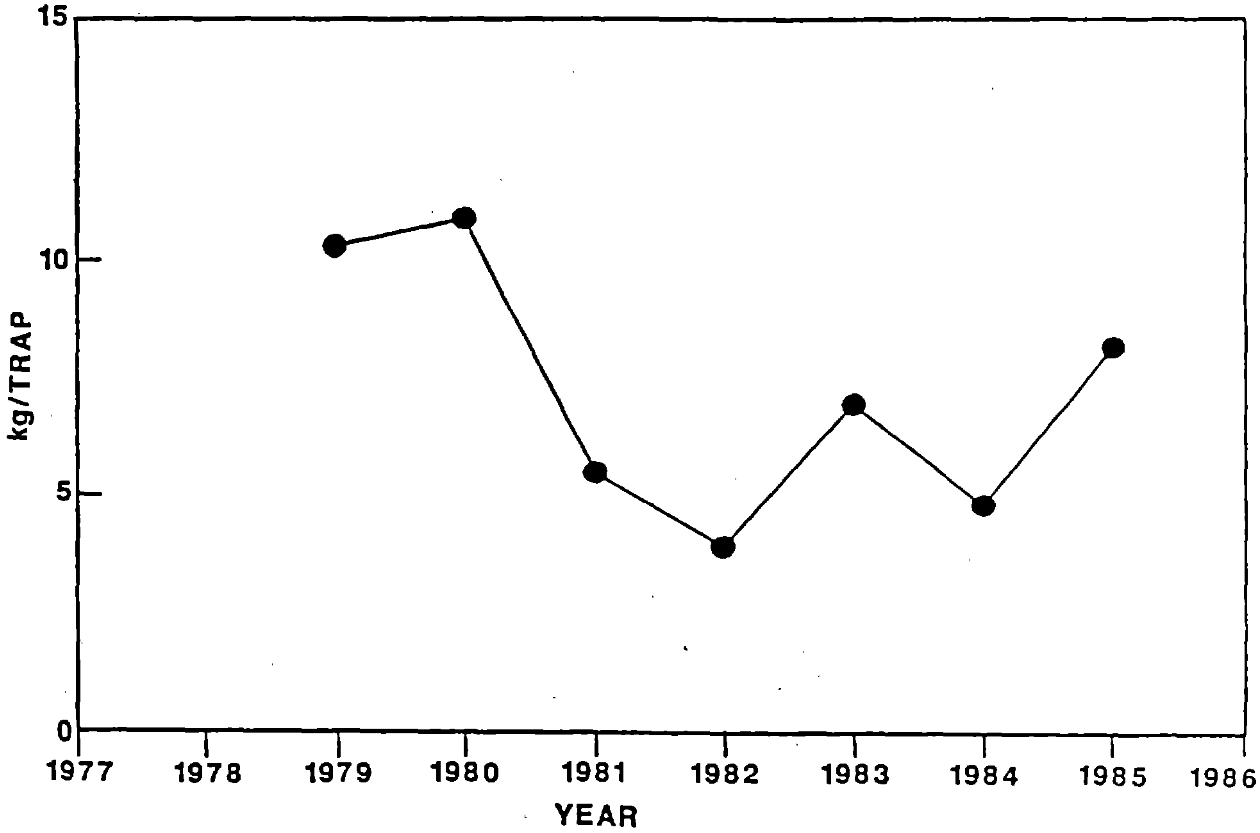

Figure 3. --Sablefish (Anoplopoma fimbria) catch rates based on combined data from four indexing sites, outside waters of southeastern Alaska, 1979-85. Data were not included for 1978, when only three indexing sites were fished.

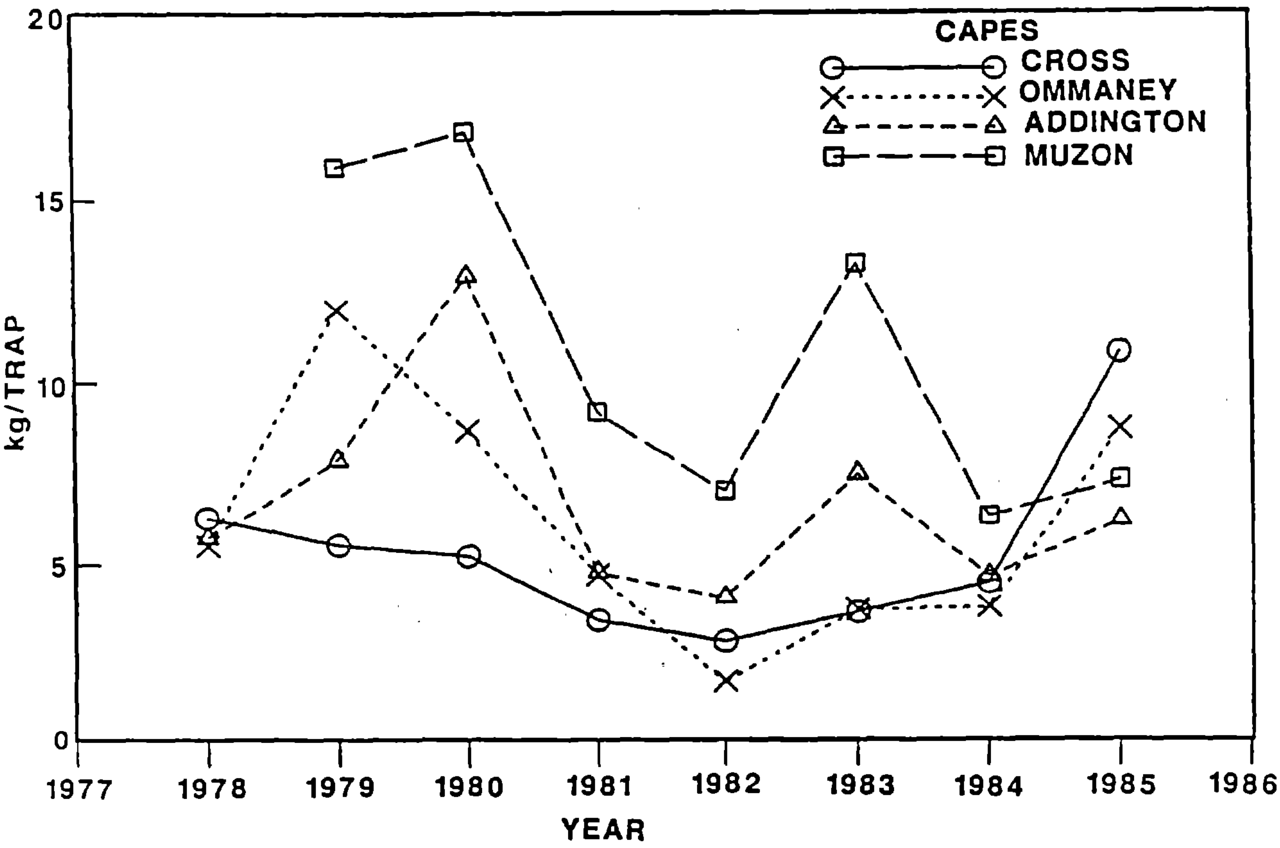

Figure 4.--Sablefish (Anoplopoma fimbria) catch rates at four indexing sites, outside waters of southeastern Alaska, 1978-85. The Cape Muzon indexing site was not fished in 1978.

when all sites except Cape Muzon showed their lowest catches. Catch rates after 1982 generally showed an upward trend. There were large increases at the two southern sites, Capes Addington and Muzon, in 1983, and at the two northern sites, Capes Cross and Ommaney, in 1985.

Trends in catch rates for the three size categories of sablefish can be used to more fully explain the overall trends in catch rates by weight (Fig. 5; Table 6). Decreasing overall catch rates by weight in 1980-82 were apparently caused by a sharp decrease in catches of medium- and large-sized sablefish. Catches of medium and large sablefish greatly decreased at all sites in 1980-81 and decreased again in 1982. Overall increases in catch rates in 1983 were attributable to increases in catches of small and medium fish. Increases in 1985 were mostly due to increases in catches of medium fish, along with some increases in large fish.

Trends in annual length frequency distributions for all sites combined (Fig. 6) were generally analogous to trends observed in the three size categories (Fig. 5). Length frequency distributions in 1978 essentially were symmetric and centered around 60-65 cm FL. Distributions after 1979 were markedly influenced by smaller sablefish, especially in 1982-83 when small sablefish dominated the length frequencies. Mean FL of sablefish decreased in 1979-82 from 64.4 to 58.2 cm FL partly because of the abundance of these small fish and also because fewer large sablefish were caught. Length frequency distributions in 1984-85 showed increasing sizes of sablefish. In 1985, fish averaged 62.7 cm FL and distributions were again symmetric, somewhat similar to 1978.

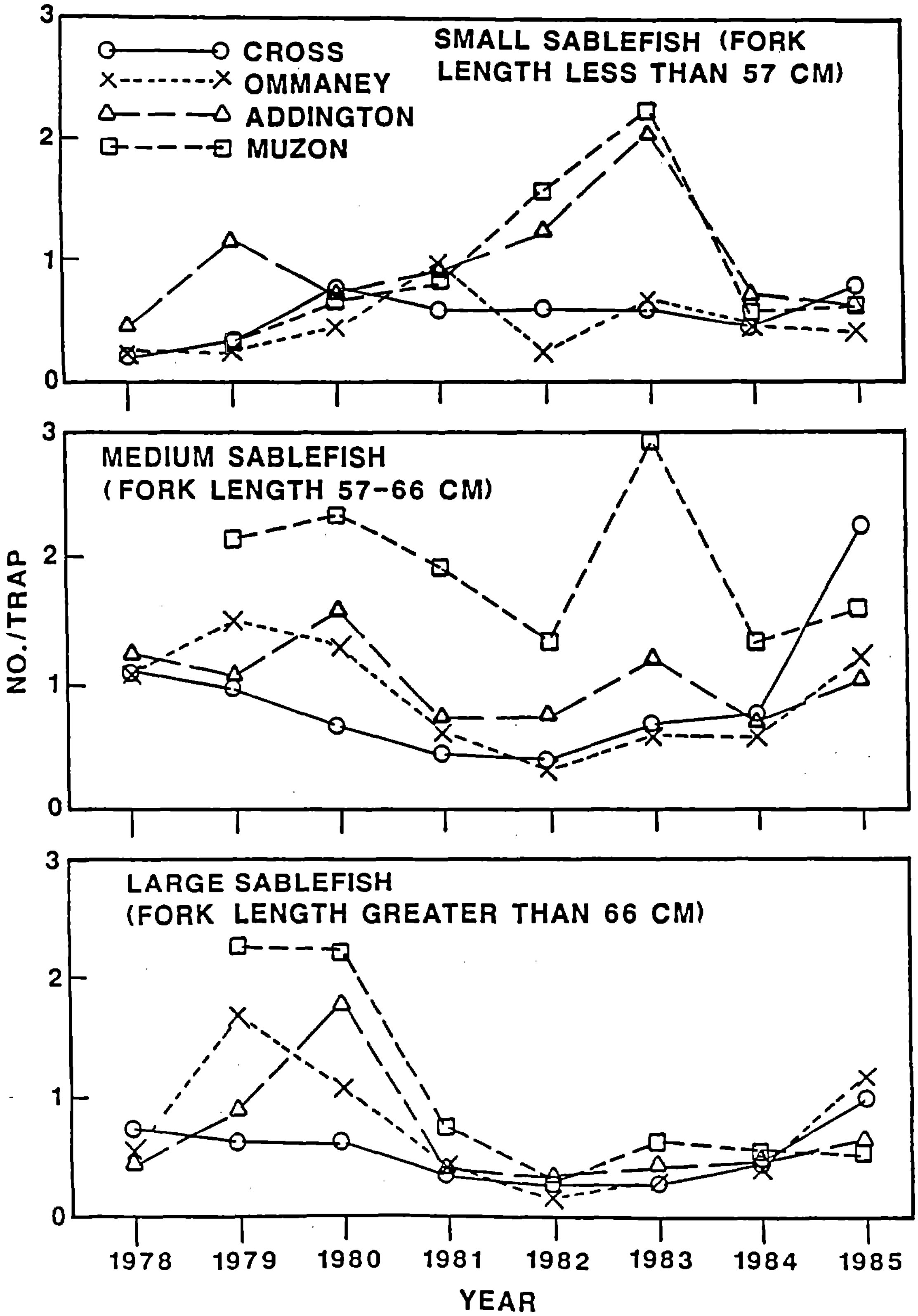

Figure 5.--Catch rates of sablefish (Anoplopoma fimbria) by size at four indexing sites, outside waterssoutheastern Alaska, 1978-85. The Cape Muzon site was not fished in 1978.

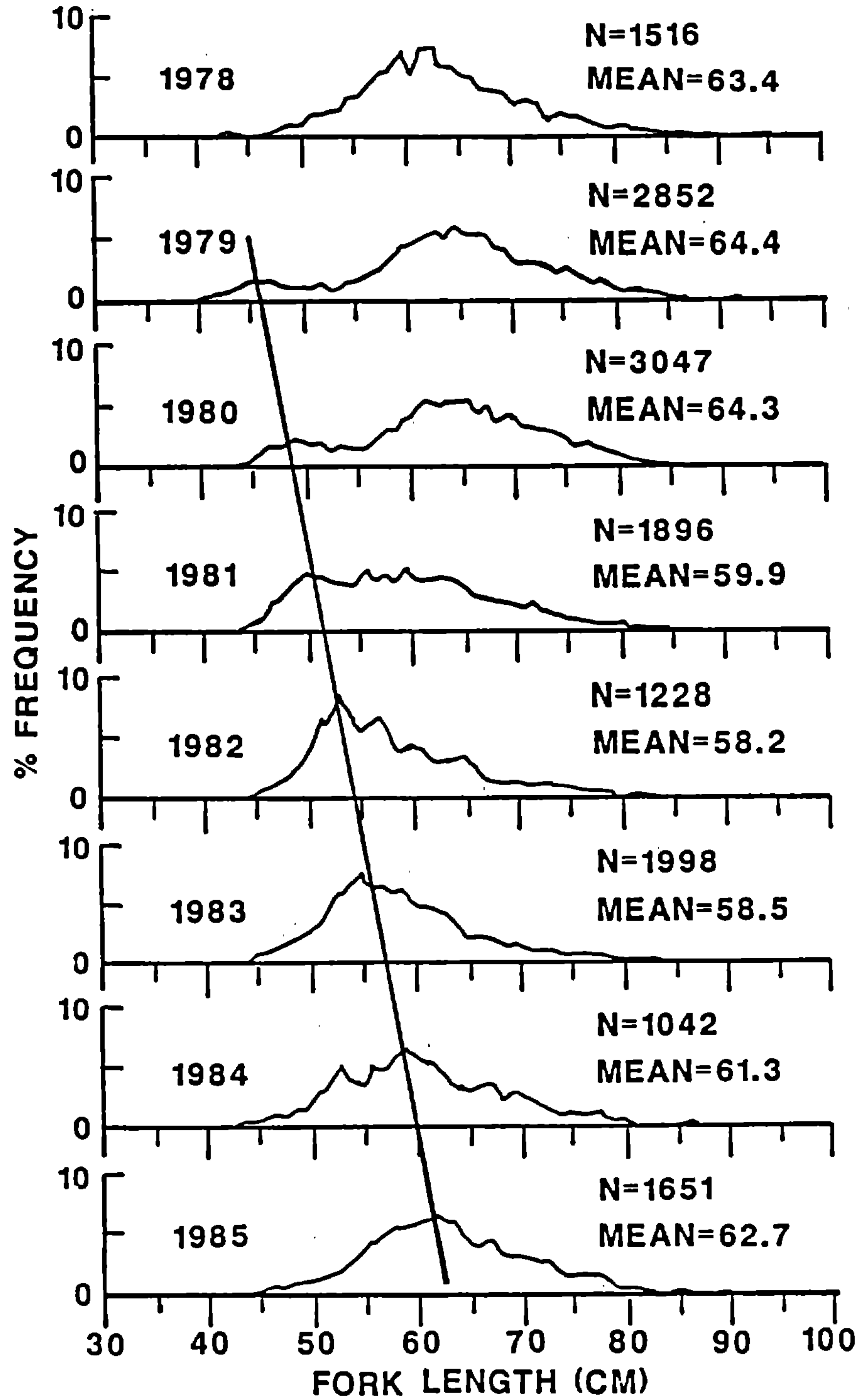

Figure 6.--Sablefish (Anoplopoma fimbria) length frequency distributions based on combined data from four indexing sites, outside waters of southeastern Alaska, 1978-85. Graph for 1978 does not include the Cape Muzon site. Dark bar identifies the modes probably corresponding to the 1977 year class.

Table 6. --Summary of catches of small (<57 cm FL), medium (57-66 cm FL), and large (>67 cm FL) sablefish (Anoplopoma fimbria) at four indexing sites, outside water of southeastern Alaska, 1978-85. (Numbers of sablefish caught are in parentheses.)

Year	No. sablefish caught per trap		
	Small	Medium	Large
Cape Cross			
1978	0.21 (52)	1.10 (274)	0.73 (182)
1979	0.29 (73)	0.97 (242)	0.62 (156)
1980	0.76 (190)	0.66 (165)	0.60 (149)
1981	0.59 (148)	0.43 (107)	0.33 (82)
1982	0.59 (88)	0.39 (59)	0.23 (34)
1983 a/	0.57 (142)	0.69 (171)	0.26 (65)
1984 a/, b/	0.46 (138)	0.77 (230)	0.46 (137)
1985	0.78 (117)	2.25 (335)	0.97 (144)
Cape Ommaney			
1978	0.23 (58)	1.10 (276)	0.55 (138)
1979	0.24 (59)	1.50 (376)	1.67 (418)
1980	0.44 (111)	1.30 (325)	1.06 (265)
1981	0.97 (242)	0.63 (157)	0.42 (106)
1982	0.23 (34)	0.32 (48)	0.14 (21)
1983 a/	0.67 (165)	0.60 (149)	0.29 (72)
1984 a/, b/	0.45 (110)	0.59 (144)	0.38 (92)
1985	0.39 (57)	1.24 (182)	1.16 (170)
Cape Addington			
1978	0.46 (114)	1.24 (310)	0.45 (112)
1979	1.15 (287)	1.08 (271)	0.87 (218)
1980	0.70 (175)	1.57 (393)	1.77 (442)
1981	0.90 (224)	0.74 (184)	0.38 (95)
1982	1.23 (246)	0.75 (149)	0.31 (61)
1983	2.07 (309)	1.20 (179)	0.39 (58)
1984 b/	0.69 (102)	0.70 (104)	0.44 (65)
1985	0.61 (91)	1.07 (160)	0.61 (91)

Table 6. --Continued.

Year	No. sablefish caught per trap		
	Small	Medium	Large
		Cape Muzon	
1978c/	-	-	-
1979	0.33 (52)	2.14 (342)	2.24 (358)
1980	0.67 (107)	2.33 (372)	2.21 (353)
1981	0.80 (128)	1.92 (307)	0.73 (116)
1982	1.58 (235)	1.34 (200)	0.29 (43)
1983	2.26 (269)	2.92 (347)	0.61 (72)
1984b/	0.55 (65)	1.34 (158)	0.49 (58)
1985	0.62 (69)	1.61 (179)	0.50 (56)

a/Includes combined catches for visits I and II.
b/ Includes corrected data for catches in conical traps with drooping tunnels.
c/Not fished.

Length frequencies for individual indexing sites (Figs. 7-10) showed annual changes that were similar to the combined data. Length frequencies at each site were symmetric in the first years of the surveys, were skewed toward smaller sablefish in 1980-83, and again appeared symmetric in 1984-85.

One dominant year class of sablefish, believed to be the 1977 year class, was strikingly apparent in the length frequency data (Fig. 6). This year class first appeared in 1979 as a small mode of fish centered around 45 cm FL. Based on information on growth of young sablefish in Canadian waters (McFarlane and Beamish 1983b), these fish were probably age 2+, making them members of the 1977 year class. This year class can be traced through each subsequent year of the surveys as the fish grew (Fig. 6). In 1982-83, this year class dominated the length frequencies 'as fish of 50-60 cm FL. The high catch rates of small- 'and medium-sized fish in 1983 (Fig. 5) apparently were caused by the 1977 year class. .Even in 1984-85, effects of the 1977 year class can be seen as a modal shift in length frequencies as these fish continued to grow. Other than the 1977 year class, no particularly strong year classes are evident in the length frequency distributions.

The strong 1977 year class was noted by many investigators in other areas of the northeastern Pacific Ocean. Existence of this dominant year class was reported in the Bering Sea (Umeda et al. 1983), in the Aleutian Islands and throughout the Gulf of Alaska (Sasaki 1985a), and off British Columbia (McFarlane and Beamish 1983a). Funk and Bracken (1984) suggested year class strength in sablefish appeared highly variable from year to year, with infrequent strong year classes contributing greatly to stock abundance. Results of the indexing

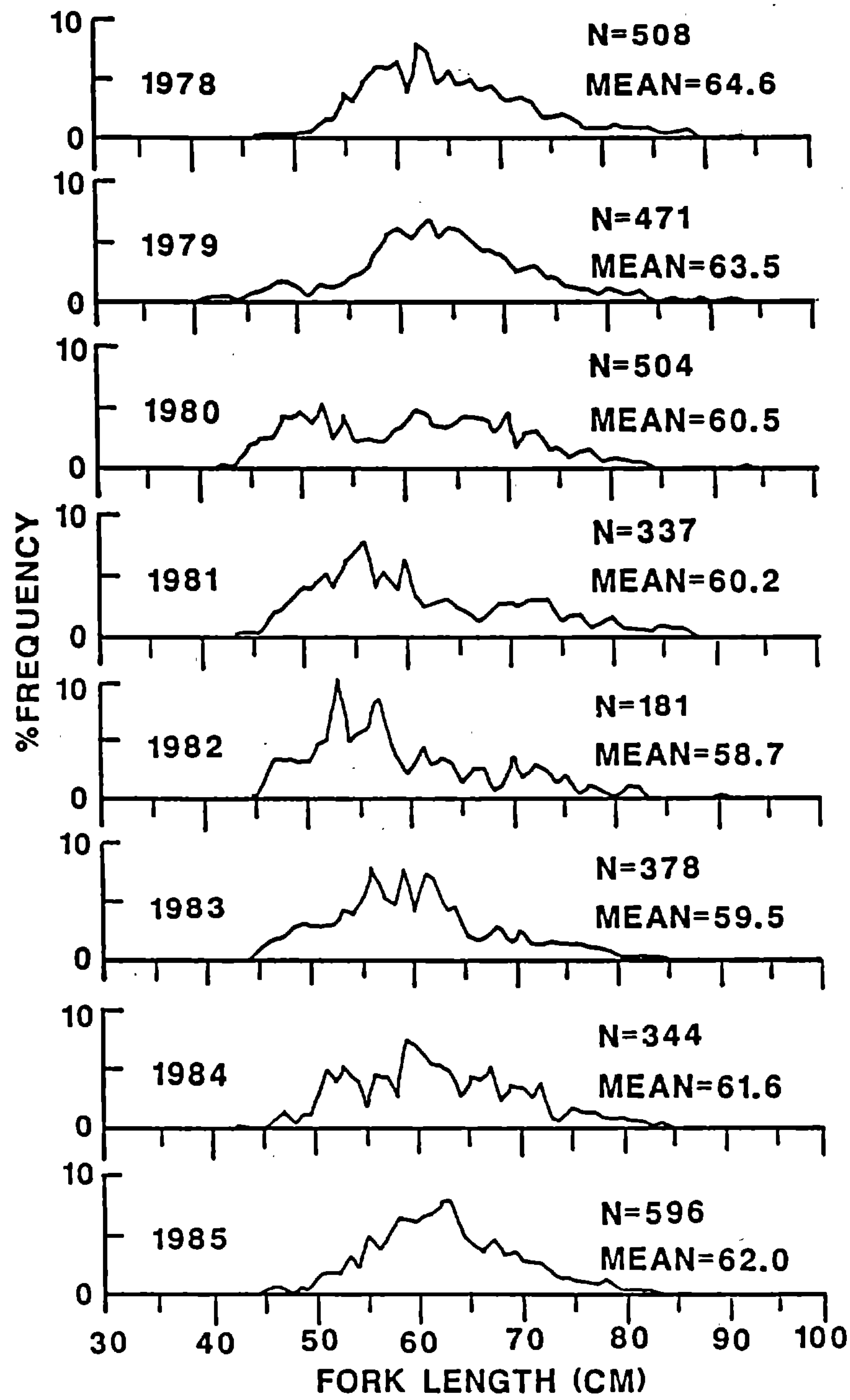

Figure 7.--Sablefish (Anoplopoma fimbria) length frequency distributions at the Cape Cross indexing site, outside waters of southeastern Alaska, 1978-85.

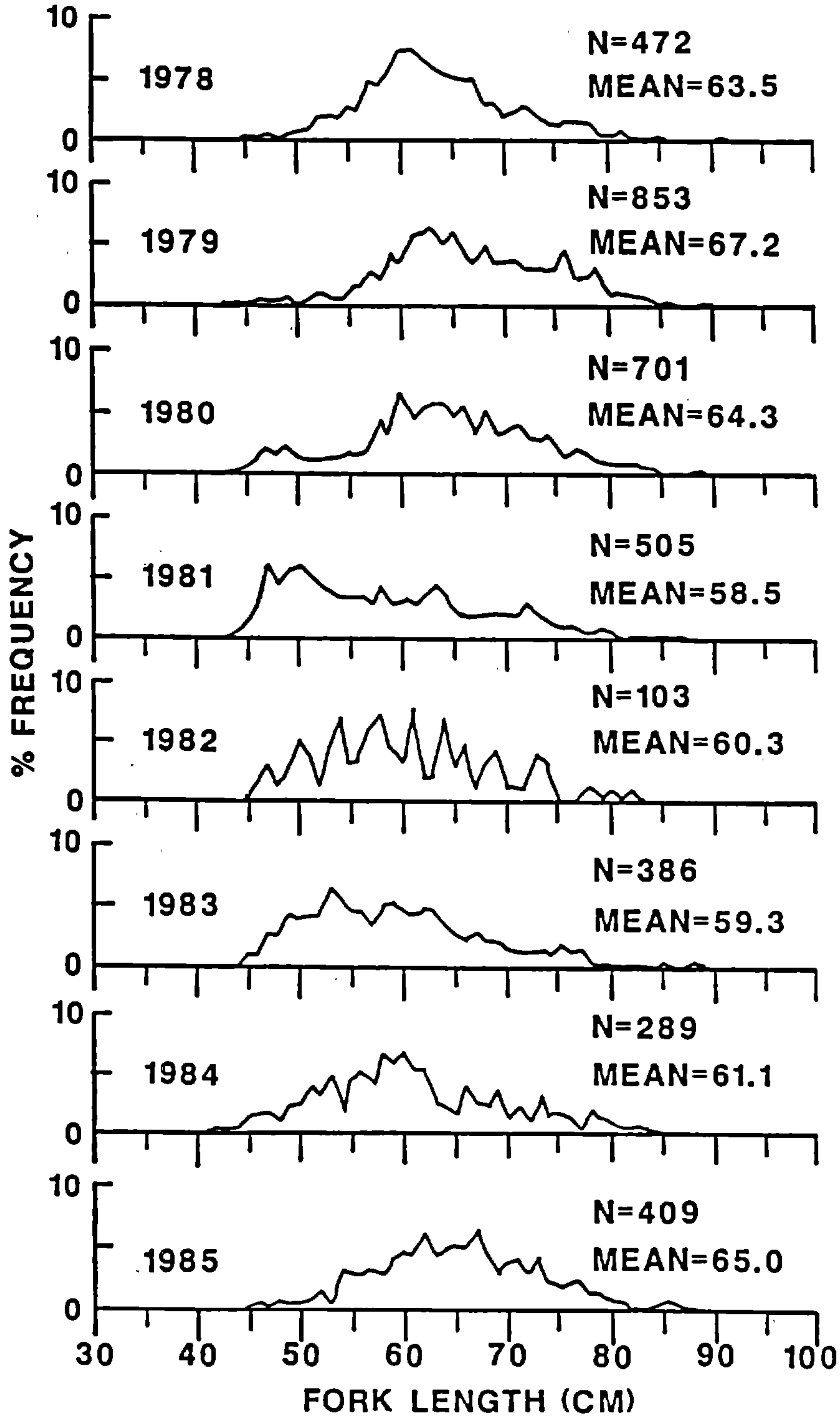

Figure 8.--Sablefish (Anoplopoma fimbria) length frequency distributions at the Cape Ommaney indexing site, outside waters of southeastern Alaska, 1978-85.

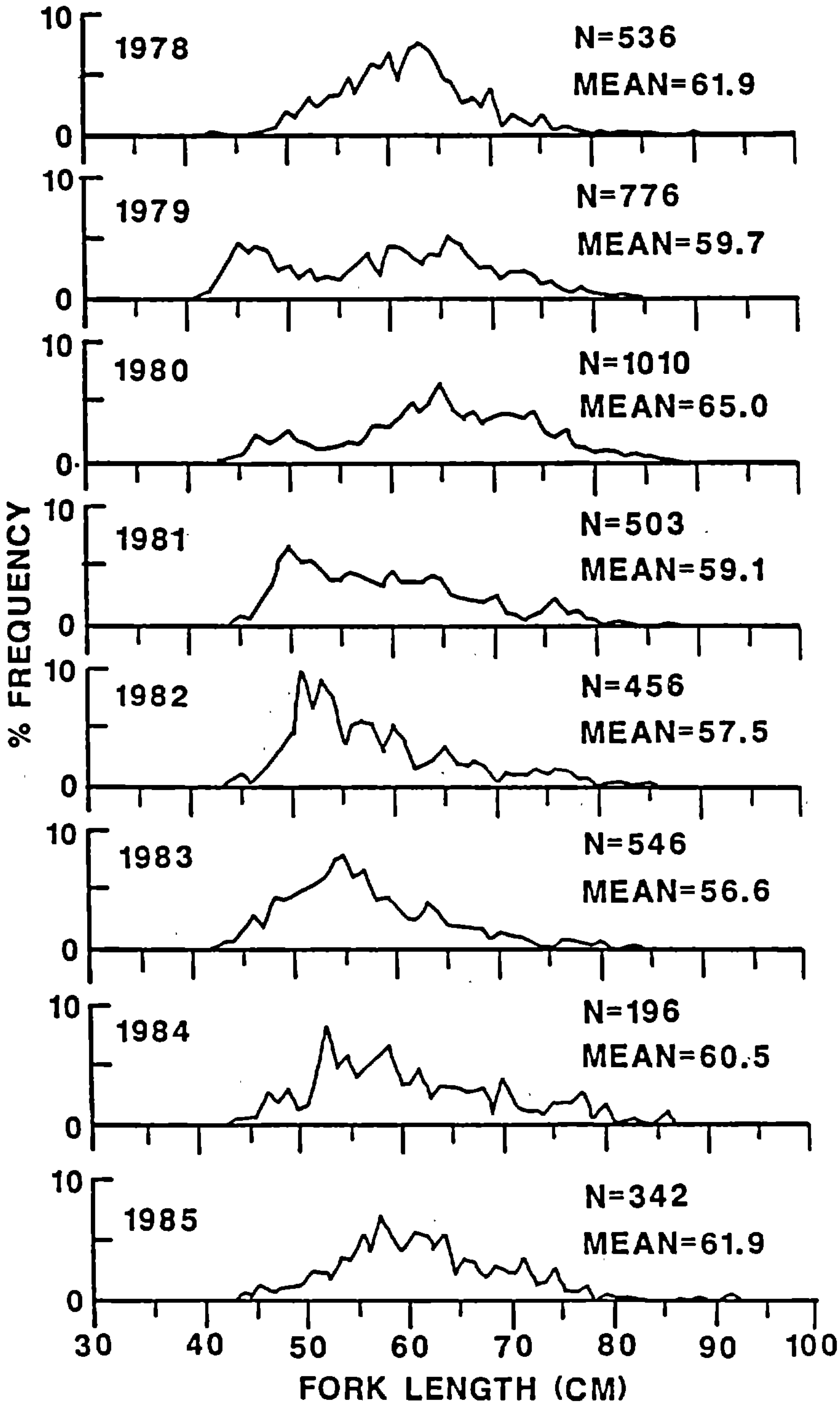

Figure 9.--Sablefish (Anoplopoma fimbria) length frequency distributions at the Cape Addington indexing site, outside waters of southeastern Alaska, 1978-85.

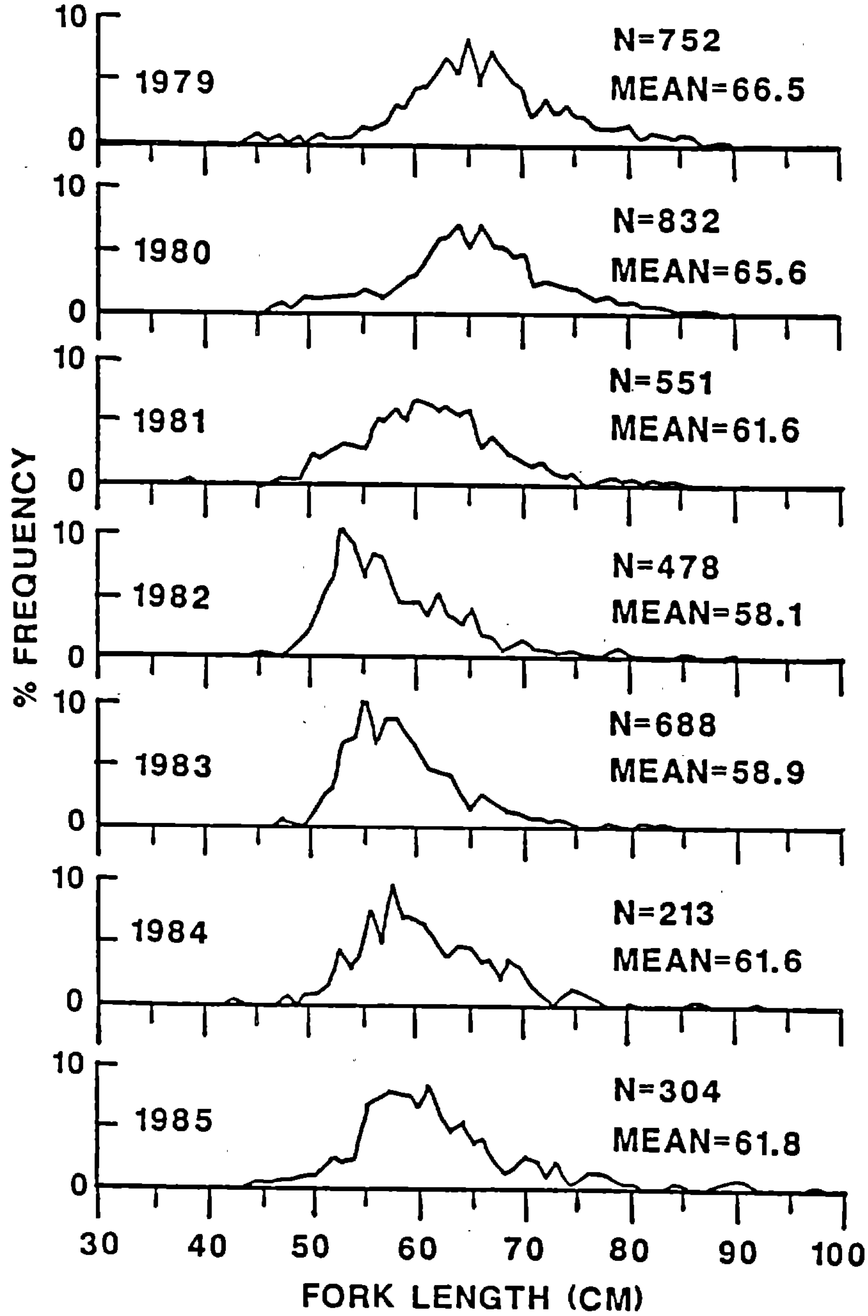

Figure 10.--Sablefish (Anoplopoma fimbria) length frequency distributions at the Cape Muzon indexing site, outside waters of southeastern Alaska, 1979-85.

surveys in southeastern Alaska, where only one strong year class was identified over an 8-year period, support this hypothesis.

Depth Distribution

Annual sablefish catch rates in the surveys were always lowest at the shallowest (274-m) depth fished, whereas catch rates were variable at other depths (Figs. 11 and 12). Catch rates were relatively high in 1978-80 at the three deepest (549-, 686-, and 823-m) strata; however, rates reached a distinct peak in 1981 and in 1983-85 at the 549-m depth, with lower rates above and below this depth. Catch rates in 1982, when at their lowest level in the surveys, were similar at all depths.

Annual mean FL's of sablefish were generally similar at all depths fished (Table 7). This similarity was especially pronounced in 1978 and in 1984-85. However, in 1979-80 and to a lesser degree in 1981-83, fish tended to be smaller at the 274-m depth. In 1979-80, these smaller fish probably reflected the initial recruitment of the 1977 year class to continental slope waters. Results from longline surveys in the Gulf of 'Alaska also showed small, 1977 year-class fish first appearing strongly in waters <400 m in 1979-80 (Sasaki 1979, 1981).

Other studies on sablefish depth distributions showed results similar to the trap indexing surveys. Longline surveys for sablefish in outside waters of southeastern Alaska had highest catch rates of sablefish from the 400- to 800-m depths and had much lower catch rates at <400 m (Sasaki 1984, 1985a, 1985b). Similar trends were observed off British Columbia (McFarlane and Beamish 1983a), Washington and Oregon (Parks 1984)) and in the Bering Sea (Kulikov 1965). In these latter three areas, FL's of sablefish were similar at all depths >200-400 m, analogous to results of the indexing surveys.

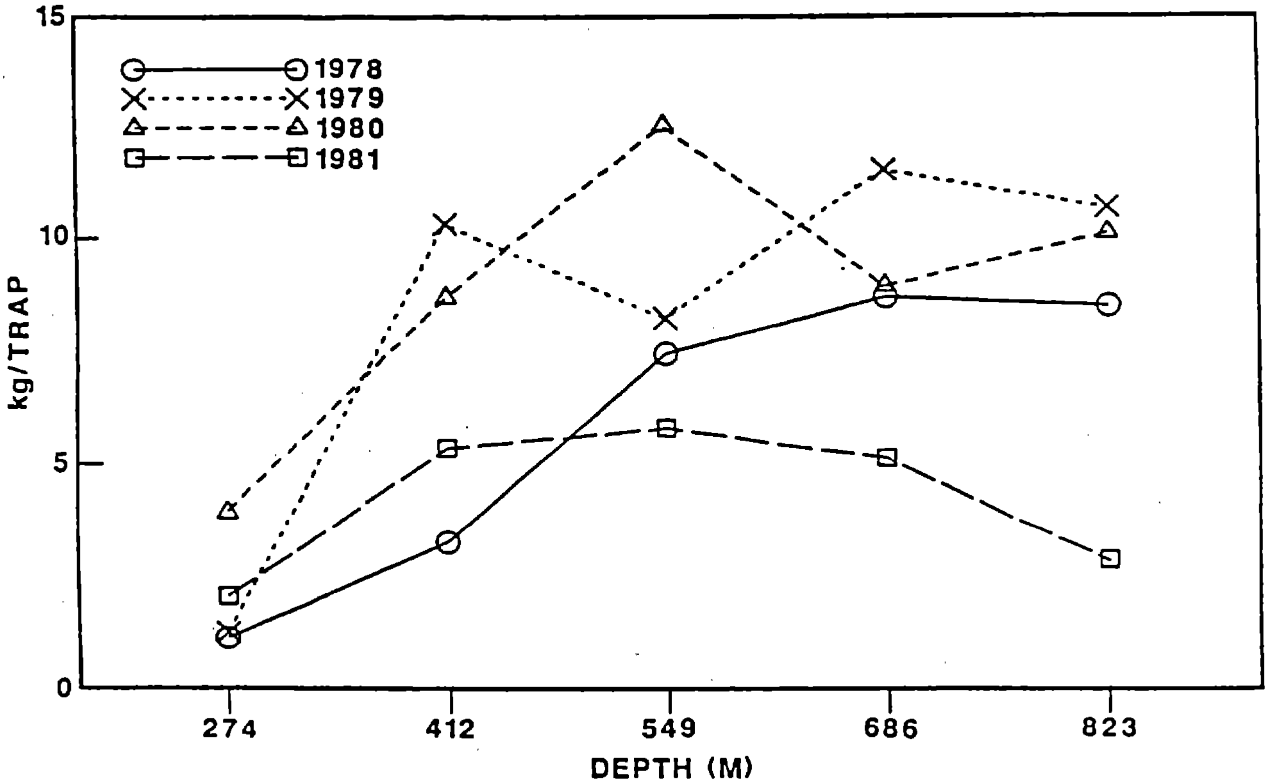

Figure 11.--Depth distribution of sablefish (Anoplopoma fimbria) catch rate at the Capes Cross, Ommaney, and Addington indexing sites combined, outside waters of southeastern Alaska, 1978-81.

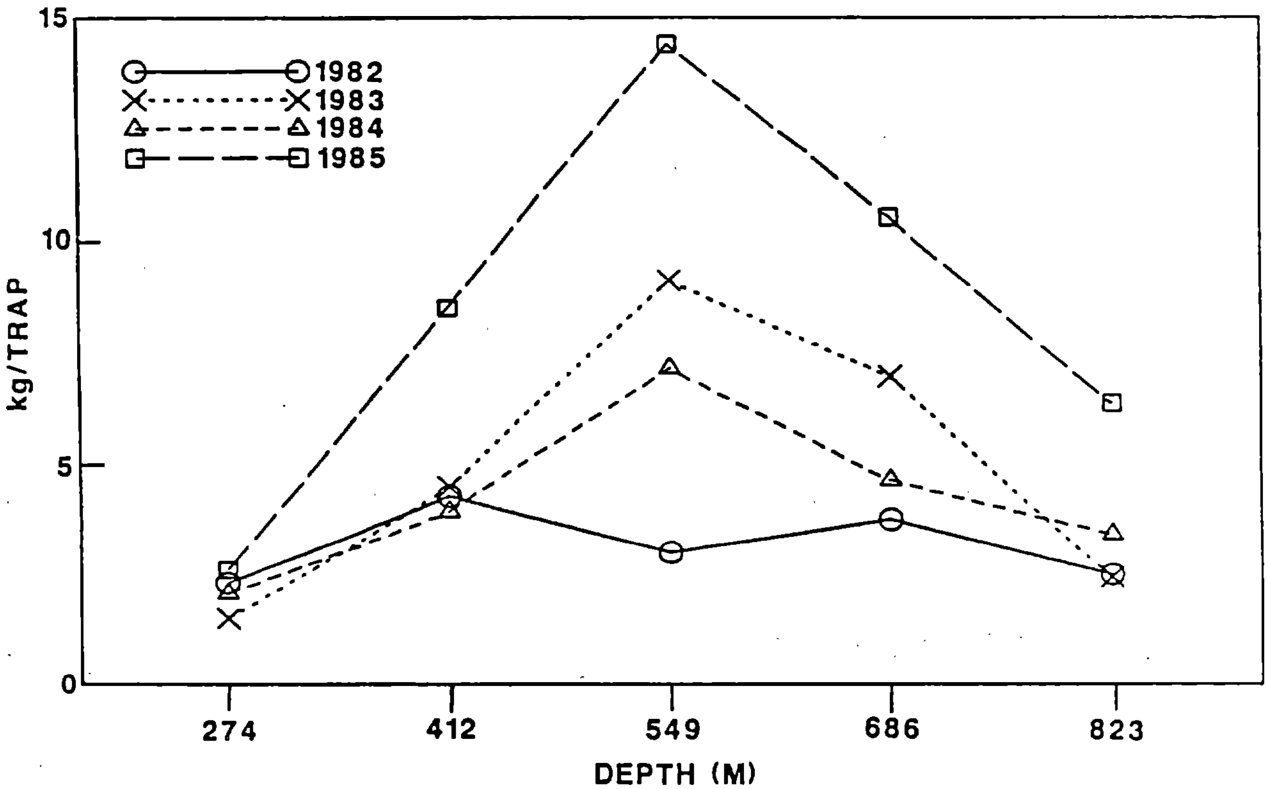

Figure 12.--Depth distribution of sablefish (Anoplopoma fimbria) catch rate at the Capes Cross, Ommaney, and Addington in-sites combined, outside waters of southeastern Alaska, 1982-85.

Table 7.--Mean fork length (FL) of sablefish (Anoplopoma fimbria) by depth of capture during sablefish indexing surveys at Capes Cross, Ommaney, and Addington sites, outside waters of southeastern Alaska, 1978-85. (Numbers of sablefish caught are in parentheses.)

Year	Mean FL (cm) by depth				
	274 m	412 m	549 m	686 m	823 m
1978	62.8 (62)	63.6 (172)	63.3 (382)	62.7 (483)	64.1 (417)
1979	52.8 (109)	67.6 (437)	61.7 (447)	62.5 (621)	65.5 (486)
1980	58.8 (253)	67.6 (206)	61.7 (684)	64.3 (438)	66.1 (465)
1981	57.6 (143)	60.5 (324)	58.5 (379)	57.8 (361)	62.6 (138)
1982	54.5 (144)	59.7 (197)	56.3 (159)	59.2 (160)	62.6 (90)
1983	56.4 (85)	60.6 (199)	57.6 (498)	59.6 (437)	64.0 (91)
1984	64.7 (60)	63.1 (123)	60.0 (291)	60.4 (278)	62.7 (77)
1985	63.1 (81)	64.3 (251)	61.8 (508)	62.3 (322)	64.7 (185)

Sex Composition

The overall ratio of male to female sablefish was about 1:1 in most survey years (Table 8). Similarly, sex ratio of sablefish in British Columbia also may be close to 1:1 (McFarlane and Beamish 1983a). However, in the indexing surveys in 1978, 1982, and 1985, the percentage of males was higher than females. The reason males predominated during these years is unknown, but this predominance may reflect localized, fortuitous variations in sex composition at the indexing sites rather than the true sex ratio of the population.

Table 8.--Sex composition of sablefish (Anoplopoma fimbria) randomly subsampled at all sites and depths-g the sablefish indexing surveys, outside waters of southeastern Alaska, 1978-85.

Year	Males (%)	Females (%)	N
1978	66.7	33.3	790
1979	51.5	48.5	1,146
1980	52.4	47.6	1,702
1981	49.2	50.8	891
1982	59.3	40.7	668
1983	51.4	48.6	399
1984	52.1	47.9	326
1985	65.5	34.5	670

Geographic Differences in Catch Rates

Catch rates of sablefish were higher in most survey years at the two southern sites, Capes Addington and Muzon, than at the northern sites, Capes Cross and Ommaney (Fig. 4). Catches in 1985 were an exception to this pattern. The pattern was contrary to reported catches in the commercial fishery in which most fish were caught between Cape Spencer and Helm Point in outside waters of southeastern Alaska (Table 1). This possible discrepancy between survey catches and commercial catches was particularly evident at the Cape Cross site. Catches at the Cape Cross site were generally the lowest of the four survey sites, yet the area around the site appeared to be a major fishing ground for the commercial fleet.

The causes of these geographic differences between catches in the surveys and catches in the commercial fishery are unclear. Evidently, commercial fishing effort in the southern part of southeastern Alaska has been low, possibly because most processing plants that buy sablefish are located in the northern part of southeastern Alaska. In past years, fishermen in outside waters apparently were able to take most of the sablefish quota from the area between Cape Spencer and Helm Point, closer to port, without having to run the longer distance to fishing grounds south of Helm Point. Based on catch rates in the indexing surveys, greater commercial fishing effort apparently could have been directed toward sablefish in the southern part of southeastern Alaska.

At first glance, data for the Cape Muzon site appear biased because only one depth stratum (412 m) was fished, whereas five depth strata, including the relatively unproductive 274-m stratum, were fished at the other sites. However, when catch rates at the four sites were compared for just the 412-m stratum (Fig. 13), they were higher at the Cape Muzon site than at the two northern sites. As before, the 1985 survey was an exception to this trend.

Relative Abundance in Inside Waters

Although the primary objective of the studies in Chatham Strait and Lynn Canal was experimental, the sampling provided data on sablefish abundance in these inside waters. In addition to the sites fished in 1983-84, three sites in Chatham Strait were fished in 1981 using the same standardized trap gear (Fig. 1; Table 3; see also Zenger 1981). Thus, since 1981, seven sites have been fished in Chatham Strait and Lynn Canal, and two of these sites have been fished in more than one year. Similar to the analysis for the indexing surveys, kilograms of sablefish caught annually per trap were computed for each of these sites. Length frequency distributions of sablefish were also determined for each site.

Catch rates at some survey sites in Chatham Strait and Lynn Canal were relatively high (Table 9). St. James Bay, where most traps were fished at <350-m depth (Table 3), had by far the lowest catches, similar

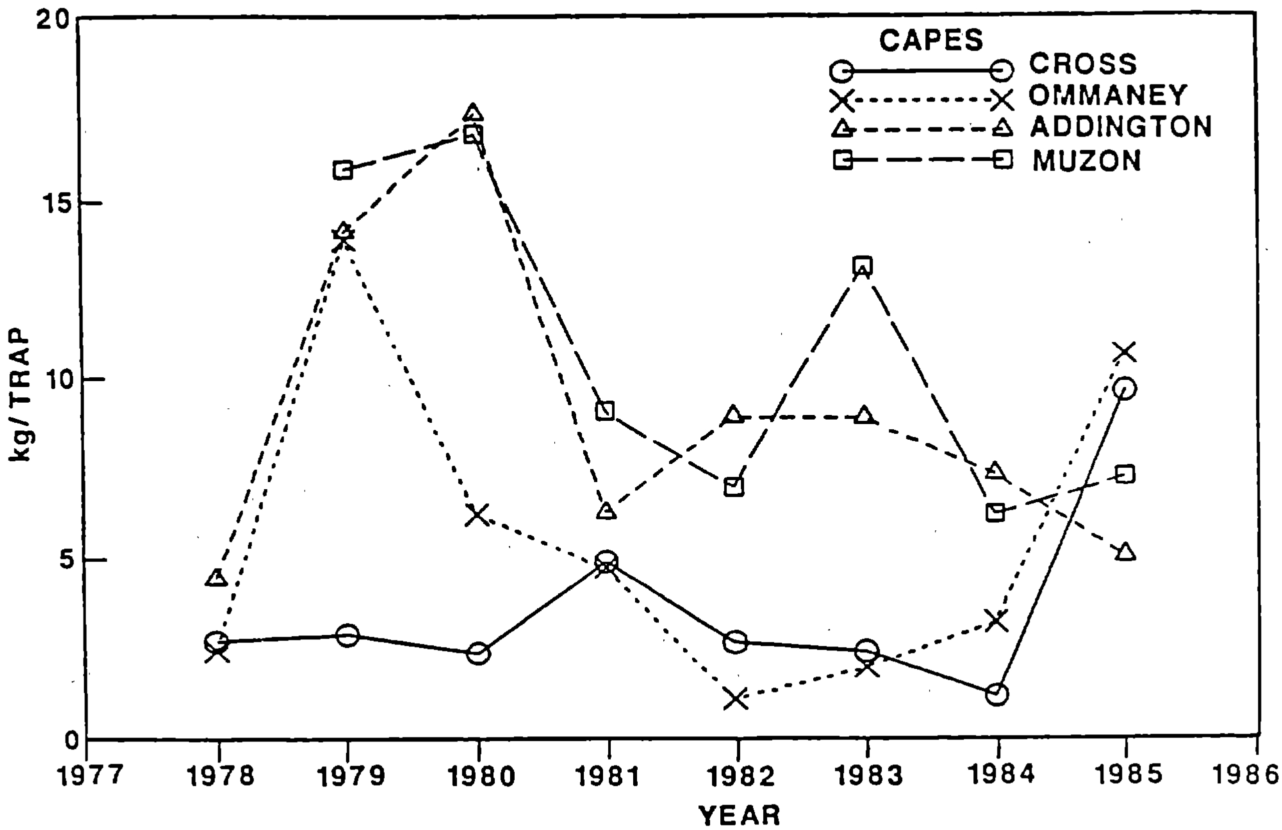

Figure 13.--Sablefish (Anoplopoma fimbria) catch rates at the 412-m depth stratum, outside waters of southeastern Alaska, 1978-85. The Cape Muzon indexing site was not fished in 1978.

Table 9.--Catch rates of sablefish (Anoplopoma fimbria) at sites in Chatham Strait and Lynn Canal in inside waters of southeastern Alaska, 1981-84.

Site	Year	Sablefish caught (No.)	Sablefish caught/ trap (kg)
Point Augusta	1981	658	8.43
Washington Bay	1981	1,306	16.94
Funter Bay	1981	1,365	19.68
	1983	1,171	18.06
	1984	123	4.13*
Point Retreat	1983	551	11.75
	1984	174	6.07*
St. James Bay	1983	25	0.48
Point Gardner	1984	703	23.33*
Tenakee	1984	3,481	16.53

*Includes corrected data for catches in conical traps with drooping tunnels.

to catches at the 274-m depth in outside waters. At the two sites fished in more than one year, Funter Bay and Point Retreat, catch rates were similar at Funter Bay only in 1981 and 1983, and both sites showed a sharp decrease in catch rates between 1983 and 1984 (Table 9).

Catch rates for sablefish at most sites in Chatham Strait (Table 9) were much higher than in outside waters (Fig. 4). However, catch rates for these two areas were not directly comparable because a much wider range of depths was fished at the indexing sites, including shallow and deep strata where relatively few sablefish were caught. To avoid biases due to these depth differences between areas, only the highest catch rate (i.e., the depth stratum with the highest catch) at each site in outside waters was compared to catch rates at the sites in Chatham

Strait. Each year, one or two sites in Chatham Strait showed higher catch rates, often two or three times higher, than the catch rates at the best fishing depths of any site in outside waters (Table 10). The five highest catch rates occurred in Chatham Strait. Thus, relative abundance of sablefish during these years was apparently higher in Chatham Strait than in outside waters.

Table 10.--Comparison between catch rates (kilograms per trap) of sablefish (*Anoplopoma fimbria*) at sites in outside waters and catch rates at sites in Chatham Strait, southeastern Alaska, 1961 and 1983-84. For each site and year in outside waters, catch rates listed are from the depth stratum with the highest catch rate.

	Sablefish caught per trap (kg)									
	Outside waters				Chatham Strait					
Year	Cape Cross	Cape Ommaney	Cape Addington	Cape Muzon	Point Augusta	Washington Bay	Funter Bay	Point Retreat	Point Gardner	Tenakee
1981	4.97	6.27	7.39	9.05	8.43	16.94	19.68	-	-	-
1983	7.46	7.08	14.75	13.06	-	-	18.06	11.75	-	-
1984	9.08	5.22	7.32	6.26	-	-	4.13	6.07	23.33	16.53

Length frequency distributions for the Chatham Strait sites (Fig. 14) showed the predominance of the 1977 year class, similar to distributions in outside waters. Large numbers of small (about 55 cm FL) fish, presumably from the 1977 year class, comprised most of the catch in 1981. Subsequently, FL's increased at all sites fished in 1983-84, apparently as a result of growth of the 1977 year class.

Sablefish from the 1977 year class appeared in large numbers earlier in Chatham Strait sites than in outside waters. The 1977 year class was identifiable in outside waters as early as 1979 (Fig. 6), but

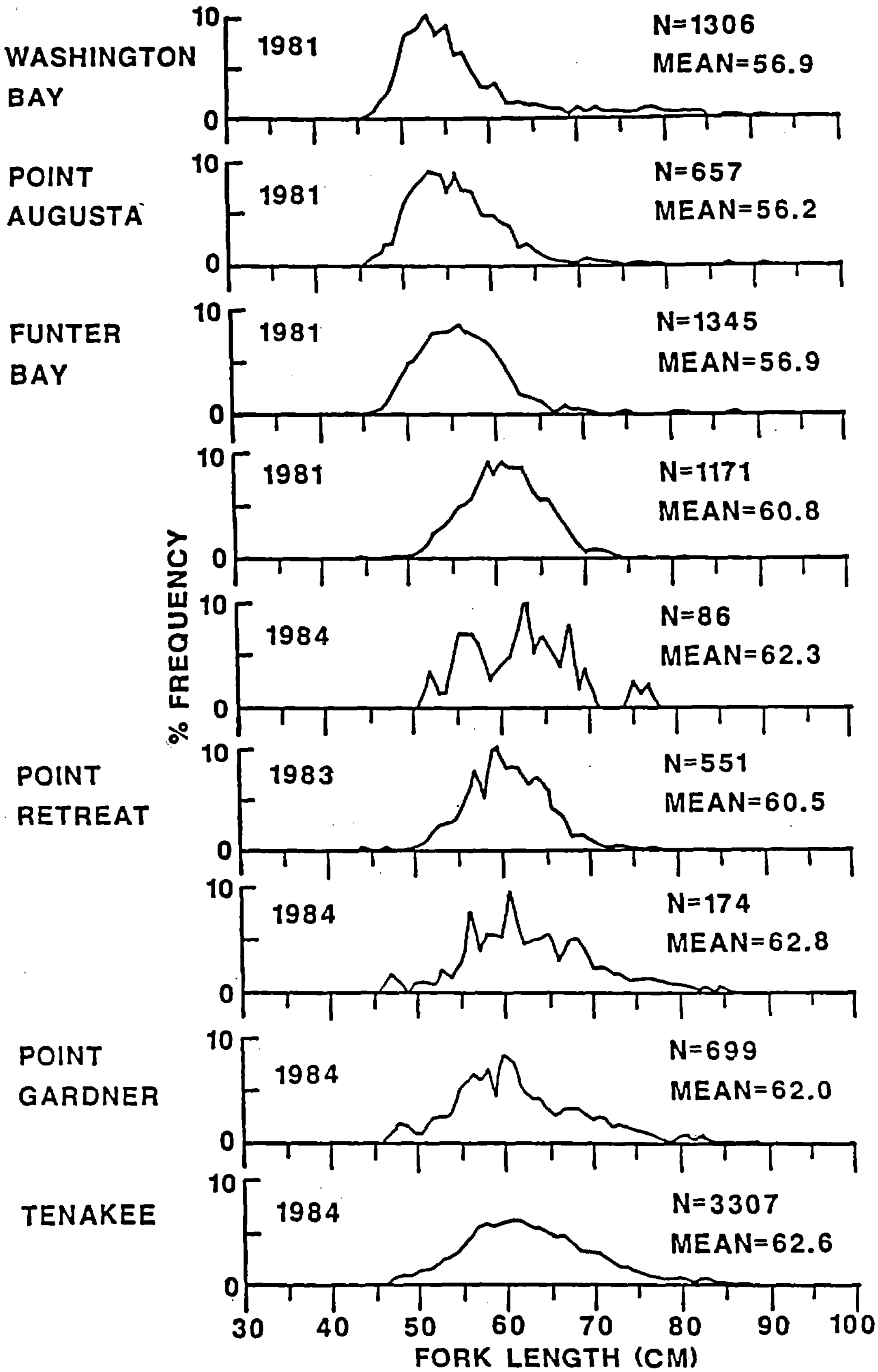

Figure 14. --Sablefish (<u>Anoplopoma</u> fimbria) length frequency distributions at SIX experimental fishing sites in Chatham Strait, inside waters of southeastern Alaska, 1981 and 1983-84.

fish from this year class did not dominate the length frequencies until 1982. In Chatham Strait, however, fish from the 1977 year class greatly predominated a year earlier, in 1981.

Comparison with Results of Japan/U.S. Longline Survey

Results from the trap indexing surveys can be compared with results from another sablefish survey, the Japan/U.S. joint longline survey. The joint longline survey has been conducted annually throughout the continental slope area of the entire Gulf of Alaska since 1979 (Sasaki 1983). Thus, the longline survey overlaps the trap indexing surveys in southeastern Alaska. Statistical analysis of the longline surveys showed no significant difference in sablefish abundance in southeastern Alaska in 1979-85, and sablefish abundance appeared to fluctuate without trend (Sigler and Fujioka, in prep.). However, the analysis was in terms of relative population numbers of sablefish, an index of abundance based on catch rates weighted by areas of the depth strata fished, and was therefore not directly comparable to the catch rates in the indexing surveys.

To allow a better comparison of the two surveys, the unweighted catch rates of the surveys were compared (Fig. 15). Data used from the indexing surveys included combined numbers of all sizes of sablefish caught per trap annually at the four indexing sites. Data used from the longline surveys included combined numbers of all sizes of sablefish caught per hachi (a standardized unit of Japanese longline gear 100 m long with 45 hooks) at all stations fished in southeastern Alaska. The longline surveys fished shallower depths than did the indexing surveys, and data from these shallower (100- to 200-m) depths were not included in the analysis in order to make the two surveys more comparable.

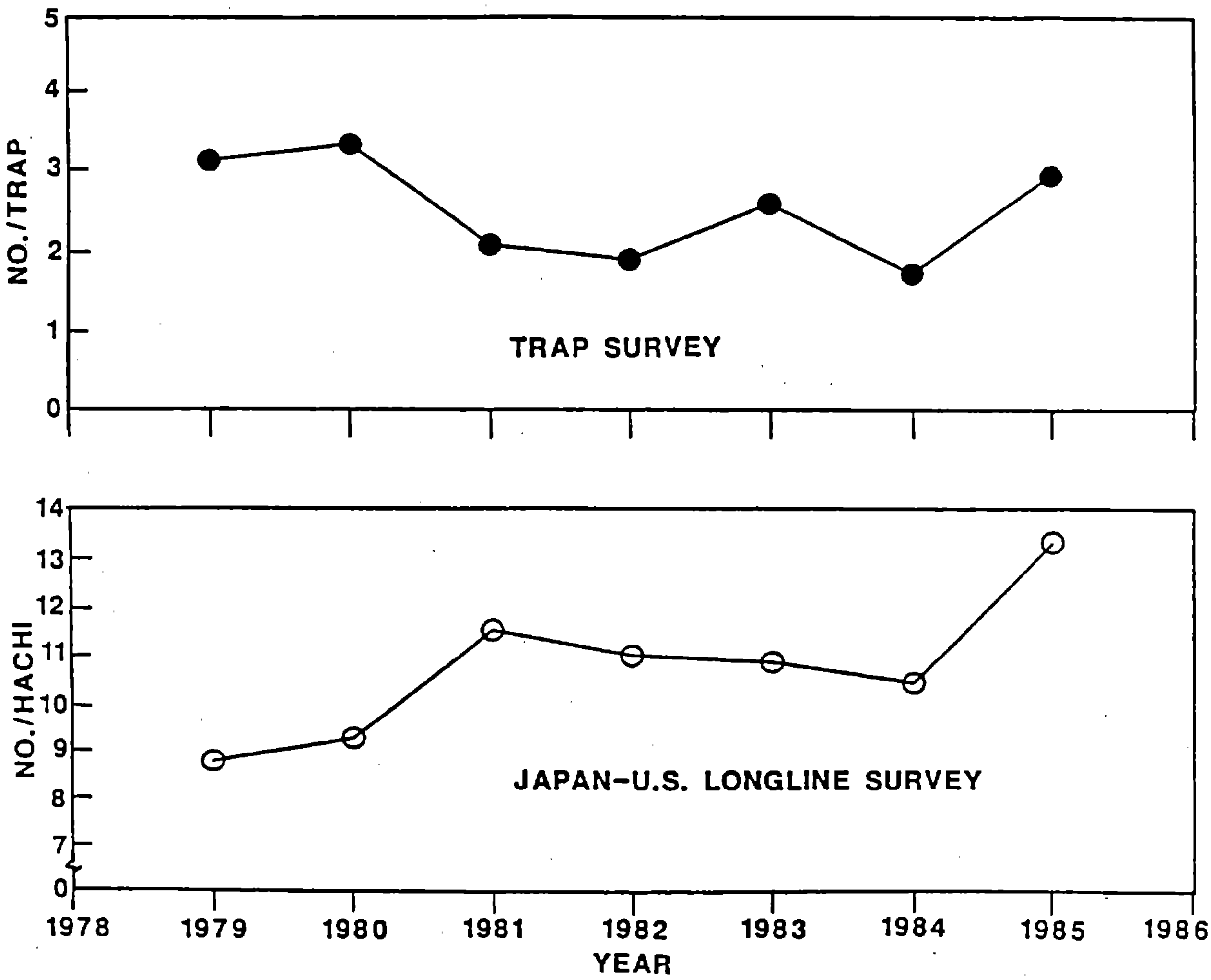

Figure 15.--Comparison of sablefish (Anoplopoma fimbria) catch rates in the trap indexing survey with sablefish catch rates in the Japan/U.S. longline survey, outside waters of southeastern Alaska, 1979-85. Catch rates for the longline survey based only the 200- to 1,000-m depths.

Catch rates of the two surveys were similar and dissimilar, depending upon the years examined. The biggest difference between surveys was in 1981 when the indexing survey showed a large decrease in catch rates, whereas the longline survey showed a large increase. Much of this increase in the longline survey was caused by large numbers of sablefish 50-60 cm FL (Sasaki 1985a) from the 1977 year class. Fish from the 1977 year class also predominated in 1981 at the trap indexing sites in Chatham Strait but were not caught in large numbers at the indexing sites in outside waters. Apparently, young sablefish from the 1977 year class were abundant throughout southeastern Alaska in 1981 but for unknown reasons were not available in large numbers at the trap sites. More detailed analysis is needed to reconcile this difference between the two surveys. However, both surveys in 1985 showed that catch rates of sablefish increased sharply in southeastern Alaska.

Trends in Abundance

When the first trap indexing surveys began in 1978, sablefish stocks in outside waters of southeastern Alaska were considered to be in poor condition. This conclusion was based on trends in the catch per unit effort (CPUE) for sablefish in the Japanese longline fishery (Fig. 16). In 1967-77, the CPUE in this fishery showed a gradual but consistent decrease, with a particularly sharp decrease in 1977, the last year of the fishery.

Results from the trap indexing surveys show that the decline in sablefish abundance continued in 1978-82 after the Japanese were excluded and the fishery became entirely domestic. The overall catch rates of sablefish in the indexing surveys in 1979-82 decreased from about 10 to <4 kg/trap (Fig. 3), despite a conservative management

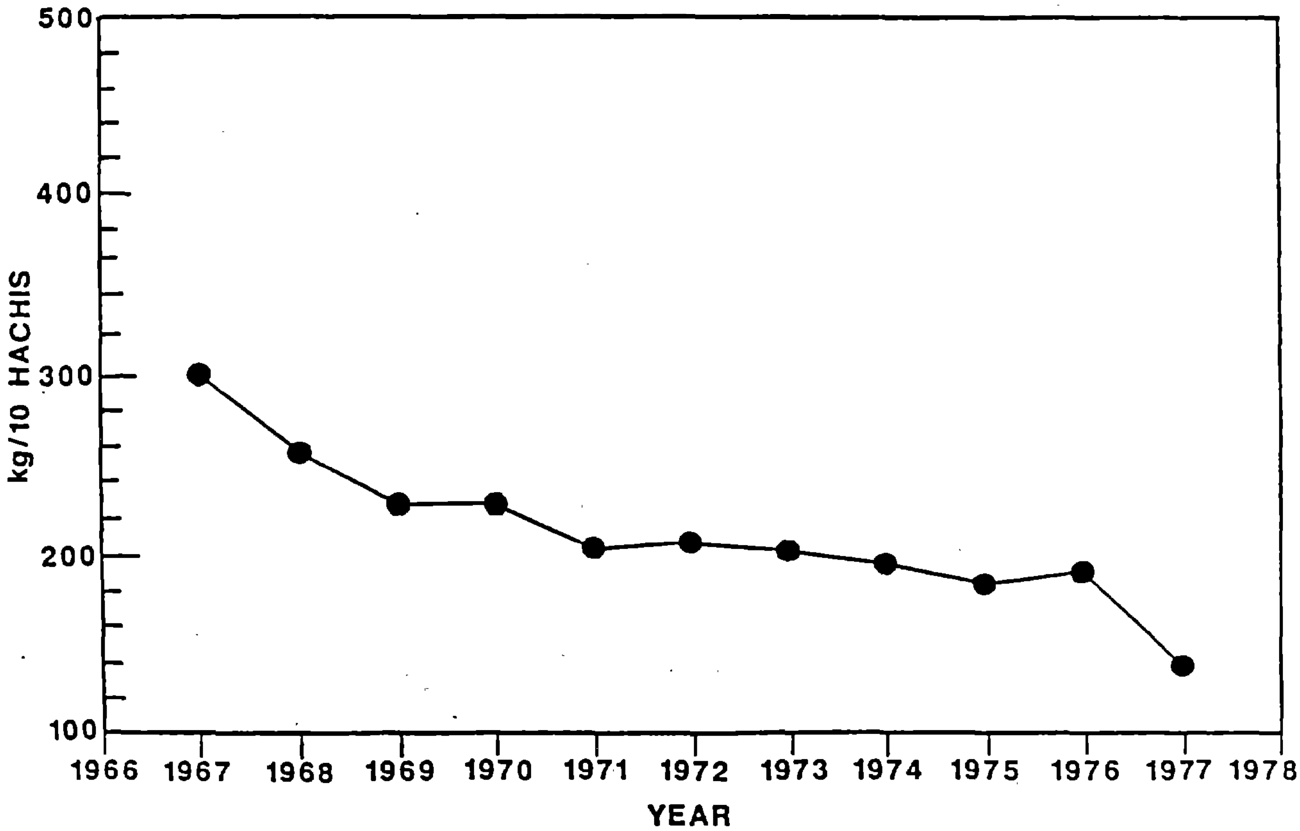

Figure 16.--Sablefish (Anoplopoma fimbria) catch per unit effort in the Japanese longline fishery, southeastern Alaska, 1967-77 (from Balsiger 1983). Hachi is a' standardized unit of Japanese longline gear.

scheme that imposed relatively low quotas on the U.S. fishery. The indexing surveys indicated this decline was caused by decreasing numbers of medium and large sablefish on the fishing grounds (Fig. 5). As a result, mean FL of sablefish decreased from 64.4 cm FL in 1979 to 58.2 cm FL in 1982 (Fig. 6). Presumably, recruitment of smaller sablefish was not replacing the larger fish caught by the commercial fishery.

Sablefish abundance in southeastern Alaska has shown an increasing trend since 1982 as fish from the strong 1977 year class recruited to the fishing grounds and grew. The 1977 year class was first identifiable in length frequency distributions in 1979-80 but was not markedly evident in the catch rates until 1983. Because of this year class, overall catch rates in the surveys increased more than twofold from 1982 to 1985 (from 3.9 to 8.2 kg/trap), with sharp increases in 1983 and 1985. Mean FL also increased progressively, (from 58.2 to 62.7 cm) in 1982-85 as fish from the 1977 year class grew. Thus, sablefish stock condition in southeastern Alaska in 1985 appeared substantially improved compared to 1980-82. Overall catch rates, however, were still somewhat lower than in 1979-80.

The increases in 1985 were especially encouraging because most of the improvement occurred at the two northern sites, Capes Cross and Ommaney. Most commercial fishing for sablefish in outside waters of southeastern Alaska occurs in this northern area, and results from both indexing sites showed relatively low catch rates prior to 1985. However, catch rates increased markedly in 1985 at these two sites (Fig. 4). At the Cape Cross site, in particular, catch rates in 1985 were much higher than in any survey year. Additionally, increases at both sites were caused by increased catch rates of medium and large sablefish (Fig. 5), the fish most valuable to commercial fishermen on a price-per-pound basis.

Some trends in the overall catch rates of sablefish in recent indexing surveys may be explained by current theories on migration of sablefish. Based on analysis of tag recoveries, Bracken (1982) suggested small sablefish migrate westward from southeastern Alaska as they grow, and then move back to southeastern Alaska when they near sexual maturity. Other tagging studies (Dark 1983; Fujioka and Sigler 1984) seem to support this hypothesis. In our sablefish trap research, large numbers of sablefish 50-60 cm FL, presumably from the 1977 year class, were seen in Chatham Strait in 1981 and in outside waters in 1983. If we assume these fish had mostly emigrated from southeastern Alaska by 1984, as Bracken's (1982) theory postulates, then this emigration would account for the drop in survey catch rates-observed in 1984. Similarly, the large increase in catch rates in 1985, caused by increases in numbers of medium and large fish, could be explained by the migration of maturing 1977 year class fish to southeastern Alaska. Additional data from future tagging studies and fishery assessment surveys will be necessary to determine whether this migration scenario is plausible.

ACKNOWLEDGMENTS

We thank all the staff members of the Auke Bay Laboratory who helped with the field work in these surveys, especially Evan Haynes, Mike Sigler, Tom Rutecki, Dick Haight, and Bruce Wing. We also thank the crew of the NOAA research vessel *John N. Cobb* for their diligent work in the fishing operations, and Dave King and other members of the NWAFC RACE Division net-loft crew for the preparation and maintenance of the fishing gear.

REFERENCES

Alaska Department of Fish and Game. 1985. 1985 Southeastern-Yakutat groundfish fishery. Report to the Board of Fisheries, 28 p. Available Alaska Dep. Fish Game, Commercial Fish. Div., P.O. Box 3-2000, Juneau, AK 99802-2000.

Balsiger, J. W. 1983. Sablefish. In D.H. Ito and J.W. Balsiger (editors), Condition of groundfish resources in the Gulf of Alaska in 1982, p. 63-86. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-52.

Bracken, B. E. 1982. Sablefish (*Anoplopoma fimbria*) migration in the Gulf of Alaska based on gulf-wide tag recoveries, 1973-1981. Alaska Dep. Fish Game Inf. Leafl. 199, 24 p.

Brown, E. S. 1986. Preliminary results of the 1984 U.S.-Japan cooperative bottom trawl survey of the central and western Gulf of Alaska. In R. Major (editor), Condition of groundfish resources in the Gulf of Alaska region as assessed in 1985, p. 259-296. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-106.

Clausen, D. M., and J. T. FUJIOKA. 1985. Fishing performance of rectangular and conical sablefish traps off Southeastern Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-76, 22 p.

Cochran, W. G. 1963. Sampling techniques. John Wiley and Sons, New York, 413 p.

Dark, T. A. 1983. Movement of tagged sablefish released at abundance index sites off Southeastern Alaska, Washington, Oregon, and California during 1978-81. In Proceedings of the International Sablefish Symposium, p. 191-207. Alaska Sea Grant Rep. 83-8, University of Alaska- Fairbanks, Fairbanks, AK 99701.

Edgington, E. S. 1980. Randomization tests. Marcel Dekker, New York, 287 p.

Fujioka, J. 1986. Sablefish. In R. Major (editor), Condition of groundfish resources in the Gulf of Alaska region as assessed in 1985, p. 79-108. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-106.

Fujioka, J. T., and M. F. Sigler. 1984. Time-location traces of sablefish tag recoveries released by the U.S. National Marine Fisheries Service and the Fisheries Agency of Japan, 1972-83. (Document submitted to International North Pacific Fisheries Commission, November 1984.) Auke Bay Laboratory, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, P.O. Box 210155, Auke Bay, AK 99821, 19 p.

Funk, F., and B. E. Bracken. 1984. Status of the Gulf of Alaska sablefish (*Anoplopoma fimbria*) resource in 1983. Alaska Dep. Fish Game Inf. Leafl. 235, 55 p.

Hipkins, F. W. 1974. A trapping system for harvesting sablefish *Anoplopoma fimbria*. U.S. Natl. Mar. Fish. Serv., Fish. Facts-7, 20 p.

Hughes, S. E., D. D. Worlund, and F. W. Hipkins. 1970. Adaptations of king crab pots for capturing sablefish (*Anoplopoma fimbria*). J. Fish. Res. Board Can. 27(10):1747-1755.

Kulikov, M. Y. 1965. Vertical distribution of sablefish (*Anoplopoma fimbria* (Pallas)) on the Bering Sea continental slope. In Russ. Sovetskie rybokhozyaistvennye issledovaniya v severo-vostochnoi chasti Tikhogo okeana. (Engl. transl., Israel Program Sci. Transl., 1968. In Soviet fisheries investigations in the northeast Pacific, Part IV, p. 157-161. Available Natl. Tech. Info. Serv., Springfield, VA 22161, as TT67-51206.)

McDevitt, S. A. 1986. A summary of sablefish catches in the Northeast Pacific Ocean, 1956-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-101, 34 p.

McFarlane, G. A., and R. J. Beamish. 1983a. Biology of adult sablefish (*Anoplopoma fimbria*) in waters off western Canada. In Proceedings of the International Sablefish Symposium, p. 59-80. Alaska Sea Grant Rep. 83-8, University of Alaska-Fairbanks, Fairbanks, AK 99701.

McFarlane, G. A., and R. J. Beamish. 1983b. Preliminary observations on the juvenile biology of sablefish (Anoplopoma fimbria) in waters off the west coast of Canada. In Proceedings of the International Sablefish Symposium, p. 119-135. Alaska Sea Grant Rep. 83-8, University of Alaska-Fairbanks, Fairbanks, AK 99701.

Parks, N. B. 1984. Changes in relative abundance and size composition of sablefish in coastal waters of Washington and Oregon, 1979-83. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-61, 23 p.

Sasaki, T. 1979. Preliminary report on black cod and Pacific cod survey by Ryusho maru No. 15 in the Aleutian region and the Gulf of Alaska in the summer of 1979. (Document submitted to International North Pacific Fisheries Commission, September 1979.) Far Seas Fisheries Research Laboratory, Fisheries Agency of Japan, 1000 Orido, Shimizu 424, Japan, 46 p.

Sasaki, T. 1981. Preliminary report on U.S./Japan longline survey for sablefish and Pacific cod by Fukuyoshi maru No. 8 in the Gulf of Alaska in the summer of 1980. (Document submitted to International North Pacific Fisheries Commission, April 1981.) Far Seas Fisheries Research Laboratory, Fisheries Agency of Japan, 1000 Orido, Shimizu 424, Japan, 56 p.

Sasaki, T. 1983. Relative abundance and size structure of sablefish in the eastern Bering Sea, Aleutian region and Gulf of Alaska based on results of Japan/U.S. joint longline surveys from 1979 to 1982, p. 239-253. In Proceedings of the International Sablefish Symposium. Alaska Sea Grant Rep. 83-8, University of Alaska-Fairbanks, Fairbanks, AK 99701.

Sasaki, T. 1984. A prompt report on Japan/U.S. joint longling survey by Anyo maru No. 21 in 1983. (Document submitted to International North Pacific Fisheries Commission, August 1984.) Far Seas Fisheries Research Laboratory, Fisheries Agency of Japan, 1000 Orido, Shimizu 424, Japan, 17 p.

Sasaki, T. 1985a. Studies on the sablefish resources in the North Pacific Ocean. Far Seas Fish. Res. Lab. Bull. 22, 108 p. Far Seas Fisheries Research Laboratory, Fisheries Agency of Japan, 1000 Orido, Shimizu 424, Japan.

Sasaki, T. 1985b. Preliminary report on Japan/U.S. joint longline survey by Ryusho maru No. 15 in 1984. (Document submitted to International North Pacific Fisheries Commission, September 1985.) Far Seas Fisheries Research Laboratory, Fisheries Agency of Japan, 1000 Orido, Shimizu 424, Japan, 17 p.

Sigler, M. F., and J. T. Fujioka. In preparation. Variability of relative population numbers of sablefish Anoplopoma fimbria, in the Gulf of Alaska, 1979-1985, Auke Bay Laboratory, Northwest and Alaska Fish. Cent., P.O. Box 210155, Auke Bay, AK 99821.

Umeda, Y., T. M. Sample, and R. G. Bakkala. 1983. Recruitment processes of sablefish in the eastern Bering Sea. In Proceedings of the International Sablefish Symposium. Alaska Sea Grant Rep. 83-8, p. 291-303. University of Alaska-Fairbanks, Fairbanks, AK 99701.

Zenger, H. H., Jr. 1981. Relative abundance and size composition of sablefish in coastal waters of southeastern Alaska, 1978-81. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-20, 42 p.