CONDITION OF GROUNDFISH

RESOURCES OF THE GULF OF ALASKA REGION

AS ASSESSED IN 1986

Edited by

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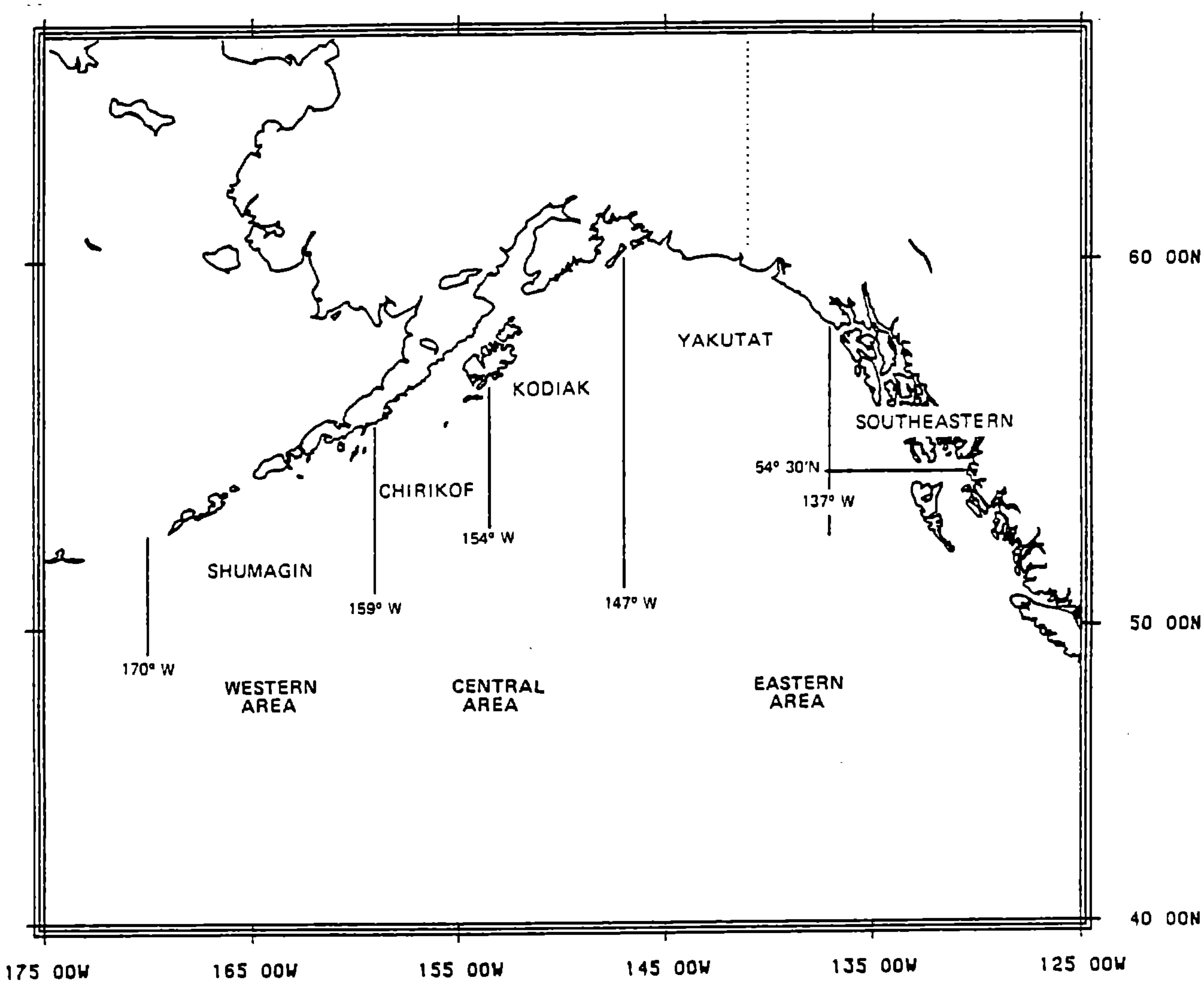

Gulf of Alaska: International North Pacific Fisheries Commission statistical areas (Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern and North Pacific Fishery Management Council regulatory areas (Western, Central, and Eastern).

PREFACE

The all-nation catch of groundfish in the Gulf of Alaska in 1985 was 321,920 metric tons (t), down 10% from 356,309 t in 1984 (Table A). The 1984 catch had, in turn, been the largest since the Magnuson Fishery Conservation and Management Act was implemented in 1977. Reduced catches of walleye pollock (Theragra chalcogramma), Pacific cod (Gadus macrocephalus), the Pacific ocean perch complex of Sebastes alutus, and four similar congeneric species, and flatfish were the main contributors to the decline--down 7.1, 38.4, 75.6, and 55.1%, respectively Although the decline in the pollock catch was not that great in terms of percentage, it was the greatest factor in terms of sheer weight--a ,21,867 t decline for pollock; a 34,389 t decline overall.

All elements of the fishing fleet were not equally affected. The total allowable level of foreign fishing was reduced sharply from 1984 levels;,-down 82.2 and 68.6% for pollock and cod, respectively, and down to token amounts'-:'.- for the remaining species or species groups. As a direct result, the foreign catch was down 68.2% for pollock, 42.8% for cod, and was practically eliminated for the other categories. The joint venture and U.S. domestic components of the fishery continued to increase, with the joint venture portion of the overall catch increasing from 61.6% in 1984 to 76.8% in 1985 and the U.S. domestic portion increasing from 3.6% in 1984 to 10.5% in 1985. For certain select fishes, however, the U.S. domestic share of the total catch became very large: 89.4% of the various rockfishes (Sebastes spp.), for example, and 97.7% of the sablefish (Anoplopoma fimbria).

Presented here are 14 contributions by U.S. scientists dealing with the Gulf of Alaska groundfish resources. Ten papers summarize information on commercially important species or groups of species. There are also descriptions of 1) the commercial fisheries for pollock in 1985 and 1986, 2) research on the age composition and recruitment of Pacific ocean perch, and 3) the 1986 acoustic assessment of the pollock population. Finally, the 1986 U.S. research surveys are reviewed and plans for 1987 are outlined.

Table A.--Gulf of Alaska groundfish: optimum yield (OY) and catch (t) 1977-86, current status of stocks, and abundance trends.

Species and year	OY	Catch				Status of stocks	Abundance trend
		Foreign	J. venture	Domestic	Total		
Walleye pollock							
1977	150,000	117,834	0	228	118,064		
1978	168,800	96,392	34	1,044	97,470		
1979	168,800	103,187	566	2,031	105,784		
1980	168,800	112,997	1,136	904	115,037		
1981	168,800	130,324	16,857	563	147,744		
1982	168,800	92,612	73,917	2,217	168,746		
1983	256,600	81,358	134,131	120	215,649		Exploitable
1984	416,600	99,260	207,104	329	306,693		biomass
1985	321,600	31,587	237,860	15,379	284,826		increasing
1986	116,600	-	-	-	-	Depressed	in 1987
Sablefish							
1977	22,000	15,957	0	1,179	17,136		
1978	15,000	7,128	0	1,738	8,866		
1979	13,000	6,885	18	3,447	10,350		
1980	13,000	6,139	20	2,384	8,543		
1981	12,300	7,975	0	1,941	9,916		
1982	12,300	5,645	1	2,910	8,556		
1983	8,980	4,965	275	3,761	9,001		
1984	8,980	1,108	528	8,594	10,230		
1985	8,980	38	226	12,215	12,479		
1986	15,000	-	-	-	-	Good	Increasing
Pacific cod							
1977	6,300	1,988	0	270	2,258		
1978	40,600	11,371	7	785	12,163		
1979	34,800	13,174	713	985	14,872		
1980	60,000	34,245	466	611	35,322		
1981	60,000	34,969	58	1,060	36,087		
1982	60,000	29,936	193	2,250	29,379		
1983	60,000	29,777	2,426	4,198	36,401		
1984	60,000	15,897	4,649	2,672	23,217		
1985	60,000	9,086	2,266	2,954	14,306		
1986	75,000	-	-	-	-	Good	Stable
Atka mackerel							
1977	22,000	19,455	0	0	19,455		
1978	24,800	19,588	0	0	19,588		
1979	26,800	10,948	1	0	10,949		
1980	28,700	13,163	3	0	13,166		
1981	28,700	18,727	0	0	18,727		
1982	28,700	6,760	0	0	6,760		
1983	28,700	11,470	790	0	12,260		
1984	28,700	537	585	31	1,153		
1985	5,278	2	1,846	0	1,848		No apparent
1986	5,278	-	-	-	-	Depressed	recruitment
Pacific ocean perch							
1977	30,000	23,439[a]	0	12	23,451		
1978	25,000	8,174	0	5	8,179		
1979	25,000	9,750	68	105	9,923		
1980	25,000	12,447	20	4	12,471		
1981	25,000	12,176	1	7	12,184		
1982	11,475	7,988	3	2	7,993		
1983	11,475	5,416	1,975	15	7,406		
1984	11,475	2,599	1,734	119	4,452		
1985	6,083	8	254	825	1,087		
1986	3,702	-	-	-	-	Depressed	Stable
Thornyheads							
1977	-	0[b]	0[b]	0[c]	0		
1978	-	0[b]	0[b]	0[c]	0		
1979	-	0[d]	0[d]	0[c]	0		
1980	3,750	1,351	0	0[c]	1,351		
1981	3,750	1,340	0	0[c]	1,340		
1982	3,750	788	0	0[c]	788		
1983	3,750	718	12	0[c]	730		Rebounded
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]

Table A.--Continued.

Species and year	OY	Catch: Foreign	J. venture	Domestic	Total	Status of stocks	Abundance trend
Other rockfish							
1977	5,000	139[a]	0	143[c]	282		
1978	7,600	1,896	1	103[c]	2,000		
1979	7,600	1,426	22	226[c]	1,674		
1980	7,600	2,849	8	203[c]	3,060		
1981	7,600	4,341	0	346[c]	4,687		
1982	7,600	1,692	0	259[c]	1,951		Unknown gulf-
1983	7,600	1,712	289	420[c]	2,421		wide; believed
1984	7,600	414	284	811	1,509		declining in
1985	5,000	2	45	1,812	1,859		central south-
1986	5,000	-	-	-	-	Depressed	eastern Alaska
Platfish							
1977	23,500	16,038	0	684	16,723		
1978	33,500	14,341	5	852	15,198		
1979	33,500	13,474	70	384	13,930		
1980	33,500	15,497	209	140	15,846		
1981	33,500	14,443	18	403	14,864		
1982	33,500	8,986	18	274	9,278		
1983	33,500	9,531	2,692	439	12,661		
1984	33,500	3,033	3,449	397	6,879		
1985	33,500	170	2,447	461	3,078		Assumed
1986	14,380	-	-	-	-	Good	stable
Squid							
1977	-	0[b]	0	0	0		
1978	2,000	322	0	0	322		
1979	5,000	425	0	0	425		
1980	5,000	841	0	0	841		
1981	5,000	1,135	0	0	1,135		
1982	5,000	278	16	0	294		
1983	5,000	267	4	0	271		
1984	5,000	120	5	0	125		
1985	5,000	6	7	0	13	Probably	Assumed
1986	5,000	-	-	-	-	good	stable
Other species[e]							
1977	16,200	4,642	0	NA	4,642		
1978	16,200	5,989	1	NA	5,990		
1979	16,200	4,081[d]	34[d]	NA	4,115		
1980	16,200	5,555	49	NA	5,604		
1981	16,200	7,112	33	NA	7,145		
1982	16,200	2,049	301	NA	2,350		
1983	18,743	2,255	391	NA	2,646		
1984	28,780	576	1,268	NA	1,844		
1985	22,460	97	2,246	NA	2,343	Probably	Assumed
1986	12,186	-	-	-	-	good	stable

[a]Japan reported only a "rockfish" catch, which is reported here as Pacific ocean perch.

[b]There probably were small catches of thornyheads in 1977 and 1978 (and squid in 1977) but the source used here (Berger et al. 1986) does not list them because OY had not yet been established.

[c]Thornyheads were included in the "other rockfish" category.

[d]Thornyheads were included in the "other species" category.

[e]After numerous changes, the "other fish" category was stabilized in 1981 to include sharks, skates, sculpins, eulachon, capelin (and other smelts of the family Osmeridae), and octopus.

Definition of Pacific ocean perch: 1) the OY and the foreign and joint venture catches 1977-78: only Pacific ocean perch (except as noted by footnote a), 2) the OY and the foreign and joint venture catches 1979-86: Pacific ocean perch and four similar species, and 3) domestic catches: only Pacific ocean perch.

NA: Not available

Sources: 1) the OY and the foreign and joint venture catches 1977-84: adapted from Berger et al. (1986), 2) the OY and the foreign and joint venture catches 1985-86: personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE.,

CONTENTS

WALLEYE POLLOCK FISHERIES IN THE GULF OF ALASKA, 1985-86

by

Miles S. Alton

INTRODUCTION

This is an update of the report by Alton (1986) on the pollock (*Theragra chalcogramma*) fisheries of the Gulf of Alaska including data through August 1986. The portion of the Gulf of Alaska lying within the fishery conservation zone extends eastward from 170° W. long. to Dixon Entrance. Included are the North Pacific Fishery Management Council's Western and Central Regulatory Areas, where most of the pollock catch is taken, and the Eastern Regulatory Area (Fig. 1).

In 1985 the pollock catch declined to 284.9 thousand metric tons (t) from a peak of 306.7 thousand t in 1984. New developments in 1985 were the sharp decline in the foreign catch and the dramatic rise in the domestic catch (Table 1). The catch by joint venture fisheries continued to increase.

Regions of high catch were similar to past years. Substantial catches (219.6 thousand t) were taken by joint venture fisheries in Shelikof Strait early in the year. For the remainder of the year, fishing by both the joint venture and foreign fleets was centered south of Kodiak Island, in the vicinity of the Shumagin Islands, and south of the Fox Islands.

Because of declining stock size, optimum yield was reduced to 116,600 t for 1986. Through August the 1986 catch was 57.0 thousand t, most of which was harvested in January-April in Shelikof Strait.

DATA SOURCES AND COMPILATION PROCEDURES

Catch

Each foreign nation reports catch and effort by month, vessel class, and statistical block (1° long. x 1/2° lat.). This information is used here to describe the time-space distribution of the pollock catch by each foreign nation. Catches by foreign nations and by joint venture fisheries are "best blend" estimates. These estimates are developed on the basis of information obtained via the U.S. Foreign Fisheries Observer Program as described by Wall et al. (1981). Domestic catches are from the Alaska Department of Fish and Game. Observer coverage (number of observer days/ total vessel days x 100) of the foreign trawl and joint venture fisheries in 1985 was greater than 90%.

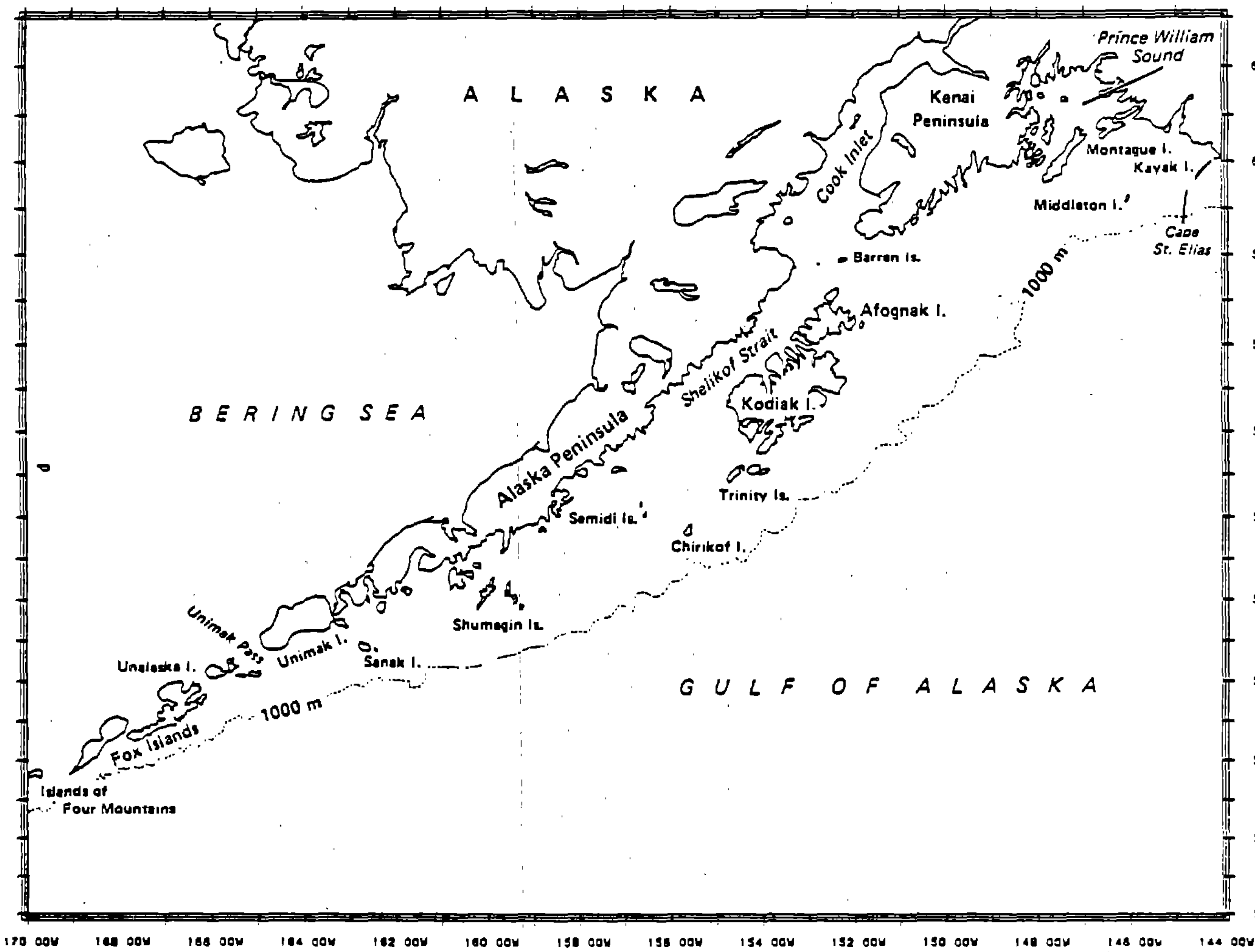

Figure 1.--Geographical areas of the central and western Gulf of Alaska.

Table 1.--Catch (1,000 t) of pollock in the Gulf of Alaska, by fishery category, 1977-86.

Year	Foreign	Joint venture	Domestic	Total
1977	117.8	0	T	117.8
1978	96.3	T	1.0	97.3
1979	103.8	0.6	2.0	106.4
1980	113.0	1.1	0.9	115.0
1981	130.3	16.8	0.6	147.7
1982	92.6	73.9	2.2	168.8
1983	81.4	134.1	0.1	215.6
1984	99.3	207.1	0.3	306.7
1985	31.6	237.9	15.4	284.9
1986*	0.1	52.3	4.6	57.0

*Jan.-Aug.

T: Trace.

Sources: Foreign and joint venture catches 1977-84: Berger et al. (1986); 1985 and 1986: personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point Way NE., Seattle, WA 98115. Domestic catches 1978-80: Rigby (1984); 1981-86: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201.

Length and Age Composition

Estimates of the length and age composition of the foreign and joint venture catches are also based on data collected by U.S. observers aboard foreign trawlers and processors. A description of the sampling procedures used by the observers to obtain length information and age structures was given by Nelson et al. (1981). Procedures for determining the age of pollock from otoliths was described by LaLanne (1979), and the procedure for estimating the age composition of the pollock catch was given by Alton and Deriso (1983).

CATCH INFORMATION

Foreign Fisheries

Japan and the Republic of Korea (ROK) were the only foreign nations that harvested pollock in the Gulf of Alaska in 1985. Japanese fisheries accounted for 8% (22.9 thousand t) of the total pollock catch and ROK for only 3% (8.6 thousand t). The overall foreign catch of pollock declined from 99.3 thousand t in 1984 to 31.6 thousand t in 1985, a 68% decrease.

In the Japanese fisheries most of the catch was taken by surimi trawlers (Table 2). These vessels concentrated their effort in two regions: south of Kodiak Island July-December and in the vicinity of the Shumagin Islands October-December (Fig. 2). Catch per unit effort (CPUE) was highest in the Kodiak region in July-September but highest in the Shumagin Island region in the fall.

In contrast to the Japanese fishery, ROK trawlers took most of their catch just south of the Fox Islands--mainly in the fall quarter (Fig. 3). The CPUE on the Fox Islands grounds decreased from summer to fall,

Joint Venture Fisheries

The catch by joint venture fisheries continued to climb in 1985, reaching almost 238 thousand t and representing 84% of the total catch (Table 3). Most was taken on the spawning grounds of Shelikof Strait January-April. The catch dropped off during spring and summer months but increased in the fall when fishing was concentrated south of Kodiak Island and south of the Fox Islands (Fig. 4).

Domestic Fisheries

There was a dramatic increase of the pollock catch by domestic fisheries in 1985 (Table 3). Most of the 15.4 thousand t catch was landed at shore-based plants (13.9 thousand t) with the remainder (1.5 thousand t) being taken by catcher-processors. The catch in the western Regulatory Area (8.5 thousand t) was slightly greater than that from the Central Regulatory Area (6.9 thousand t).

Table 2.--Japanese catch (1,000 t) of pollock in the Gulf of Alaska by trawler class, 1976-85.[a,b]

Year	Trawler Class: Surimi factory trawler (1,500-4,505 gross tons)	Small freezer trawler (<1,500 gross tons)	Large freezer trawler (1,500-4,504 gross tons)	Total
1976	4.9	0.3	6.6	11.8
1977	19.0	7.0	15.0	41.0
1978	17.8	6.7	1.5	26.0
1979	10.6	5.5	15.7	31.8
1980	20.4	8.6	8.5	37.5
1981	30.4	12.3	8.8	51.5
1982	34.0	14.5	6.3	54.8
1983	31.5	10.6	5.3	47.4
1984	45.1	11.7	1.0	57.8
1985	22.9	T	0.0	22.9

[a]Foreign reported catch for 1976 and 1977; best blend estimate for 1978-85.

[b]Vessel classification used by U.S. Foreign Fisheries Observer Program.

T: Trace.

Source: Personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point Way NE., Seattle, WA 98115.

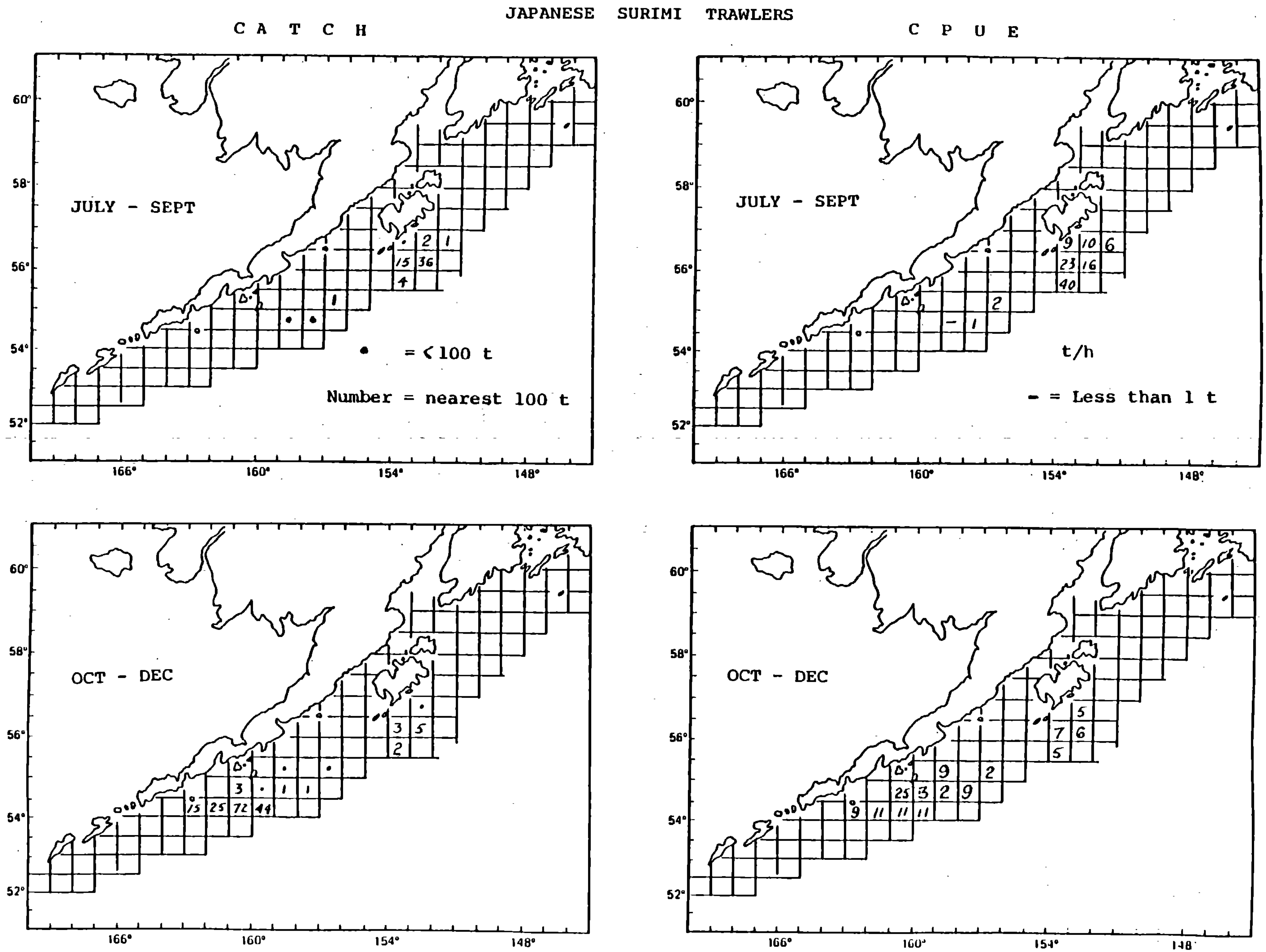

Figure 2.--Distribution of catch and catch per unit effort (CPUE) of pollock by Japanese surimi trawlers in the Gulf of Alaska, 1985.

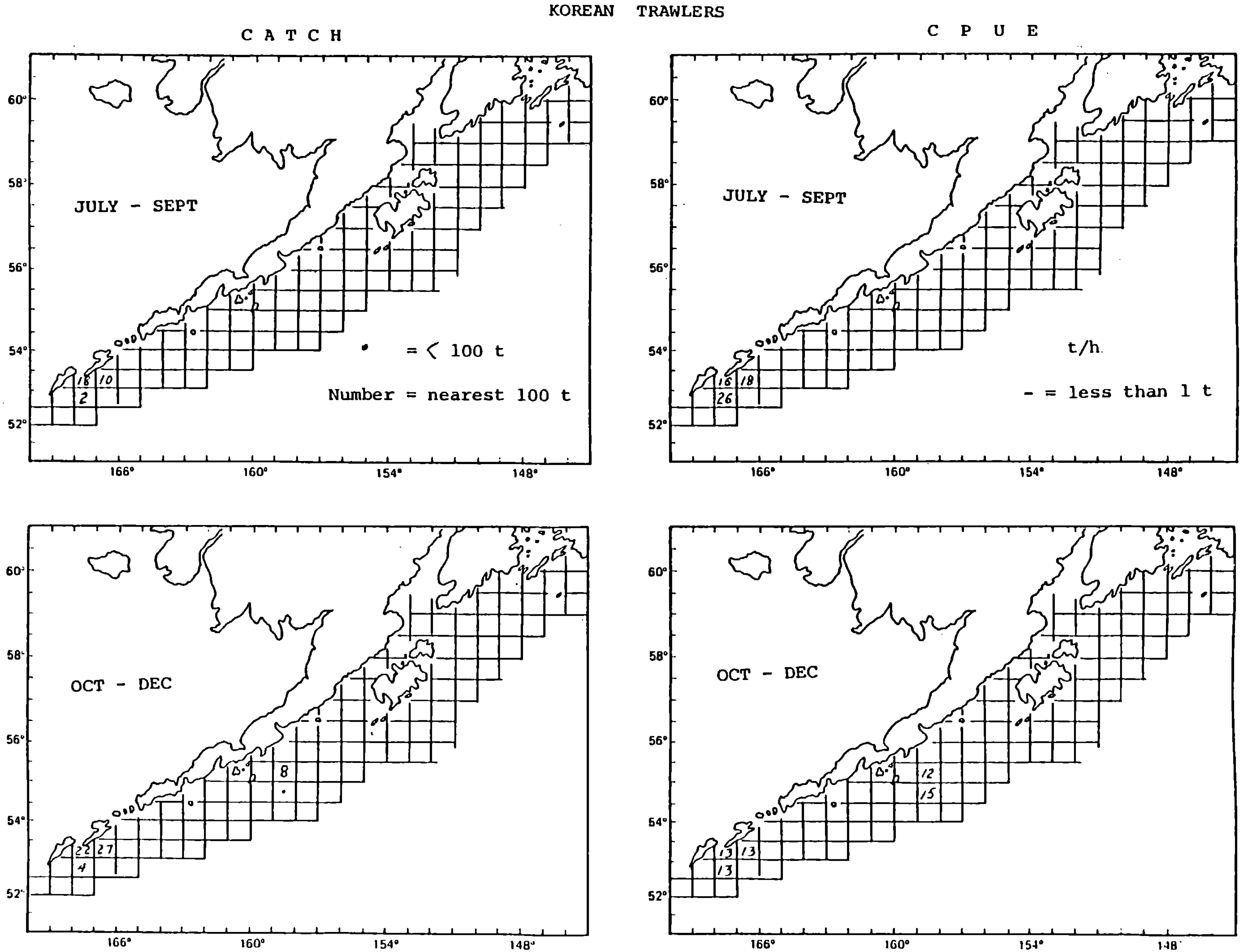

Figure 3.--Distribution of catch and catch per unit effort (CPUE) of pollock by Republic of Korea trawlers in the Gulf of Alaska, 1985.

Table 3.--Catch (t) of pollock in the Gulf of Alaska, by fishery category and by North Pacific Fishery Management Council regulatory area, 1985.

Fishery category	Area			
	Western	Central	Eastern	All area
Japan*	15,980	6,957	0	22,937
Republic of Korea	7,841	809	0	8,650
Joint venture	12,246	225,614	0	237,860
Domestic	8,458	6,920	T	15,378
Total	44,525	240,300	0	284,825

*Includes 15 t taken in longline fisheries.

T: Trace.

Sources: Foreign and joint venture catches: personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point Way NE., Seattle, WA 98115. Domestic catch: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201.

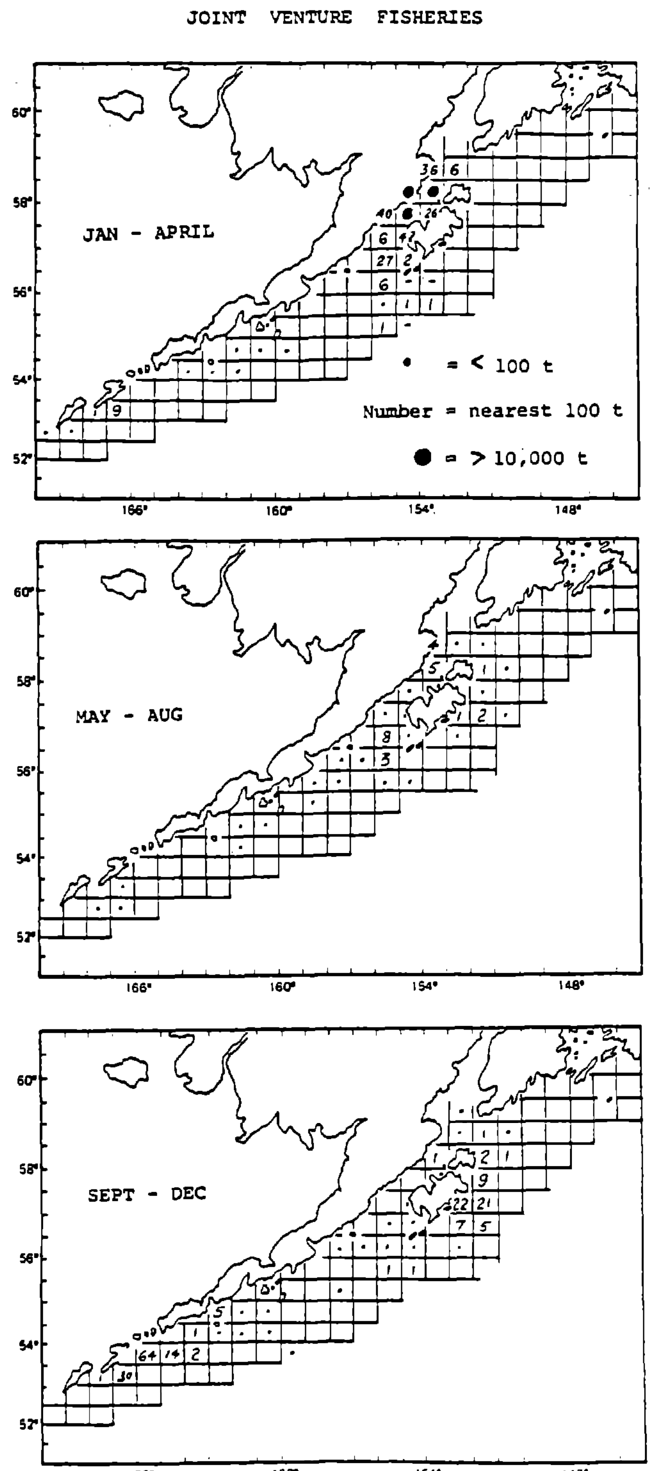

Figure 4.--Distribution of pollock catch by joint venture fisheries in the Gulf of Alaska, 1985.

LENGTH AND AGE-COMPOSITION

Outside the Shelikof Strait region in 1985 the fisheries continued, as in 1984, to take fish that had a unimodal length distribution (Fig. 5). Modal lengths were 46 to 50 cm depending upon the fishery, and were greater than those of last year (44-47 cm). The increasing mode reflects the continued dominance of the strong year classes of 1978 (7-year-old fish) and 1979 (6-year-old fish) (Table 4).

On the spawning grounds in Shelikof Strait, two length modes were present (Fig. 5). The smaller (23 cm) mode represents 2-year-old fish of the 1983 year class; the larger mode represents a mixture of older fish dominated by the 1978 and 1979 year classes. The 1982 year class (as 3-year-old fish) was poorly represented in the catch from Shelikof Strait, which may be an indication that its abundance relative to other year classes is low.

Table 4.--Catch (t and number of fish) of Gulf of Alaska* pollock, by age and fishery category, 1985. The joint venture catch is by region and period.

Age	Foreign fisheries		Joint venture fisheries: Shelikof Strait Jan.-Apr.		Joint venture fisheries: Other May-Dec.		Foreign and joint venture fisheries	
	t	nos. (1,000)	t	nos. (1,000)	t	nos. (1,000)	t	nos. (1,000)
1					T	3	T	3
2	12	33	1,600	12,310	75	191	1,687	12,534
3	539	949	1,200	3,751	405	699	2,144	5,399
4	3,166	4,358	13,003	25,495	2,071	2,827	18,240	32,680
5	3,117	3,130	20,304	33,285	2,047	2,005	25,468	38,420
6	8,038	7,983	49,110	60,629	4,766	4,676	61,914	73,288
7	10,818	10,367	94,019	104,465	5,714	5,513	110,551	120,345
8	4,162	3,547	29,306	29,904	2,086	1,740	35,554	35,191
9	1,254	1,148	8,702	7,769	742	671	10,698	9,588
10+	482	394	2,400	1,920	310	243	3,192	2,557
	31,588	31,909	219,644	279,528	18,216	18,568	269,448	330,005

*Foreign and joint venture fisheries in 1985 occurred only in the Western and Central Regulatory Areas.

T: Trace (catch < 0.5 t).

Source: Catches were obtained by personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point Way NE., Seattle, WA 98115.

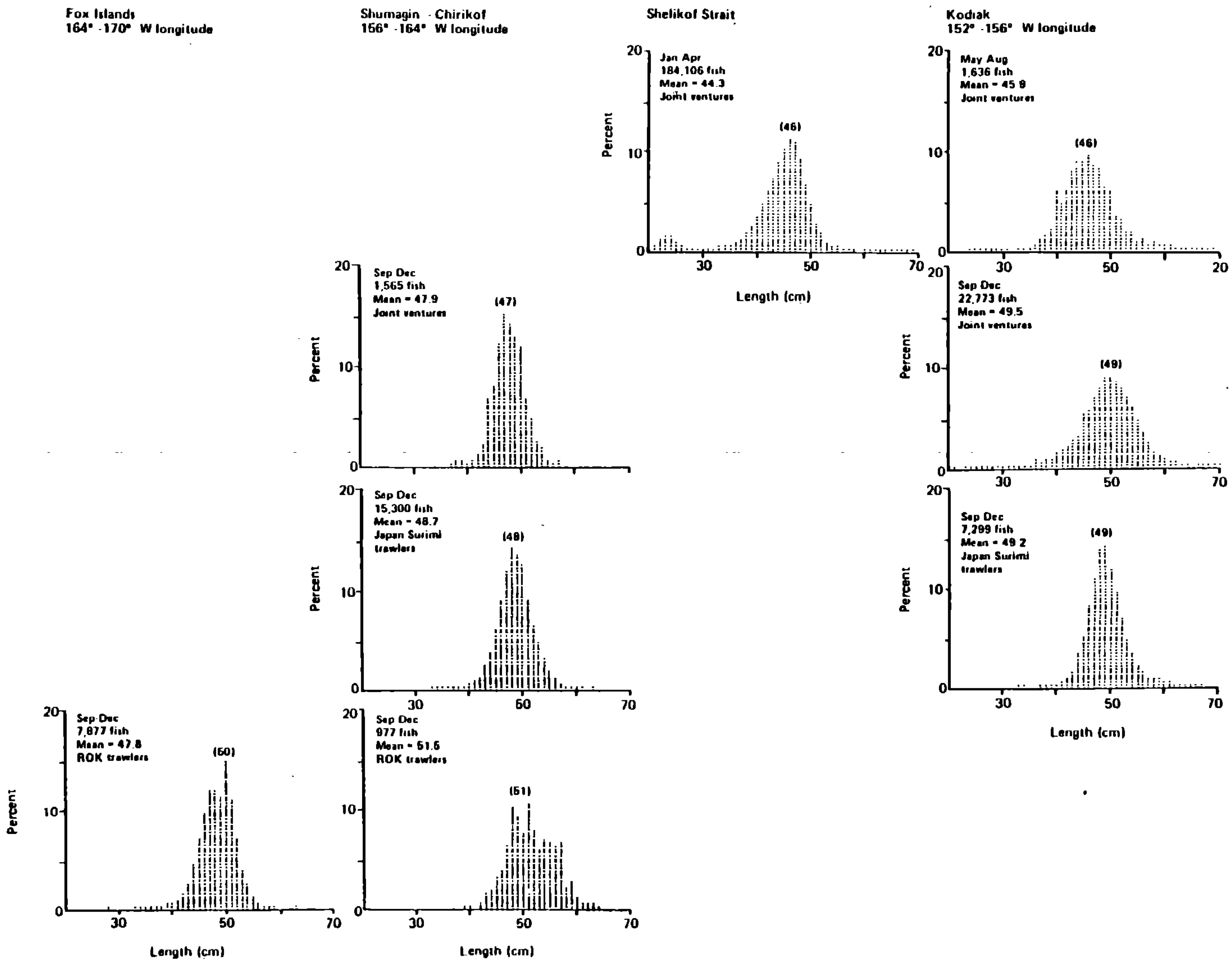

Figure 5.--Length composition of the pollock catch in the Gulf of Alaska, by region and fishery, 1985. (Mode is in parentheses.)

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RESULTS OF ACOUSTIC-TRAWL SURVEYS FOR WALLEYE POLLOCK IN THE GULF OF ALASKA IN 1986

by

Martin O. Nelson and Edmund P. Nunnallee

INTRODUCTION

During March-April 1986, acoustic-trawl surveys of Gulf of Alaska walleye pollock (*Theragra chalcogramma*) stocks were conducted in Shelikof Strait using the National Oceanic and Atmospheric Administration (NOAA) vessel *Miller Freeman* and in a major part of the gulf region outside of the strait by the Soviet research vessel *Gissar*. Three echo integrator-midwater trawl surveys of the Shelikof spawning stock were completed. The survey periods were : 1) March 5-12, 2) March 13-21, and 3) March 22-30. The surveys, which were comparable to those conducted in 1981 and 1983-85 (Nelson and Nunnallee 1985; Nelson and Nunnallee 1986), were designed to provide age-specific biomass and population estimates of the midwater (off-bottom) component of the pollock stock during that portion of the prespawning-spawning period when the abundance of adult fish was at a maximum. Another main objective of the Shelikof surveys was to collect data on the in situ target strength (acoustic reflectivity) of individual pollock using dual beam and split beam acoustic systems.

A highly qualitative echo sounder-trawl (midwater and bottom) survey of the area between Kodiak Island and Yakutat was conducted aboard the *Gissar* during March 19-29 as part of an effort to determine the distribution and relative abundance of spawning pollock in areas other than Shelikof Strait. In addition, the *Gissar* carried out an ichthyoplankton survey of the entire gulf area approximately between Cape St. Elias and Unimak Pass, March 29-April 18. During this survey, trawl sampling was done opportunistically on concentrations of pollock observed on the echo sounder.

This report presents the pollock abundance estimates obtained from the 1986 Shelikof surveys and compares them with estimates from prior years. It also describes the principal results of the *Gissar*'s surveys.

SURVEY AND ANALYSIS METHODS

Shelikof Strait Surveys

Acoustic data were collected with a 38 kHz echo sounder interfaced to computer systems programmed to implement echo integration and target strength data collection (dual beam and split beam). The sounder's transducer was housed in a deadweight body that was towed at an average depth of approximately 17 m. The entire acoustic system was calibrated before and after the surveys. Echo sign was sampled with a Diamond 1000 midwater trawl equipped with 6 ft x 9 ft steel V doors and a cable netsounder system (the same trawl was used for all surveys conducted during 1981-85). Its vertical mouth opening was 15-18 m and the codend mesh size (stretched measure) was 3.8 cm.

Survey operations were conducted 24 hours per day along zig-zag trackline patterns which covered the area between the 91 m (50 fm) bottom depth contours on either side of the strait (Fig. 1). Each survey was run "down" the strait, i.e., in a NE. to SW. direction, and the average distance between adjacent transects was approximately 5 nautical miles (nmi). Average vessel speed on the tracklines was approximately 9 knots (kn). Echo integrator density estimates were obtained along each transect at 5-minute intervals for each of up to 30 non-overlapping depth strata between 15 m below the transducer and the bottom. Usually, targets located more than about 3 m above the bottom could be detected and distinguished from bottom echoes.

Midwater trawl hauls were made during each survey to provide data on the biological composition of the pollock stock and on the occurrence and length distributions of other midwater species. The distribution of trawl haul stations was roughly proportional to the relative abundance of pollock echo sign. The duration of each haul depended on the density of the target echo sign, the time required to accurately position the trawl, and the time necessary (based on interpretation of the netsounder echo display) to capture a sample of fish large enough to satisfy biological sampling requirements. The average trawl towing speed was approximately 3 kn. Standard catch sorting and enumeration procedures were used to provide estimates of weight and numbers by species for each haul. The total catch was sorted, except when it exceeded approximately 2,500 lbs. Pollock length, sex, age (from otoliths) and maturity composition data were obtained from a randomly selected sample, from each haul. Collections of individual pollock weight data were stratified by length.

Pollock biomass estimates for each survey were determined by multiplying the average biomass density per unit surface area (kg/m^2) by the survey area. The surface density estimates were calculated by summing volumetric densities (kg/m^3) over depth. The echo integrator data were scaled to estimates of absolute density by using the following average target strength[1/] estimates: 1) -23 dB/kg for age-l pollock, 2) -27 dB/kg for age-2 fish, and 3) -31.3 dB/kg for age-3 fish and older. Because species other than pollock occurred in minor quantities, no corrections were made for their contribution to the echo integrator output.

Age-specific biomass and population estimates and population length distributions were calculated for each survey, using the total biomass estimate, length frequency data, a length-weight relationship, and an age-length key. The abundance estimation procedure and the methods used to estimate confidence intervals for the total biomass estimates were basically the same as those described by Traynor and Nelson (1985).

Soviet Research Vessel Gissar Surveys

Echo sounder data (paper records and a color scope display) were obtained using a 25 kHz echo sounder-operated with a hull mounted transducer. Rough

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1/ "Average target strength" is the target strength of the average scattering cross section.

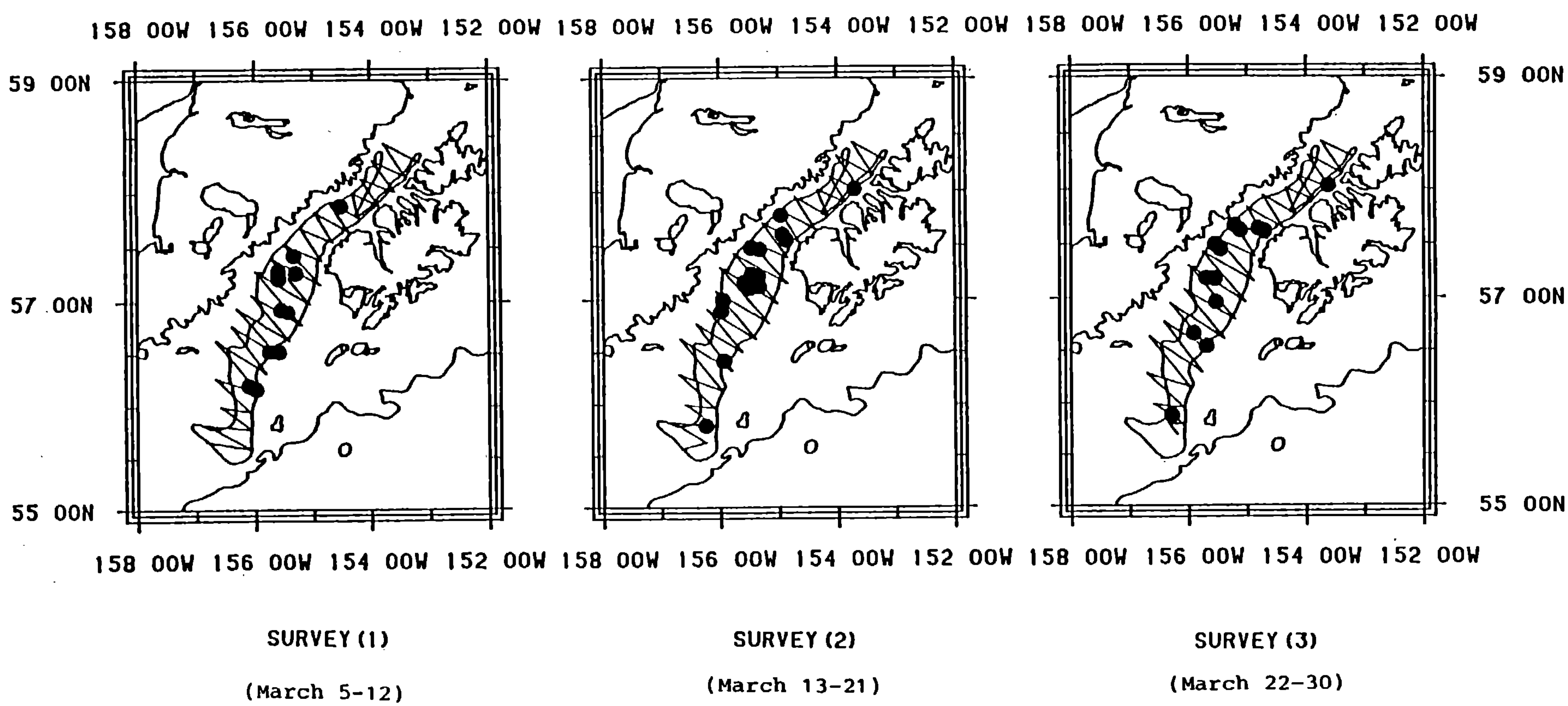

Figure 1.--Acoustic survey tracklines and midwater trawl stations, 1986 Shelikof Strait pollock surveys.

estimates of relative density ("low," "medium," and "high") were made from an examination of the paper records.

A rope trawl ("RT/TM 118") was used to sample midwater echo sign. This trawl had a vertical mouth opening of about 60 m with mesh sizes (stretched measure) ranging from 80 cm forward to 3 cm in the codend. On-bottom sampling was done with a trawl which had a 9 m vertical mouth opening and a codend liner mesh size of about 2 cm. Both trawls were fished with 3.5 m oval steel doors.

During its first survey (March 19-291, the Gissar operated 24 hours per day along a parallel transect trackline that covered a bottom depth range of 50 m to 750 m in the region between Kodiak Island and Yakutat. The distance between transects was usually 10 nmi and the survey was done at an average vessel speed of 11 kn. Both midwater and bottom trawl hauls were made to identify echo sign and provide biological information on pollock and other species. The enumeration and sampling of trawl catches followed standardized procedures which were similar to those employed on the Miller Freeman during the Shelikof Strait survey.

During the Gissar's ichthyoplankton survey (March 29-April 181, trawl sampling was limited to relatively large concentrations of pollock observed on the echo sounder while traveling between stations. Also, estimates of the relative abundance of pollock were not obtained from the echo sounder records collected during the ichthyoplankton survey.

RESULTS OF SHELIKOF STRAIT SURVEYS

Sampling Effort and Species Composition of Trawl Catches

Total distances of the tracklines on surveys l-3 (Fig. 1) were 918 nmi (1,700 km), 932 nmi (1,726 km), and 881 nmi (1,632 km), respectively. Thirty-nine midwater trawl hauls were completed during the surveys (Table 1). The frequency of occurrence and total catch of each species are shown in Table 2. As in previous years, the occurrence and total weight of species other than pollock in the trawl catches was relatively insignificant. Eulachon (*Thaleichthys pacificus*) were, again, the most frequently occurring "incidental" species. Pacific cod (*Gadus macrocephalus*) were caught less frequently than in past years.

Biomass and Population Estimates

The 1986 "annual" estimate of pollock biomass for age-2 and older fish was the lowest obtained during the 6-year period that comparable acoustic surveys have been conducted (Table 3 and Fig. 2). However, the 11% (77,000 metric ton (t)) change in biomass estimates between 1985 (700,000 t) and 1986 (623,000 t) was minor compared to the pronounced decrease that occurred between 1984 and 1985, when there was an unusually large decline in the abundance of the 1978 and 1979 year classes (Fig. 3 and Tables 4 and 5). Also, the 1986 estimate of the biomass of the age-3 and older population (490,000 t) exceeded the 420,000 t forecasted by Alton and Megrey (1986). This is the first time that the projected biomass estimate (which includes only fish > age 3) has been less than the survey estimate.

Table 1.--Midwater trawl haul station and catch data for 1986 Shelikof Strait pollock surveys.

Haul no.	Date	Time (AST)	Start position Lat.(N)	Start position Long.(W)	Average depth (fm) (footrope/ bottom)	Catch (lb) Pollock Age 1	Pollock >Age 1	Eulachon	Pacific cod	Other species
Survey 1										
1	3/07	1309-1324	57°52'	154°30'	55/133	0	478	2	0	0
2	3/08	0925-1005	57°26'	155°20'	64/138	0	2,500	0	0	0
3	3/08	1906-1918	57°16'	155°18'	139/139	0	573	94	22	756
4	3/09	1058-1108	57°16'	155°37'	149/159	0	1,607	62	0	276
5	3/09	1242-1302	57°14'	155°35'	101/155	0	1,230	0	0	0
6	3/09	2350-2355	56°55'	155°31'	105/155	0	900	0	0	0
7	3/10	0052-0108	56°56'	155°30'	140/153	0	1,460	19	11	5
8	3/10	1809-1819	56°32'	155°45'	75/115	T	431	63	0	0
9	3/10	1904-1919	56°32'	155°38'	72/78	4	92	76	11	22
10	3/11	1333-1337	56°12'	156°06'	94/136	T	239	0	0	0
11	3/11	1455-1515	56°11'	156°07'	117/138	1	653	98	0	71
Survey 2										
12	3/13	2210-2257	58°01'	153°41'	53/112	0	251	1	9	3
13	3/15	0054-0154	57°47'	154°57'	54/154	0	99	1	0	0
14	3/15	1412-1452	57°35'	154°55'	76/127	T	422	0	0	2
15	3/15	1608-1627	57°34'	154°53'	114/125	1	962	107	0	24
16	3/16	0044-0104	57°28'	155°20'	73/152	T	349	0	6	5
17	3/16	0213-0300	57°28'	155°24'	144/161	T	2,611	10	0	2
18	3/18	0218-0242	57°10'	155°22'	79/145	T	378	1	0	3
19	3/18	0310-0340	57°13'	155°25'	129/147	T	2,157	3	0	0
20	3/18	1200-1215	57°13'	155°26'	69/145	0	1,053	0	0	27
21	3/18	1559-1609	57°10'	155°25'	132/145	0	2,010	3	0	0
22	3/19	0333-0424	57°07'	155°29'	87/153	T	87	1	0	10
23	3/19	1825-1838	56°59'	155°57'	96/156	0	484	0	0	0
24	3/19	1930-1935	56°55'	155°57'	136/140	3	940	21	0	8
25	3/20	1348-1358	56°25'	155°56'	105/121	9	1,758	0	0	0
26	3/21	1535-1550	55°48'	150°14'	113/131	15	0	T	0	0
Survey 3										
27	3/23	2318-0000	58°02'	153°36'	44/117	0	880	0	0	4
28	3/24	2312-2327	57°38'	154°47'	44/127	0	982	0	0	3
29	3/24	0004-0010	57°39'	154°47'	81/127	0	1,319	0	31	0
30	3/25	1556-1610	57°29'	155°29'	150/170	0	4,176	20	0	3
31	3/25	1803-1833	57°28'	155°30'	75/168	1	463	5	0	0
32	3/26	1510-1530	56°58'	155°32'	142/157	2	1,727	67	0	24
33	3/27	1015-1025	56°40'	155°54'	130/156	T	1,444	116	0	0
34	3/27	1343-1418	56°32'	155°41'	98/116	0	1,790	0	0	0
35	3/28	1750-1805	55°53'	156°18'	95/133	7	10	2	0	1
36	3/29	1027-1042	57°11'	155°36'	137/152	T	66	1	0	0
37	3/29	1225-1255	57°11'	155°36'	18/156	0	0	0	0	0
38	3/29	1740-1742	57°40'	155°10'	100/161	0	526	0	0	0
39	3/29	1837-1846	57°38'	155°05'	127/139	T	494	3	0	2
					Totals	43	37,601	776	90	1,251

T: Catch < 1 lb.

Table 2.--Frequency of occurrence and total catch by species in 39 midwater trawl hauls made during the 1986 Shelikof Strait pollock surveys.

Species	Frequency No.	Frequency %	Total catch lb.	Total catch %
Walleye pollock (*Theragra chalcogramma*)	38	97.4	37,664	94.[illegible]
Eulachon (*Thaleichthys pacificus*)	24	61.5	776	2.[illegible]
Arrowtooth flounder (*Atheresthes stomias*)	11	37.9	531	1.[illegible]
Smooth lumpsucker (*Aptocyclus ventricosus*)	11	37.9	94	0.[illegible]
Squid (Unidentified)	7	17.9	37	0.[illegible]
Flathead sole (*Hippoglossoides elassodon*)	4	10.3	23	0.1
Jellyfish (Unidentified)	3	7.7	12	T
Shrimp (Unidentified)	3	7.7	11	T
Skate (Unidentified)	2	5.1	295	0.7
Pacific cod (*Gadus macrocephalus*)	2	5.1	90	0.2
Rougheye rockfish (*Sebastes aleutianus*)	2	5.1	32	0.1
Sablefish (*Anoplopoma fimbria*)	1	2.6	176	0.4
Pacific halibut (*Hippoglossus stenolepis*)	1	2.6	40	0.1
Chinook salmon (*Oncorhynchus tshawytscha*)	1	2.6	3	T
Spinyhead sculpin (*Dasycottus setiger*)	1	2.6	1	T
		Total	39,785	

T: Catch < 1 lb.

Table 3.--Pollock biomass estimates determined from 1981 and 1983-86 Shelikof Strait acoustic-midwater trawl surveys.

Year	Survey number and period	Mean density ($kg/10^3m^2$)	Total area (km^2)	Biomass ($t \times 10^6$)	95% Confidence interval ($t \times 10^6$)
1981*	1 March 3-15	637.6	6,870	4.38	2.92 to 5.84
	2 March 24-27	363.6	8,674	3.15	2.07 to 4.23
	3 April 4-10	251.0	12,138	3.06	2.02 to 4.08
1982	- - - - - - - - - - - - - - - - - No survey - - - - - - - - - - - - - -				
1983*	1 March 6-15	144.9	17,587	2.46	1.54 to 3.40
	2 March 16-19	194.7	12,123	2.36	1.26 to 3.46
	3 April 6-13	41.2	19,733	0.82	0.57 to 1.07
1984*	1 March 3-9	133.6	16,567	2.03	1.43 to 2.64
	2 March 9-16	107.1	15,043	1.57	1.31 to 1.84
	3 March 16-18	139.3	14,383	1.90	1.06 to 2.75
	4 March 22-25	127.5	15,641	1.72	0.98 to 2.46
	5 April 1-7	119.8	15,147	1.66	1.19 to 2.13
1985*	1 Feb. 21-28	39.6	16,361	0.65	0.47 to 0.82
	2 March 1-9	43.8	15,975	0.70	0.48 to 0.92
	3 March 14-20	46.8	16,389	0.77	0.55 to 0.98
	4 March 21-28	51.9	13,736	0.71	0.51 to 0.91
1986*	1 March 5-12	42.3	15,476	0.65	0.41 to 0.90
	2 March 13-21	39.3	15,186	0.60	0.39 to 0.80
	3 March 22-30	38.3	16,127	0.62	0.33 to 0.91

Annual estimates

Year	Biomass ($t \times 10^6$)	95% confidence interval ($t \times 10^6$)	Source of estimates
1981	3.77	2.86 to 4.67	Mean of estimates for surveys 1 and 2
1982	- - - - - - - - - - - - - - No survey - - - - - - - - - - - - - - -		
1983	2.43	1.69 to 3.13	Mean of estimates for surveys 1 and 2
1984	1.84	1.21 to 2.47	Mean of estimates for surveys 1, 2, 3
1985	0.70	0.50 to 0.91	Mean of estimates for surveys 1, 2, 3
1986	0.62	0.37 tp 0.87	Mean of estimates for surveys 1, 2, 3

*Estimates for 1981, 1983, and 1984 include very small amounts of age-l fish, e.g., the biomass of age-l fish in the "annual estimates" for these years did not exceed 0.024% of the total biomass. The 1985 and 1986 estimates include only fish age 2 and older.

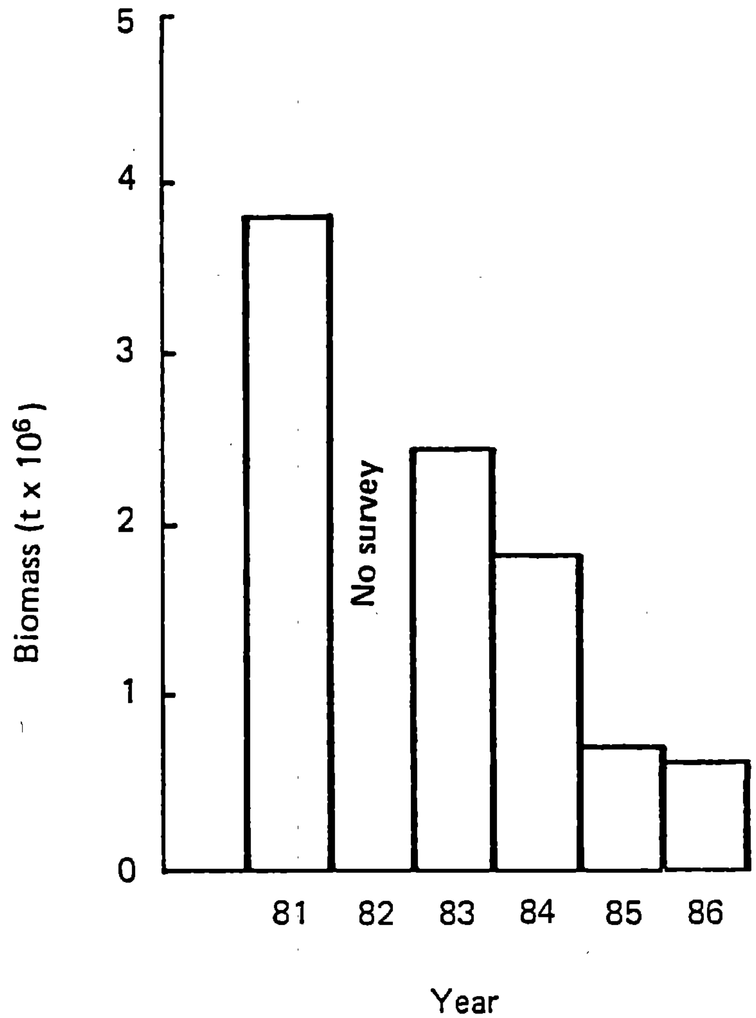

Figure 2.--Annual estimates of pollock biomass determined from 1981 and 1983-86 Shelikof Strait acoustic-midwater trawl surveys (see footnote at bottom of Table 3).

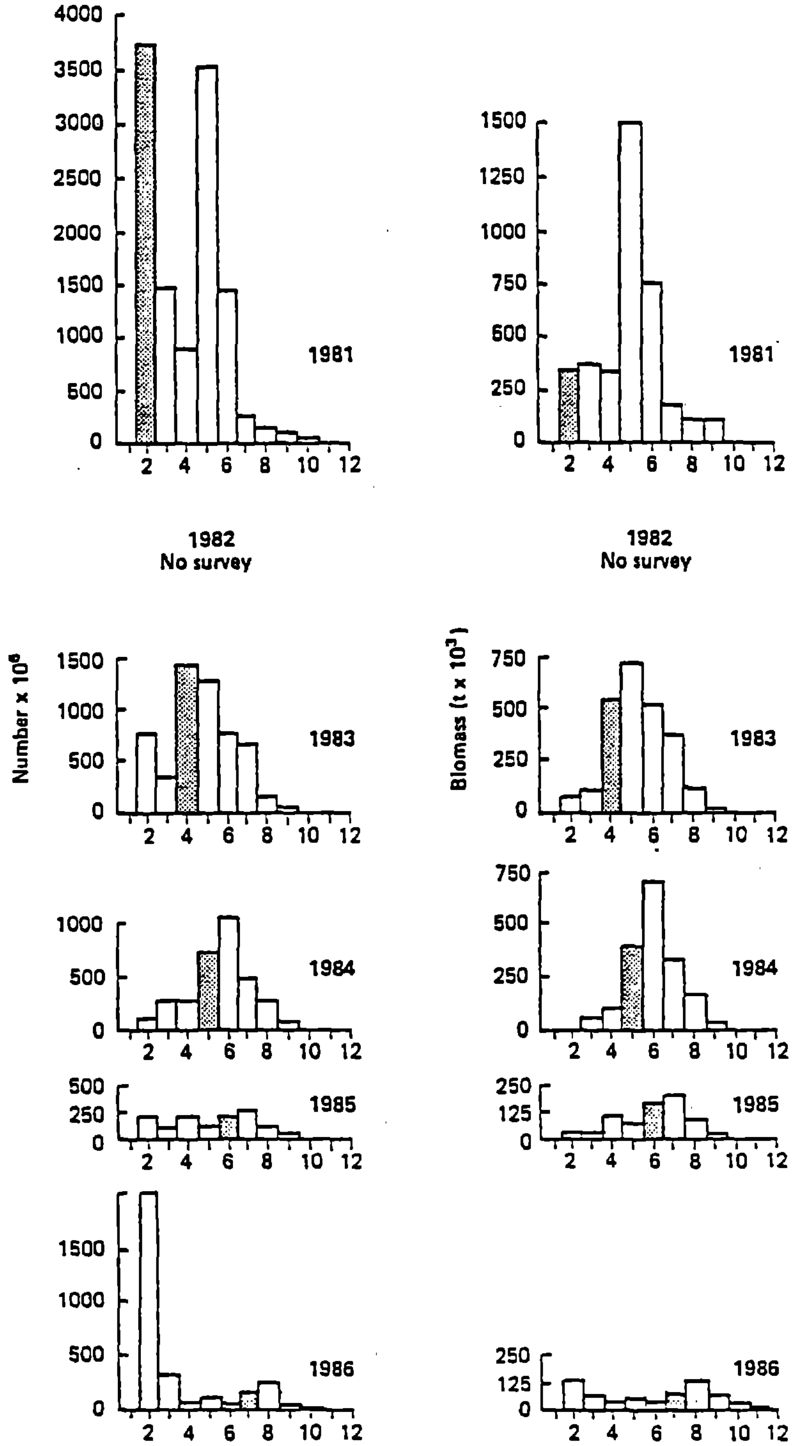

Figure 3 .--Pollock population and biomass age distributions (ages >2) determined from the 1981 and 1983-86 Shelikof Strait acoustic-midwater trawl surveys.

Table 4.--Pollock population and biomass estimates, by age (ages ≥ 2), determined from 1981 and 1983-86 Shelikof Strait acoustic-midwater trawl surveys.

Survey year	Age 2	3	4	5	6	7	8	9	10	11	12
	Numbers (millions of fish)										
1981	3,704.6	1,490.7	888.5	3,480.1	1,464.1	258.6	151.2	115.7	31.4	3.5	0.0
1982	No survey										
1983	757.8	325.7	1,410.0	1,270.3	761.7	648.4	145.2	19.5	11.9	4.1	1.9
1984	74.2	258.9	231.1	700.9	1,045.0	464.8	239.8	42.1	3.7	0.0	0.9
1985	218.6	92.4	194.9	111.5	214.0	269.2	103.5	26.0	2.9	1.5	0.6
1986	1,993.1	287.7	44.3	81.7	52.3	89.5	151.3	62.1	11.7	1.8	0.0
	Biomass (thousands of t)										
1981	350.6	375.0	339.4	1,509.0	756.1	177.3	115.8	111.0	27.9	3.2	0.0
1982	No survey										
1983	58.9	103.9	570.7	700.8	497.2	360.6	105.1	17.3	12.1	4.8	1.6
1984	8.0	64.1	105.5	405.8	710.5	333.8	169.8	34.8	4.9	0.0	0.9
1985	22.4	27.1	99.8	67.9	157.2	217.0	86.6	21.5	2.9	1.9	0.6
1986	129.5	60.0	18.6	62.3	44.8	81.8	148.4	62.4	13.2	2.6	0.0

Table 5.--Pollock population estimates (numbers in millions), by year class and age (ages ≥2), determined from 1981 and 1983-86 Shelikof Strait acoustic-midwater trawl surveys.

	Year class															
Age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2											3704.6	*	757.8	74.2	218.6	1993.1
3										1490.7	*	325.7	258.9	92.4	287.7	
4									888.5	*	1410.0	231.1	194.9	44.3		
5								3480.1	*	1270.3	700.9	111.5	81.7			
6							1464.1	*	761.7	1045.0	214.0	52.3				
7						258.6	*	648.4	464.8	269.2	89.5					
8					151.2	*	145.2	239.8	103.5	151.3						
9				115.7	*	19.5	42.1	26.0	62.1							
10			31.4	*	11.9	3.7	2.9	11.7								
11		3.5	*	4.1	0.0	1.5	1.8									
12	0.0	*	1.9	0.9	0.6	0.0										

*No survey in 1982.

The 1986 survey estimates of abundance by age confirmed results obtained in 1984 and particularly 1985 which indicated a strong decline in recruitment. Estimates for the 1980 and 1981 year classes (ages 6 and 5) again demonstrated their relative weakness. Also, the minor contribution of age-4 fish (1982 year class) is the lowest that has been estimated for that age group. The 1983 year class (age 3) also appears to be relatively weak. Except for the apparently strong 1984 year class (age 2), the 1978 and 1979 year classes (ages 8 and 7) were again the most abundant ones in the Shelikof population. The abundance of age-2 fish, which can also be seen in the prominent 20-25 cm mode in the length distribution (Fig. 4), was greater than in any previous survey year except 1981, when the 1979 year class was a major component of the population. This suggests that the 1984 year class is substantially stronger than average and supports the 1985 estimate of their relative abundance as 1-year-olds (Nelson and Nunnallee 1986).

Although not as abundant as in 1985, age-l pollock were found in significant quantities during each of the 1986 surveys. Biomass estimates for surveys l-3, respectively, were 5,700, 6,200, and 2,400 t. Corresponding number estimates were 306, 333, and 127 million fish. The abundance of age-l fish in 1986 relative to previous years (Table 6) suggests that the 1985 year class may be stronger than any of the 1980-83 year classes. The relative abundance estimates shown in Table 6 are rough approximations.

Distribution and variation in Biological Parameters

The geographic distribution of pollock during each of the three surveys is shown in Figures 5 and 6. The distribution pattern remained largely the same as those observed in prior years, with adult fish (ages >3) being concentrated in the central and western part of the strait by the time of the third survey (March 22-30). Changes in mean density between surveys, changes in the area occupied by detectable densities, and, consequently, changes in the survey biomass estimates were relatively minor. The small amount of variability in distribution and abundance during the period of the survey was similar to that observed in 1985. Length and age distributions also remained quite stable during the overall survey period (Figs. 7 and 8).

Age-l fish were found only in the most southern part of the survey area (Fig. 6). In 1985, when 1-year-olds were extremely abundant, they tended to be located only in the southern half of the strait region, but they occurred over a significantly larger area than in 1986.

Changes in maturity composition were basically similar to those observed in prior years (Table 7). Prior to the third survey, no spent fish and only a few spawning ("running-ripe") fish were caught. The maturity information suggests that, as in 1985, spawning probably reached a peak shortly after the surveys had been completed.

Pollock Target Strength Data Collection

Target strength measurements made with dual beam and split beam systems were obtained several times during the surveys. Due to the relatively higher densities which occurred during the day, these measurements were made only at night. The target strength data have not yet been analyzed.

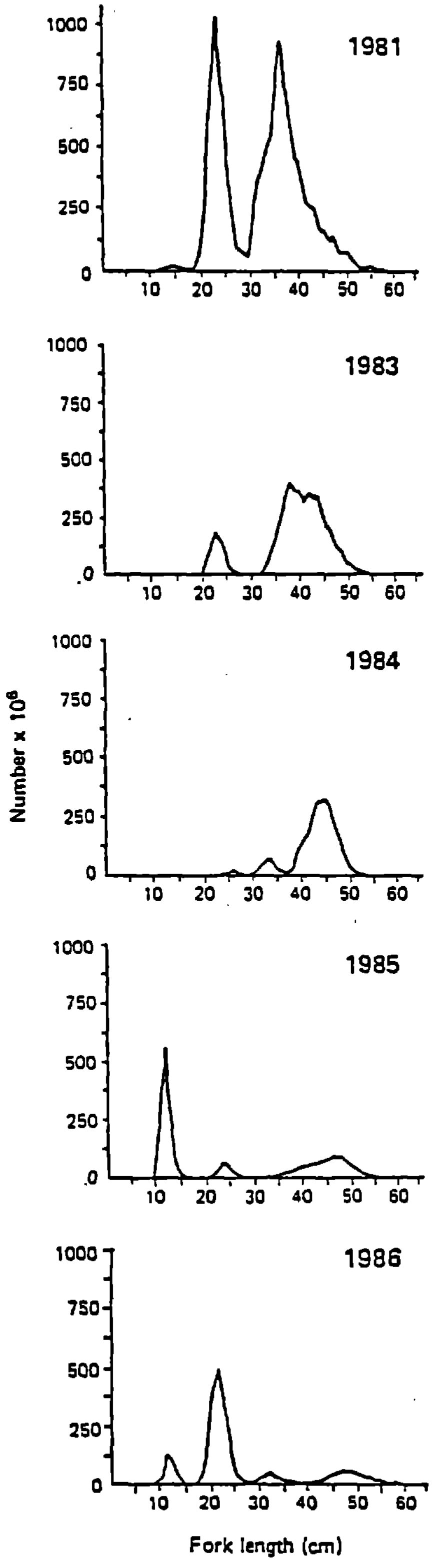

Figure 4.--Pollock population length distributions (sexes combined) determined from the 1981 and 1983-86 Shelikof Strait acoustic-midwater trawl surveys.

Table 6.--Relative abundance of age-l pollock determined from Shelikof Strait acoustic-midwater trawl surveys in 1981 and 1983-86.

Survey year	Year class	Relative abundance index*	
		Number	Biomass
1981	1980	26.3	26.3
1982	- - - - - - - - - - No survey - - - - - - - - - - -		
1983	1982	1.2	1.3
1984	1983	1.0	1.0
1985	1984	5,682.0	5,750.0
1986	1985	1,142.0	1,156.0

*Small differences between the number and biomass indices are caused by differences between years in estimates of average weight.

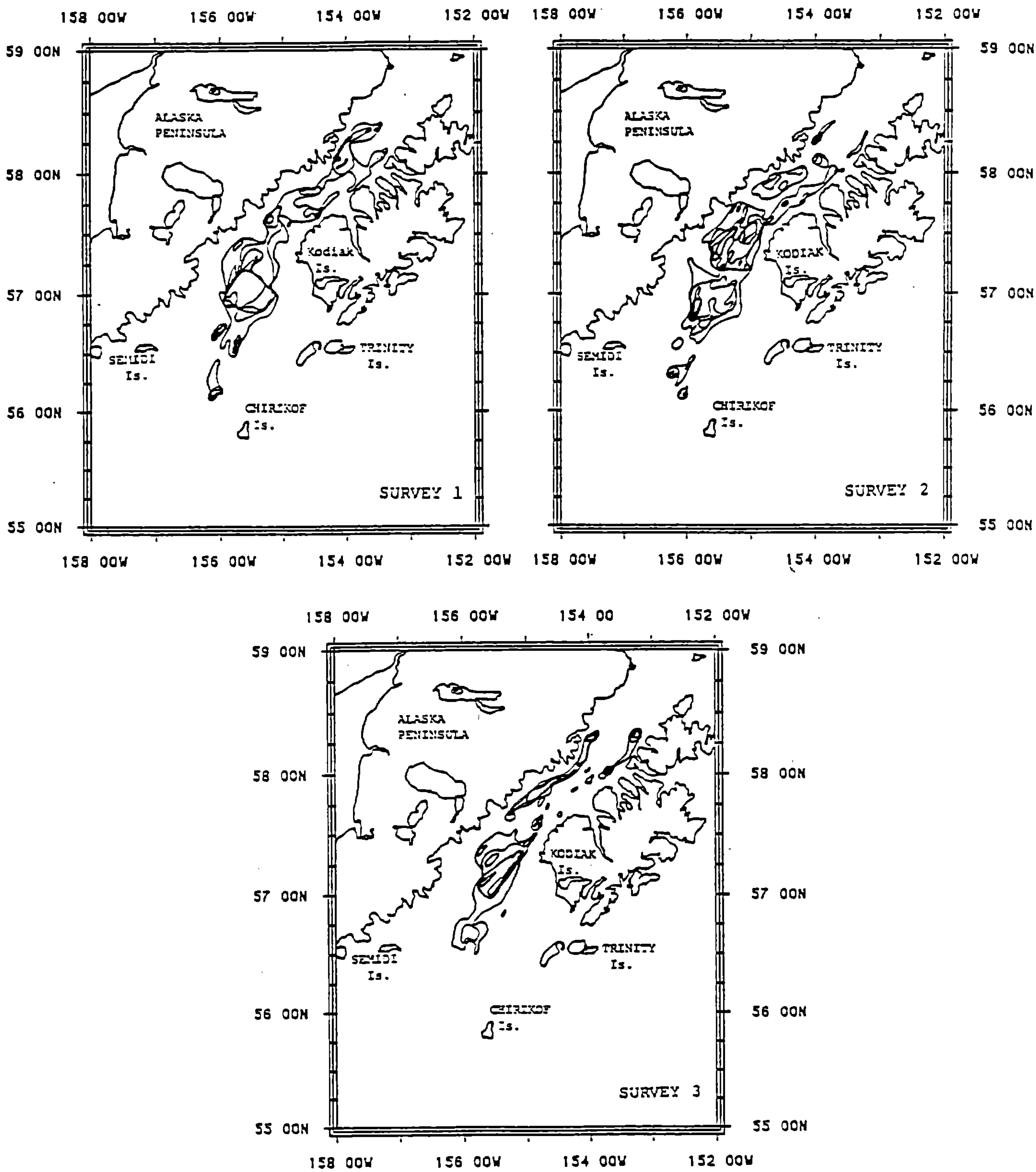

Figure 5.--Distribution of adult pollock (ages >3) in Shelikof Strait during each of the three 1986 acoustic-midwater trawl surveys.

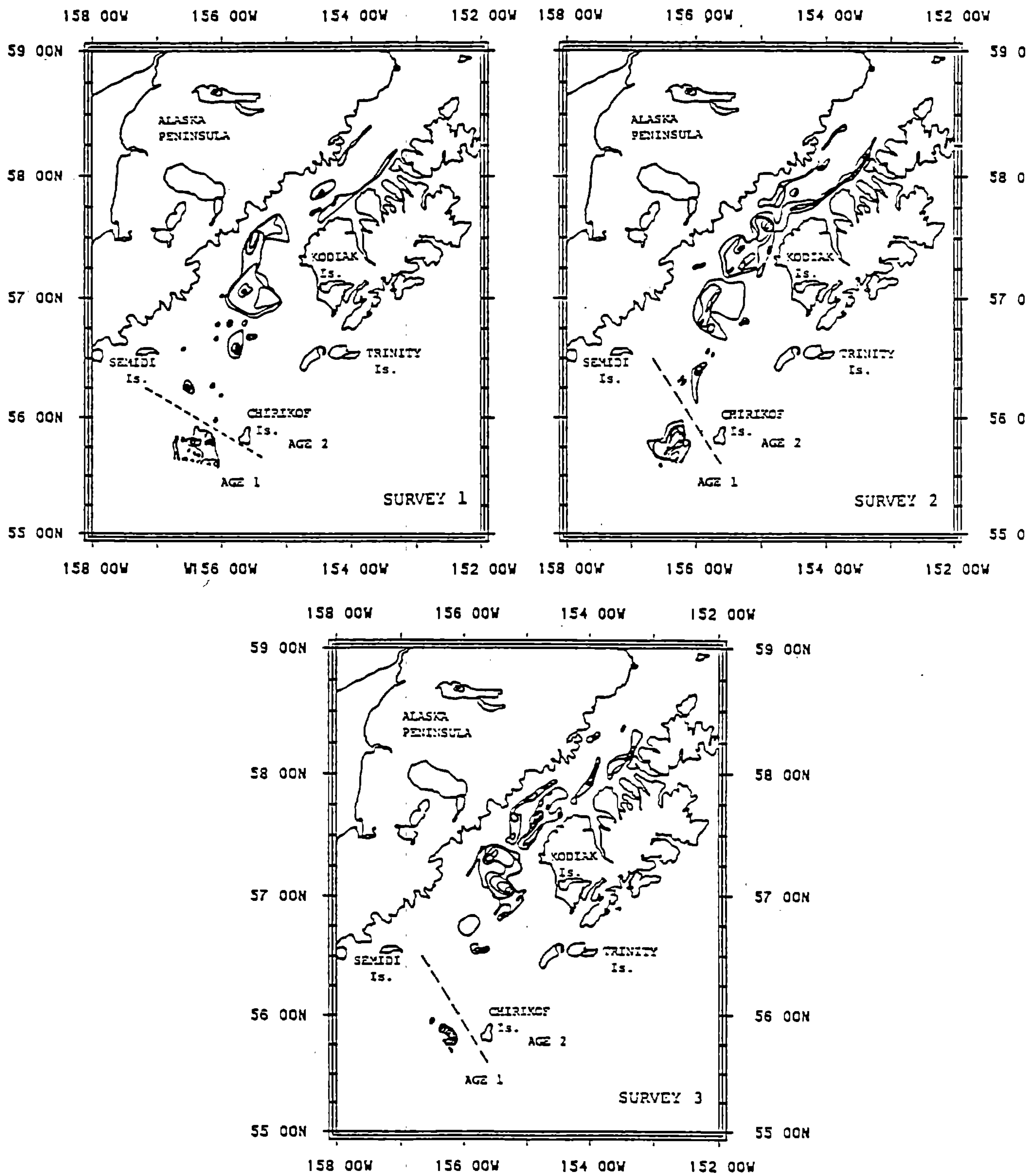

Figure 6. --Distribution of age-l and age-2 pollock in Shelikof Strait during each of the three 1986 acoustic-midwater trawl surveys.

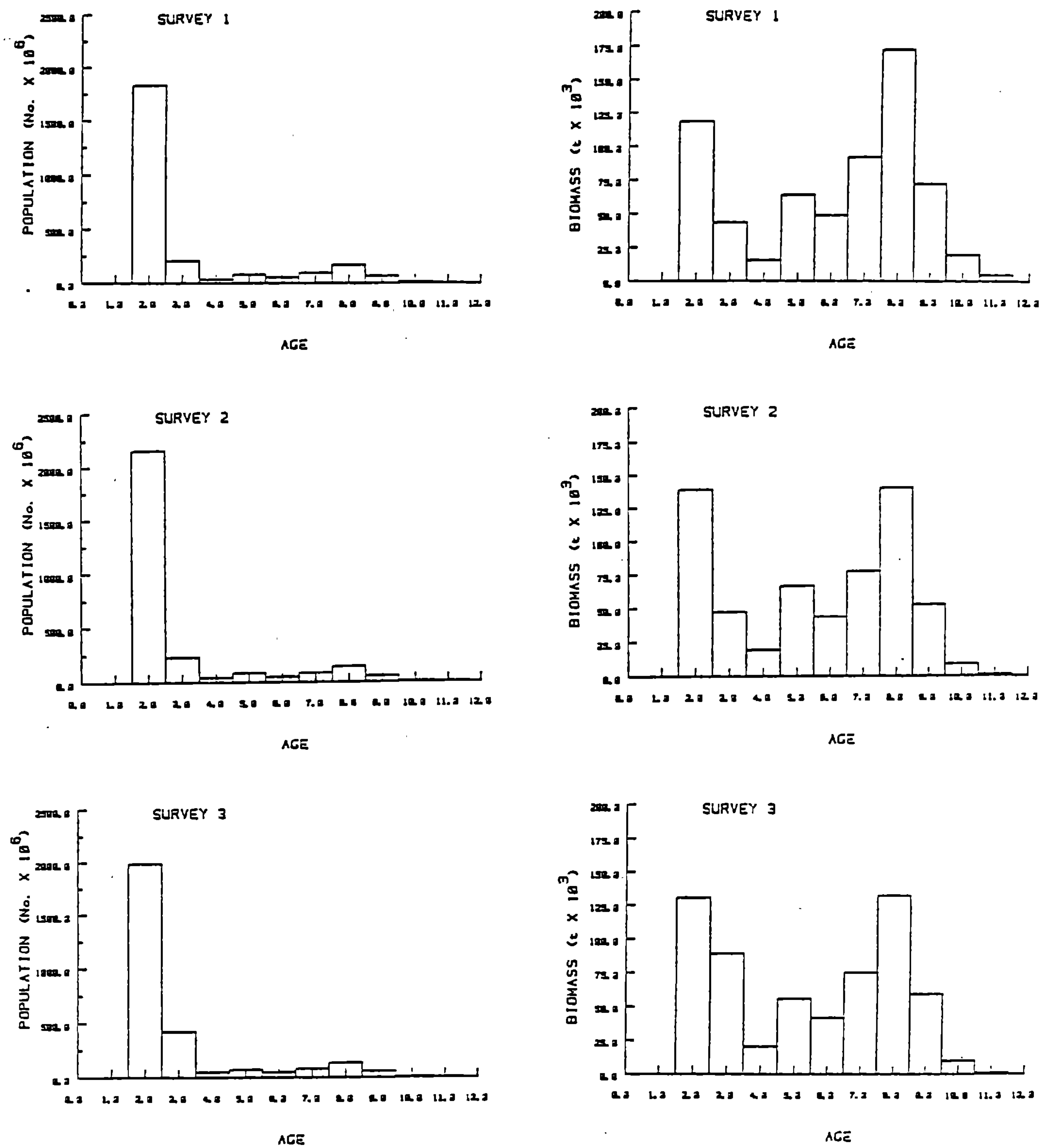

Figure 7.--Pollock population and biomass age distributions (ages >2) determined from each of the 1986 Shelikof Strait acoustic-midwater trawl surveys.

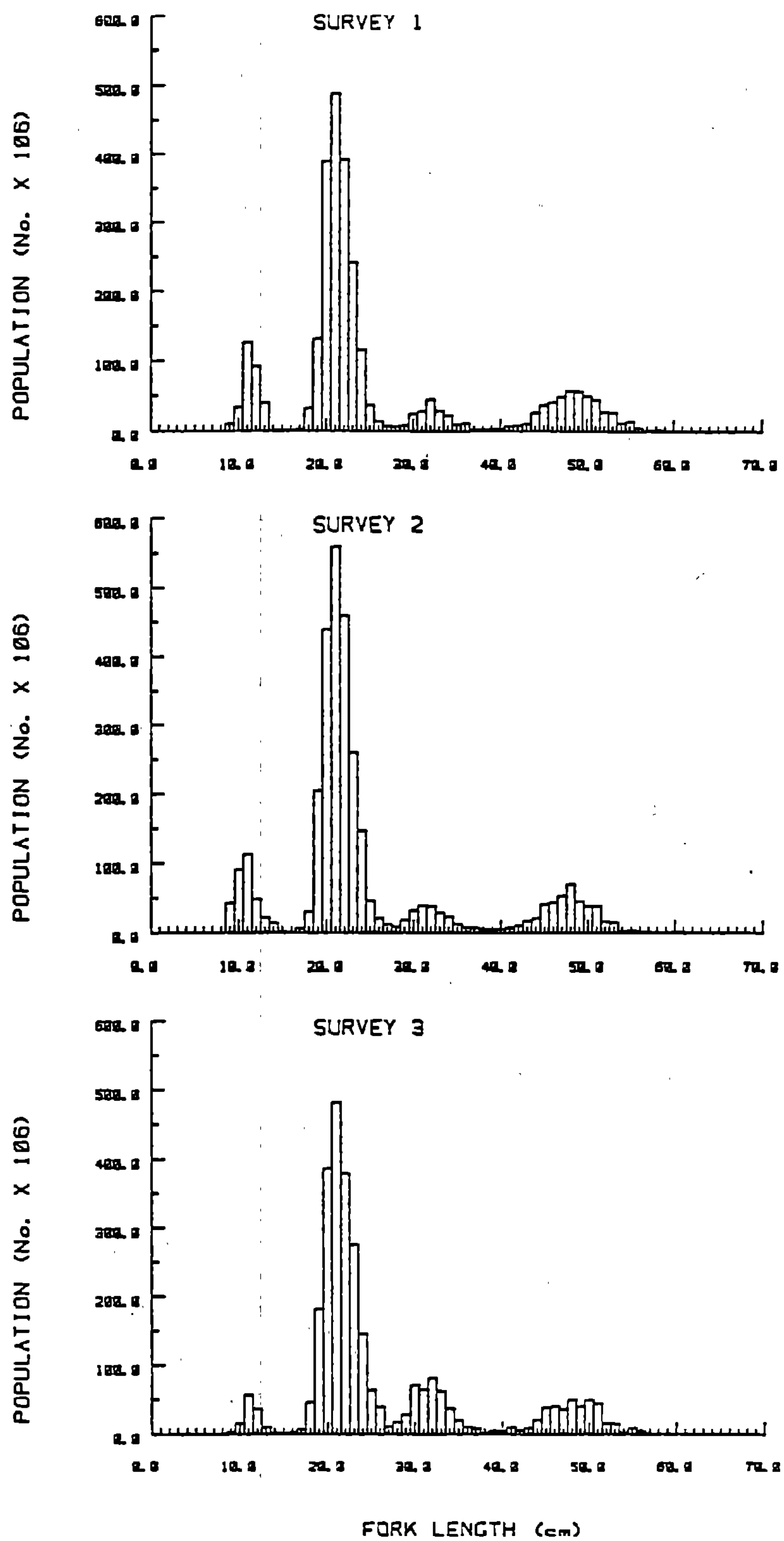

Figure 8.--Pollock population length distributions (sexes combined) determined from each of the 1986 Shelikof Strait acoustic-midwater trawl: surveys.

Table 7.--Percentage maturity compositions (percent) for age-3 and older female pollock sampled during 1983-86 Shelikof Strait acoustic-midwater trawl surveys.

Year	Survey number and period	Maturity stage: Immature	Developing	Mature	Spawning	Spent
1983	1 March 6-15	0.0	17.4	82.1	0.5	0.0
	2 March 16-19	0.0	15.2	81.2	2.8	0.8
	3 April 6-12	0.0	17.9	5.8	12.8	63.5
1984	1 March 1-9	6.4	21.6	72.0	0.0	0.0
	2 March 9-16	0.0	11.9	86.3	1.4	0.4
	3 March 16-18*	---	--	--	--	--
	4 March 22-25	0.6	14.2	48.5	33.0	3.6
	5 April 1-7	0.0	2.3	14.1	28.5	55.1
1985	1 Feb. 21-28	0.0	15.4	84.6	0.0	0.0
	2 March 1-9	3.7	33.9	62.4	0.0	0.0
	3 March 14-20	0.7	30.3	65.5	3.5	0.0
	4 March 21-28	0.3	17.9	55.4	20.1	6.3
1986	1 March 5-12	0.9	27.4	70.9	0.9	0.0
	2 March 13-21	1.7	20.8	69.2	8.3	0.0
	3 March 22-30	0.6	13.8	58.0	16.6	11.0

*Maturity by age data were not obtained for the March 16-18 survey.

RESULTS OF SOVIET RESEARCH VESSEL *GISSAR* SURVEYS

The area covered by the *Gissar*'s echo sounder survey and most of its trawl sampling is shown in Figure 9. Twenty-eight of 33 trawl hauls (Table 8) made during the two surveys were located in this area. The other five hauls, numbers 29-33 in Table 8, were made between Kodiak Island and Unimak Pass during the ichthyoplankton survey. The aggregations of echo sign outlined in Figure 9 indicate locations where pollock or other fish were detected in midwater. The data from the *Gissar*'s surveys, which were partially affected by on-board sampling problems, are still being examined. The remainder of this section is a synopsis of the main results of the surveys.

No large concentrations of adult (ages > 3) pollock were found in the area between Kodiak Island and Yakutat. There were only two significant midwater trawl catches of adults in this area. These occurred southwest of Middleton Island (haul 7) and near Amatuli Trench (haul 25). Each of the other five midwater trawl catches of pollock in this area (hauls 1, 4, 5, 23, and 28) were mainly or entirely juvenile fish (ages 1 and 2). Small quantities of adult fish were taken in five of the seven bottom trawl hauls. It appears that most of the echo sign observed in the area between Kodiak Island and Middleton Island was due to the presence of juvenile pollock (ages 1 and 2). This is based on an examination of the echo signatures and the results of the midwater trawl sampling. Bottom trawl catches made in the areas where concentrations of echo sign were located in the eastern side of the gulf (hauls 12, 13, 15, and 16) indicate that the sign was due mainly to rockfish, particularly rougheye rockfish (*Sebastes aleutianus*) and Pacific ocean perch (*Sebastes alutus*).

Pollock were caught in each of the five midwater trawl hauls made during the ichthyoplankton survey between Kodiak Island and Unimak Pass. Three of the catches (hauls 30, 32, and 33) were entirely adult fish.

DISCUSSION

The results of the 1986 Shelikof pollock surveys were basically in agreement with forecasts of the abundance and age composition of the stock. Unlike the situation observed in previous years, the survey biomass estimate of 493,000 t for adult fish (ages > 3) exceeded by 17% the forecast estimate (420,000 t). The reason for this reversal in the trend for the biomass projections to exceed the survey estimates is unknown. However, it may be related to the fact that, since 1982, the Shelikof joint venture catch has become an increasingly large fraction of the total Gulf of Alaska catch. Megrey and Alton (1986) speculated that the increasing importance of the joint venture fishery relative to the foreign fishery may be one reason why differences between the acoustic survey and catch-at-age analysis estimates of biomass decreased noticeably between 1983 and 1985. (The joint venture fishery is essentially a spring fishery, taking place at about the same time and location as the acoustic surveys. The smaller foreign fishery does not similarly coincide with the acoustic surveys.) Although the agreement between

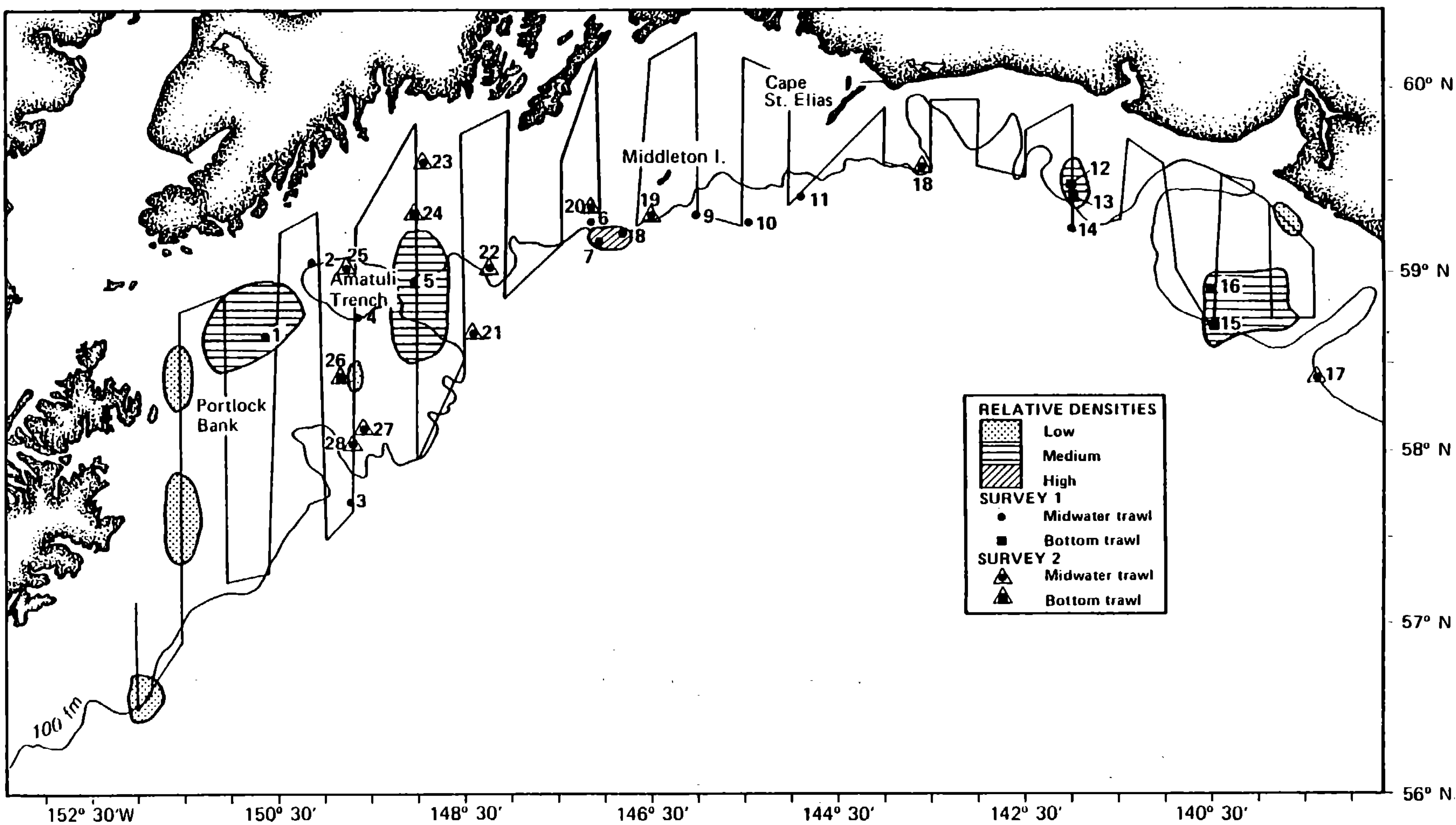

Figure 9.--Echo sounder survey trackline and trawl stations, 1986 Soviet R/V Gissar surveys in the Gulf of Alaska. Five other midwater trawl hauls were made in the area between Kodiak Island and Unimak Pass.

Table S.--Station and catch data for midwater and bottom trawl hauls made during 1906 Soviet R/V Gissar surveys in the Gulf of Alaska.

Haul No.	Date	Start position Lat.(N)	Start position Long.(W)	Duration (h)	Average depth (fm) (footrope/bottom)	Catch (lb) Pollock	Eulachon	Herring	Capelin	Other species
Survey 1 (March 19-29)										
1	3/21	58°39'	150°38'	0.25	96/118	127[a]	3	T	T	0
2	3/21	59°04'	150°08'	1.00	55/99	0	0	0	0	0
3	3/22	57°42'	149°43'	1.00	128/478	0	0	0	0	0
4[b]	3/22	58°45'	149°38'	1.00	28/100	T[a]	0	30,800	0	35
5	3/23	58°57'	149°02'	1.00	72/112	627[a]	T	5	2	1,716
6	3/24	59°17'	147°08'	1.00	72/111	0	344	13,327	344	58
7[b]	3/25	59°11'	147°04'	0.83	115/341	6,250	0	0	0	376
8	3/25	59°12'	146°47'	0.25	133/365	0	0	0	0	233
9	3/25	59°19'	146°01'	0.50	133/472	0	37	0	0	26
10	3/25	59°17'	145°27'	0.50	45/750	0	0	0	0	0
11	3/26	59°25'	144°54'	0.50	159/763	0	0	0	0	0
12[c]	3/27	59°28'	142°00'	0.50	102/102	6[a]	6	0	0	259
13[c]	3/27	59°25'	141°58'	1.00	106/106	0	47	51	2	3,104
14	3/27	59°15'	142°00'	0.50	125/347	0	0	0	0	0
15[c]	3/28	58°42'	140°29'	0.05	111/111	3[a]	0	0	0	525
16[c]	3/28	58°55'	140°30'	0.27	100/100	5[a]	7	2	0	383
Survey 2 (March 29-April 18)										
17[b]	3/30	58°30'	139°27'	1.00	61/100	0	0	11,539	0	121
18	3/31	59°34'	143°33'	0.50	50/122	0	0	0	0	15
19[b]	4/02	59°20'	146°25'	0.25	63/66	0	0	11,000	0	11
20	4/03	59°20'	147°08'	0.27	66/108	0	0	59	11	0
21	4/04	58°45'	148°21'	0.25	27/149	0	0	0	66	0
22	4/04	59°00'	148°19'	0.55	77/121	0	275	224	672	766
23	4/05	59°40'	148°54'	0.67	60/98	464[a]	8	26	37	195
24[c]	4/05	59°20'	149°01'	0.50	105/105	52	0	0	0	219
25	4/07	59°01'	149°46'	0.50	99/126	564	589	0	0	116
26[c]	4/08	58°26'	149°46'	0.50	81/81	2[a]	0	0	0	72
27[c]	4/08	58°07'	149°37'	0.50	127/127	24	2	0	T	166
28	4/08	58°04'	149°39'	0.50	66/107	1,973[a]	24	0	1,565	103

[a]Primarily juvenile fish (ages 1 and 2).

[b]Factory weight estimate.

[c]Indicates bottom trawl haul.

T: Catch <1 lb.

survey and fishery-based analyses is relatively high, it is still apparent that a basic issue affecting assessment and management of the gulf pollock resource is our lack of reliable information on the relationship between the Shelikof stock and the total resource. The Gissar's survey results, like those from other limited survey efforts conducted outside Shelikof Strait (Nelson and Nunnallee 1985), suggest that most of the spawning by western Gulf of Alaska pollock occurs in the strait. However, a more comprehensive survey of the gulf, including waters seaward of the Continental Shelf, is needed to better define the stock structure and biology of gulf pollock.

As discussed by Nelson and Nunnallee (1985) and Nelson and Nunnallee (1986), improvements in acoustic survey techniques are needed to better define the accuracy of the survey biomass estimates. In particular, it is important to obtain size-specific in situ estimates of pollock target strength during the surveys and to compare them to the estimates that have been used to date. As indicated in this report, both dual beam and split beam measurements were obtained in 1986, and results of their analysis will be available in 1987.

Research on Gulf of Alaska pollock in 1987 will include: 1) continuation of the Shelikof survey program in a manner comparable to that conducted in 1986 (i.e., a series of surveys will be conducted in March); 2) analysis and further collection of pollock target strength data; and 3) more detailed analysis of the pollock catch and biological data available from the Shelikof surveys.

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CONDITION OF THE WALLEYE POLLOCK RESOURCE OF THE GULF OF ALASKA AS ESTIMATED IN 1986

by

Bernard A. Megrey and Miles S. Alton

INTRODUCTION

We continue to treat the walleye pollock (*Theragra chalcogramma*) that inhabit the western Gulf of Alaska (from the Fox Islands, 170° W. long., to the vicinity of Prince William Sound, 147° W. long.) as one stock. Virtually all of the pollock catch from the Gulf of Alaska since 1982 has come from this region. Pollock in the eastern Gulf of Alaska (147° W. long. eastward to Dixon Entrance) is considered a separate stock whose biomass was estimated at 89,000 to 177,000 metric tons (t) from research surveys in the mid-1970s (Alton and Deriso 1983). Biomass of the western Gulf of Alaska stock has declined to less than 500,000 t in 1986 from peak levels of over 2 million t in 1981-83 (Nelson and Nunnallee 1987, in this report). Biomass is expected to increase in 1987.

Total removals from the stock have fallen from a peak of 306.7 thousand t in 1984 to 284.9 thousand t in 1985. Optimum yield (OY) was reduced by the North Pacific Fishery Management Council (NPFMC) to 100,000 t in 1986--116,000 t in the gulf overall (Table 1).

This report updates the assessment given by Alton and Megrey (1986) by providing (1) the results of an age-structured analysis that include the most recent year (1985) of catch-at-age data, and (2) a 4-year forecast (1987-90) of annual abundance.

CHANGES IN ABUNDANCE DETERMINED FROM AGE-STRUCTURED ANALYSIS

The catch-at-age data set used as input data to this year's analysis consists of estimates of pollock catch-at-age aggregated over all nations, vessel classes, and International North Pacific Fisheries Commission (INPFC) statistical areas, 1976-85. Also, fishery-independent data, consisting of hydroacoustic biomass estimates of the Shelikof Strait spawning pollock population for calendar years 1981, 1983, 1984, and 1985 (Nelson and Nunnallee 1986), were incorporated into this year's analysis. A single set of average weight-at-age values used in two previous analyses (Alton and Deriso 1983; Megrey 1985) were used in this analysis. These are shown below:

Age	3	4	5	6	7	8	9	10
Weight (kg)	0.471	0.565	0.637	0.686	0.760	0.849	0.872	0.855

Table 1 .--Catch (1,000 t) of pollock in the Gulf of Alaska, by fishery category, 1977-86.

Year	Foreign	Joint venture	Domestic	Total
1977	117.8	0	T	117.8
1978	96.3	T	1.0	97.3
1979	103.8	0.6	2.0	106.4
1980	113.0	1.1	0.9	115.0
1981	130.3	16.8	0.6	147.7
1982	92.6	73.9	2.2	168.8
1983	81.4	134.1	0.1	215.6
1984	99.3	207.1	0.3	306.7
1985	31.6	237.9	15.4	284.9
1986*	0.1	52.3	4.6	57.0

*Jan.-Aug.

T: Trace.

Sources: Foreign and joint venture catches 1977-84: Berger et al. (1986); 1985 and 1986: personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point way NE., Seattle, WA 98115. Domestic catches 1978-80: Rigby (1984); 1981-86: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201.

Model Description and Methods

The CAGEAN separable, non-linear, log catch model (Deriso et al. 1985) was applied to the all-nation catch-at-age data using a constant natural mortality rate of 0.4. All bootstrap means are based on 50 bootstrap replications. Because the fishery changed in 1982 (Alton and Deriso 1983), the model is configured to annually partition age-specific selectivities into a pre-1982 (1976-81) group and a post-1982 (1982-85) group. For the pre-1982 group, selectivities are estimated for ages 3 to 6 over the period 1976-81. Ages 7 to 10 are assumed to be fully recruited (i.e., selectivity = 1.0) over the pre-1982 period, so parameters for these selectivities are not estimated. For the post-1982 group,, selectivities for ages 3 to 6 are constrained to be equal to the 1976-81 values, while selectivities for ages 7 to 10 are allowed to be estimated from, the period 1982-85.

Deriso et al. (1987) discussed extensions to the CAGEAN model that permit the incorporation of fishery-independent data into the analysis. One of these extensions was implemented in this, year's analysis using population biomass estimates from hydroacoustic surveys.

Hydroacoustic population biomass estimates (Bh) for ages 3 to 10 were used along with the catch biomass estimates (Bc) for ages 3 to 10 to calculate an annual full-recruitment exploitation fraction (u = Bc/Bh) for years 1981, 1983, 1984, and 1985. Annual catch biomass estimates (Bc) were calculated using observed catch-at-age data (in numbers) multiplied by the average weight-at-age values provided above. These calculated exploitation fractions, along with an estimate of natural mortality (M), are used to estimate the annual instantaneous full-recruitment fishing mortality rate (F) using the equation

$$u = \frac{F}{F + M}(1-\exp(-(F+M))). \qquad (1)$$

Solutions for F from equation (1) are used as estimates of annual effective full-recruitment fishing effort in the effort-auxiliary sums of squares term of the CAGEAN model (see equation 9 in Deriso et al. 1985). This approach assumes that the relationship between fishing mortality and fishing effort is not exact. In this analysis the catchability coefficient is constrained to be equal to 1.0.

Annual effective-effort parameters estimated from the CAGEAN model can be different from values calculated from equation (1). The degree of difference depends on how strongly the effort-auxiliary sum of squares term is weighted. The weighting factor for the effort-auxiliary sum of squares term in this year's application was set to 0.5. This value is based on results of an analysis of the sensitivity of the model output to the value of the weighting factor.

Biomass Estimates

Biomass estimates (ages 3-10) from the different sources and results from calculations are presented below:

Year	Hydroacoustic biomass estimate (million t)	Catch estimate (t)	Exploitation fraction	Effective effort f (q = 1.0)
1981	3.41	113,689	0.0333	0.0411
1982	--	--	--	--
1983	2.37	224,056	0.1030	0.1328
1984	1.83	289,096	0.1580	0.2111
1985	0.68	238,716	0.3511	0.5419

Results

Results from the stock assessment show a continued decline in the abundance of pollock in 1985. Population abundance has been declining since 1983 after peaking in 1981 or 1982. Estimates of selectivity are similar to results of earlier analyses. Estimates of these parameters are:

Age	3	4	5	6	7	8	9	10
Selectivity	0.300	0.551	0.811	0.885	0.578	0.390	0.203	0.043

The abundance estimates of 3-year-old recruits are presented in Figure 1. The estimates of the population as 3-year-olds (billions of fish) are:

Year	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Year class	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Population estimate	0.39	0.32	1.27	1.78	1.61	2.11	1.26	0.28	0.24	0.025

The estimate for the 1982 year class appears to be one of the weakest on record (25.4 million fish). This value is an order of magnitude lower than the poor 1980 and 1981 year classes. There is evidence from other sources to confirm that the 1982 year class was indeed exceptionally low. This year class, observed as 3-year-olds in 1985, made a poor showing in the 1985 fishery, and it is difficult to say if the low numbers reflect reduced populations or limited availability of the age group to the fishery in 1985. This year class also showed up in very low numbers, compared to other years, in the hydroacoustic population estimates (Nelson and Nunnallee 1987, in this report). Their data show that the abundance of the 1982 year class (74.2 million, estimated as 2-year-olds in 1984) was an order of magnitude lower than the estimated

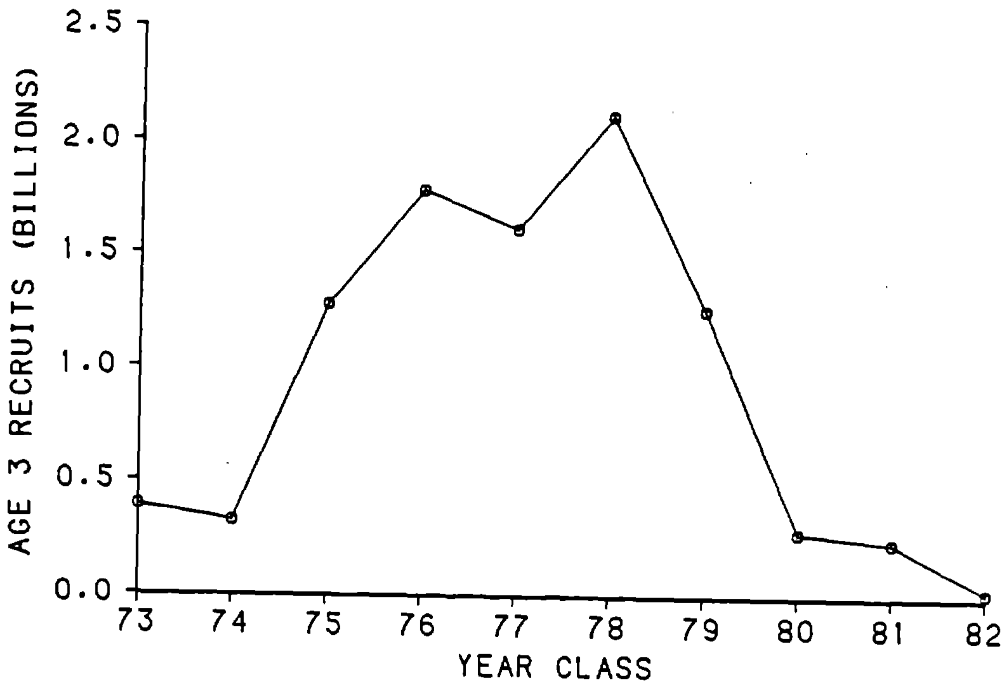


Figure 1.--Number of 3-year-old pollock, by year class, as estimated from age-structured analysis.

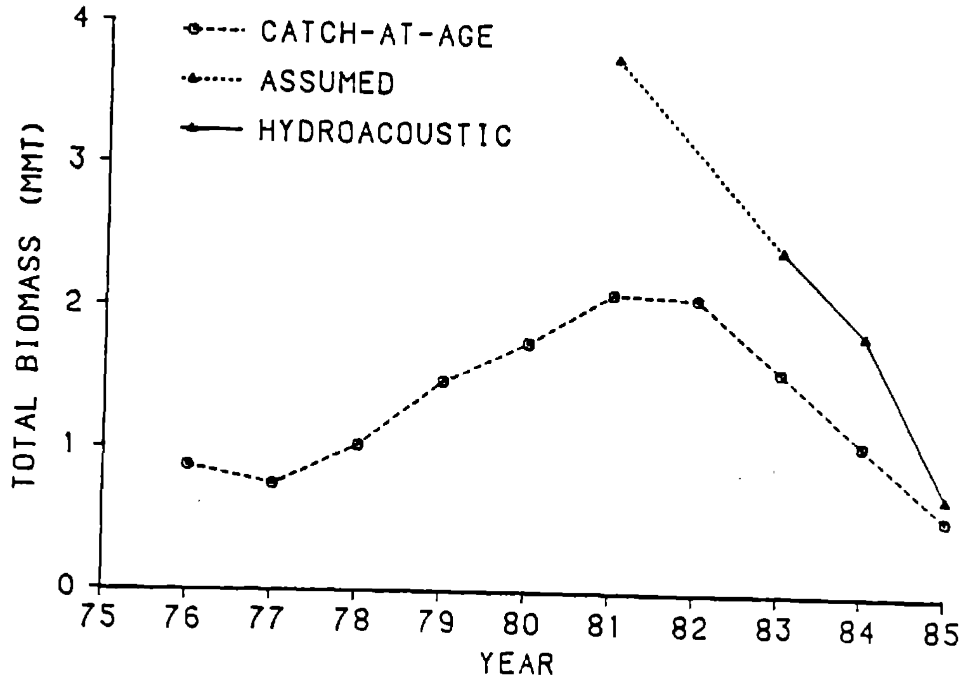


Figure 2.--Estimates of total biomass (1) from acoustic-trawl surveys in Shelikof Strait and (2) from catch-at-age analysis using both foreign and joint venture fisheries data, 1976-85.

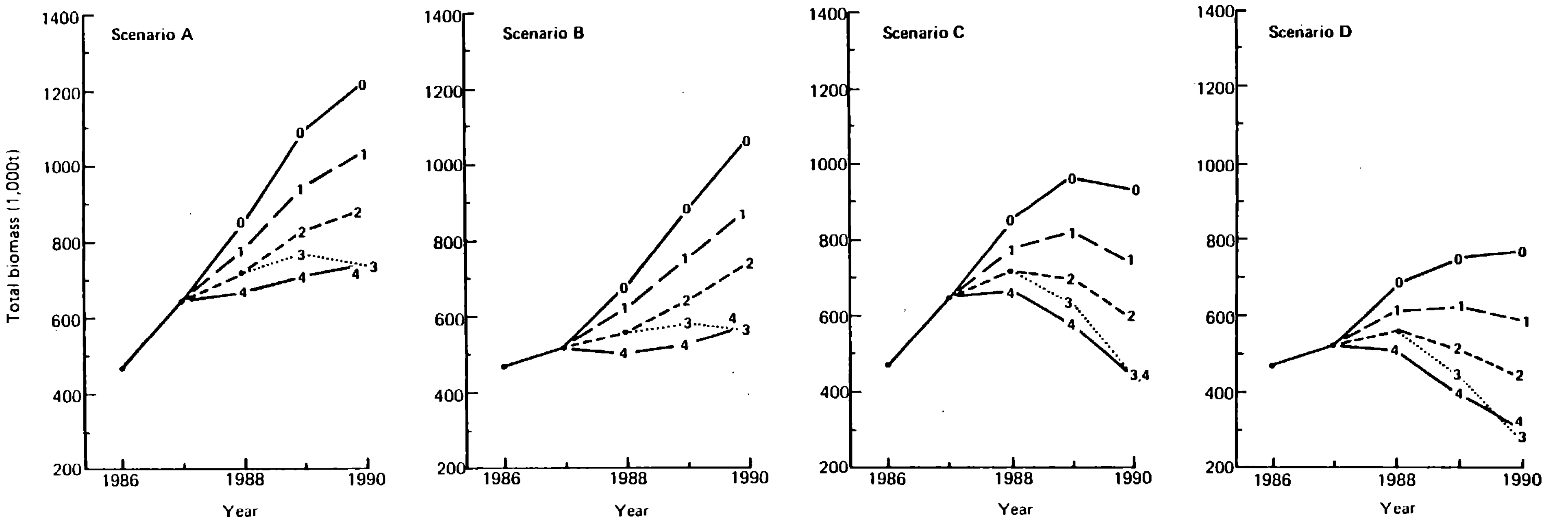
abundance of the 1981 year class (757.8 million estimated- as 2-year-olds in 1983). Since 1984, when the 1982 year class was first observed as 2-year-olds, hydroacoustic population estimates from this year class as 3-year-olds in 1985 and as 4-year-olds in 1986 have been far below estimates of the same age groups in other years. The poor 1982 year class follows two back-to-back poor year classes (1980 and 1981), thus contributing to the continual decline of the population biomass.

Estimates of total population biomass from the catch-at-age analysis agree well with independent hydroacoustic estimates (Fig. 2). The slopes of the decline from the two estimates over the 1983-84 period appear similar, but biomass estimates from catch-at-age analysis are lower than the hydroacoustic estimates by an amount that is roughly constant. The estimates have all but converged in 1985.

FORECASTS OF ABUNDANCE: 1987-90

Projections of biomass (age 3 and older fish) in Shelikof Strait for early 1987 and subsequent years are given for four recruitment scenarios and five annual catch schedules. The projections were initiated using the 1986 hydroacoustic-trawl survey estimate of biomass of age-3-and-older fish (490,000 t) and its age composition in numbers. Recruitment is defined as the number of 3-year-old fish present at the beginning of the year and is given at three levels: 0.3 billion fish for poor recruitment, 0.9 billion fish for average recruitment, and 1.5 billion for strong recruitment. These levels were approximated by averaging the population numbers of 3-year-olds estimated from age-structured analysis (Fig. 1) for poor year classes (1973, 1974, 1980, and 1981), for strong year classes (1975-79), and for all year classes (1973-82). The levels for poor and average recruitment differed from those that were used in a previous forecast (Alton and Megrey 1986) where poor recruitment was 0.5 billion fish and average recruitment was 1.0 billion fish. The new levels reflect the results of the updated age-structured analysis presented above.

All four recruitment scenarios (Fig. 3) assume that the recruitment of the 1983 year class in early 1986 was poor. For scenario A, recruitment is strong in 1987 (1984 year class) but only average for subsequent years (1988-90). That the 1984 year class is strong has so far been indicated by the exceptional numbers of this year class that have been found during the hydroacoustic-trawl surveys in 1985 (l-year-olds) and in 1986 (2-year-olds) (Nelson and Nunnallee 1987, in this report). For scenario B, however, the 1984 year class is conservatively set at average, and like scenario A, recruitment is average for 1988-90. For both scenarios C and D recruitment is given as poor in 1989 and 1990 because the recruiting 1986 and 1987 year classes were produced in years when the spawning biomass was estimated to be low (1986) or projected to be low (1987). We also assume that these biomasses are below the threshold of levels having some likelihood of producing average-to-strong year classes. This will be discussed further in the following section. Other than these poor recruitment levels for 1989 and 1990, scenario C is identical to A, and D to B for the 1986-88 recruitment schedule (Fig. 3).



Year	(Year) (class)	Scenario (age 3 population in billion fish) A	B	C	D
1986	(83)	0.3	0.3	0.3	0.3
1987	(84)	1.5	0.9	1.5	0.9
1988	(85)	0.9	0.9	0.9	0.9
1989	(86)	0.9	0.9	0.3	0.3
1990	(87)	0.9	0.9	0.3	0.3

Figure 3.--Forecasts of total biomass (age-3-and-older fish) in Shelikof Strait (Jan.-Apr.) in 1987-90 given four likely recruitment scenarios and catch schedules 0-4 (see text for description of catch schedules).

For each scenario five projections were made, each having a different annual catch schedule for years 1987-90. These schedules begin with a preliminary estimate of the 1986 catch and are as follows:

Schedule	Catch (1st half of year/2nd half of year) (1,000 t) 1986	1987	1988	1989	1990
0	52/10	0	0	0	0
1	52/10	50/20	50/20	50/30	50/30
2	52/10	100/20	100/20	100/30	100/30
3	52/10	100/20	150/20	200/30	200/30
4	52/10	150/20	150/20	150/30	150/30

For all scenarios the biomass is expected to increase to 660,000 t in 1987 if strong recruitment occurs or to 530,000 t if recruitment is only average. Beyond 1987 the biomass would continue to increase each year for the most optimistic scenarios (A and B) and if the annual catch is 130,000 t or less (schedules 0 to 2). However, for the less optimistic scenarios the biomass would markedly decline in 1989 and 1990 if annual catches follow schedules 2 through 4. Even for the optimistic scenarios biomass would either show little gain, or even a loss, if catch schedules 3 and 4 are followed. The projections for 1988 and beyond have their value in showing the consequences of catch levels set in 1987,

CONDITION OF STOCK

In the brief period for which we have estimates of changes in stock size, we have seen rapid rises as well as declines in biomass because of strong or weak pulses in recruitment. A series of weak year classes (1980-82 and possibly 1983) contributed to the current decline in biomass. The decline was particularly sharp between 1984 and 1985 when the hydroacoustically assessed biomass dropped from 1,840,000 t to 700,000 t (Nelson and Nunnallee 1986). The biomass projection for 1985 (Alton and Rose 1985) was 1,200,000 t, an overestimate of 71%. Alton and Megrey (1986) were not able to adequately explain the discrepancy and discussed the possibility that a significant portion of the stock may not have been available for assessment in early 1985. These unavailable fish may have been near the sea bottom in Shelikof Strait beyond the assessment reach of the hydroacoustical equipment or outside the Shelikof Strait area. Since the unavailable fish appeared to be mainly older fish, it also raised the possibility, that the decline was related to the older fish suffering a higher natural mortality than estimated for the 1985 projection.

In contrast to the greatly overestimated 1985 projection, the 1986 projection of 420,000 t (Alton and Megrey 1986) underestimated by 14% what was nydroacoustically assessed (490,000 t). Projections so far have been consistent with the acoustic assessment in terms of trends but inconsistent in their accuracy. Alton and Megrey (1986) forecasted that the 1986 biomass would be the lowest on record, but that there would be an upswing in 1987 because of the likelihood of strong recruitment of the 1984 year class.

Since recruitment plays a key role in the rise and fall of the pollock biomass, we need a better understanding of those conditions which bring about year-class success or failure. Megrey (1985) suggested that recruitment may be closely related to stock size and may follow the Ricker model (Ricker 1975) where, when stock size reaches a high level, density-dependent effects begin reducing recruitment, and when stock size drops below a certain level, recruitment is reduced because of the lowering of reproductive output. Currently, this relationship is based on a limited number of data points (n = 7). Until the spawner-recruitment relationship can be better defined, we are left comparing trends in year-class strength to the population biomass level that gave rise to a year class. Results from catch-at-age and hydro-acoustic analyses show that strong year classes were produced by stock biomasses that have ranged from 768,000 t (1977 year class) to 1,830,000 t (1984. year class). When stock biomass was over 2 million t, poor year classes occurred (1980-82). The 1982 year class appears to be the weakest on record. What we do not know is how low the biomass has to decline before the stock is unlikely to produce strong as well as average year-class abundance. That level of stock size is presumably somewhere below 768,000 t. In 1986 stock biomass fell to 490,000 t. In our forecasts we have considered the possibility that because of this low biomass the cohort produced that year will be poor (recruitment scenarios C and D, Fig. 3). We have also considered the 1987 year class to be poor in these scenarios, since not only will the projected 1987 biomass be low (530,000-660,000 t) but it will comprise a high proportion of immature 3-year-old fish from the strong 1984 year class. The effect of such poor recruitment from the 1986 and 1987 year classes would result in marginal gains in stock biomass in 1989 and declines in biomass in 1990 for the 70,000-80,000 t annual catch schedule (Fig. 3). But all scenarios presuppose the 1985 year class to be of average abundance, and this is because the biomass that produced this cohort (680,000 t) was less than the minimum biomass (768,000 t) which is known to have produced a strong year class. If the 1985 year class recruits strongly to the stock in 1988, following an average 1984 year class, the impact of two successive poor year classes recruiting in 1989 and 1990 would be expected to stabilize the biomass in these years at levels of 950,000 t or more (biomass change and level would be similar to scenario D where no annual catch is taken from the stock in 1987-90, Fig. 3).

Given the uncertainties of the abundance of the 1985-87 year classes, a conservative catch level for 1987 would be 70,000 to 90,000 t, with the latter catch resulting in a projected biomass slightly less than the projections for the 70,000 annual catch schedule. Catch levels of 70,000 to 90,000 t would likely allow substantial biomass gains between 1987 and 1988, whether recruitment in in 1987 is strong or just average. If the catch level is 120,000 t, only marginal gains in biomass would likely be realized in 1988, particularly if the 1984 year class recruitment is only average. However, current information (Nelson and Nunnallee 1987, in this report) continues to suggest strong recruitment in 1987.

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SABLEFISH[1]

by

Jeffrey T. Fujioka[2]

INTRODUCTION

The sablefish (Anoplopoma fimbria) resource in the northeastern Pacific Ocean extends from northern Mexico to the Gulf of Alaska, westward to the Aleutian Islands, and into the Bering Sea. This resource has been harvested by U.S. and Canadian fishermen since the early 1900s, but catches were relatively small and generally limited to areas near fishing ports from California to southeastern Alaska. Annual catches in the Gulf of Alaska averaged about 1,500 metric tons (t) in 1930-50, and exploitation rates remained low until Japanese longliners began operations in the eastern Bering Sea in 1958. The Japanese fishery expanded rapidly and took as much as 30,000 t in the Bering Sea as early as 1962 (Narita 1983). The Japanese longline fleet expanded in 1963 to the Aleutian Island region and the Gulf of Alaska. Catches rapidly escalated until the record all-nation catch from the northeastern pacific Ocean reached 67,000 t in 1972 and averaged about 50,000 t in 1973-76.

Evidence of declining stock abundance has led to significant fishery restrictions since 1977, and total catches have been reduced substantially. Until 1977, the majority of the sablefish harvest was taken from the Gulf of Alaska. But beginning in 1978, regulations on foreign fleets in the Gulf of Alaska, coupled with sharply increased U.S. effort off Washington-California, reduced the proportion of total sablefish harvested in the gulf. Catches in 1978-83 averaged 13,695 t off Washington-California, 3,212 t off Canada, 612 t in the Aleutian Islands, 2,164 t in the Bering Sea, and 9,206 t in the Gulf of Alaska. Catches in the gulf have increased steadily since 1982 to approximately 21,000 t in 1986.

FISHERY STATISTICS

A summary of the annual sablefish landings from the Gulf of Alaska, by nation, is given in Table 1. The harvest was first expanded in 1963 by the addition of the Japanese trawl fisheries. The reported landings exceeded 15,000 t in 1968, corresponding to the start of the Japanese longline fishery.

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[1]This report is a revised update of Fujioka (1986).

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Table 1.--Catch (t) of sablefish (Anoplopoma fimbria) in the Gulf of Alaska, by nation, 1958-86.

Year	U.S.	Canada	Japan	U.S.S.R.	ROK[a]	Total
1958	698	98	--	--	--	796
1959	1,048	52	--	--	--	1,100
1960	1,925	217	--	--	--	2,142
1961	866	31	--	--	--	897
1962	684	47	--	--	--	731
1963	881	109	1,819	--	--	2,809
1964	1,172	238	1,047	--	--	2,457
1965	1,047	194	2,217	--	--	3,458
1966	1,067	335	3,777	--	--	5,179
1967	946	199	4,998	--	--	6,143
1968	161	128	14,759	--	--	15,048
1969	301	72	19,003	--	--	19,376
1970	578	68	24,497	--	--	25,143
1971	387	15	25,228	--	--	25,630
1972	1,086	16	35,558	535	308	37,503
1973	1,245	10	27,264	109	58	28,692
1974	1,111	10	24,176	38	3,000	28,335
1975	1,557	16	22,072	33	2,167	26,095[b]
1976	1,151	23	21,924	41	3,551	27,738[c]
1977	1,179	3	14,350	9	1,599	17,140
1978	1,738	1	6,458	4	665	8,866
1979	3,447	0	5,919	152	759	10,350[d]
1980	2,384	0	4,831	416	891	8,542[e]
1981	1,941	0	6,910	0	1,062	9,917[f]
1982	2,910	0	4,921	0	724	8,556[g]
1983	3,761	0	4,334	0	632	9,002[h]
1984	8,594	0	844	0	256	10,230[i]
1985	12,215[j]	0	30	0	8	12,479[k]
1986	20,748	0	1	0	0	20,749[l]

[a]Republic of Korea.
[b]Includes 250 t by Taiwan.
[c]Includes 1,048 t by Taiwan.
[d]Includes 55 t by Mexico and 18 t by joint venture fisheries.
[e]Includes 20 t by joint venture fisheries.
[f]Includes 4 t by Poland.
[g]Includes 1 t by joint venture fisheries.
[h]Includes 275 t by joint venture fisheries.
[r]Includes 528 t by joint venture fisheries and 8 t by Poland.
[j]Includes 675 t caught by freezer boats and landed in Washington state and 174 t taken in Prince William Sound. Neither catch was reported to PacFIN.
[k]Includes 226 t by joint venture fisheries.
[l]Includes 45 t by joint venture fisheries (PacFin report no. 002, 12 March 1987).

Sources: 1958-83: Stauffer (1985); 1984-86: Pacific Fishery Information Network (PaCFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland; OR 97201; 1985 (catches in footnote j): personal communication with Fritz Funk, Alaska-Department of Fish and, Game, P.O. Box 3-2000, Juneau, AK 99802.

Catches peaked in 1972 at 37,503 t and averaged 27,715 t in 1973-76. In compliance with the Magnuson Fishery Conservation and Management Act, catch quotas were first implemented in 1977. The foreign harvest of sablefish has since declined from 15,961 t in 1977 to 38 t in 1985 and 1 t in 1986. U.S. domestic harvests in 1976-82 averaged 2,113 t, but increased to 9,122 t by 1984 (including 528 t taken by joint venture fisheries). The domestic sablefish fishery completely replaced the directed foreign fishery in the North Pacific Fishery Management Council (NPFMC) Central and Eastern Regulatory Areas by 1984 and nearly so in the NPFMC Western Regulatory Area in 1985. The U.S. domestic harvest climbed to 12,441 t in 1985 although the joint venture catch (which is included) decreased from 528 to 226 t. The U.S. domestic harvest in 1986 increased to 20,793 t, of which only 45 t was taken by joint venture fisheries.

During its existence, the directed foreign sablefish fishery in the Gulf of Alaska was regulated to the use of longline gear. Allowance for incidental catches of sablefish in trawls continued, and in 1979-84 the incidental catches were 686 t, 1,422 t, 919 t, 540 t, 514 t, and 371 t, respectively (average 742 t). Domestic sablefish gear in the gulf through 1983 consisted almost exclusively of longlines. Trap gear caught 105 t in 1984 and 2,141 t in 1985 (18% of the gulf-wide domestic catch). The longline fishery harvested 77% of the domestic catch in 1985, and the remaining 5% was harvested primarily by the trawl fishery (Table 2). In 1986, the longline fishery harvested roughly 75% of the domestic catch; the trawl fishery, 16%; and trap gear, 10% (Table 3).

The gulf-wide optimum yield (OY) was set at 22,000 t in 1977 (Table 4). The OY was reduced to 15,000 t in 1978 and 13,000 t in 1979 by the implementation of the fishery management plan (FMP) for the Gulf of Alaska groundfish fishery. Furthermore, the OY was prorated-- 2,100 t to the Western Regulatory Area (International North Pacific Fisheries Commission (INPFC) Shumagin Statistical Area), 3,800 t to the Central Regulatory Area (INPFC Chirikof and Kodiak Areas), and 7,100 t to the Eastern Regulatory Area (INPFC Yakutat and Southeastern Areas). The 1981 OY was 13,000 t (12,300 t in the fishery conservation zone (FCZ) and 700 t in waters under Alaskan jurisdiction). Temporarily, the 12,300 t in the FCZ was increased by 16.7% and the season was expanded to 14 months to make the reporting and calendar years coincide. In 1982, for the first time, the NPFMC Eastern Regulatory Area OY of 6,400 t was partitioned into the INPFC Yakutat and southeastern Areas. Gulf-wide, the OY remained at 13,000 t. Amendment 11 to the FMP in 1983 established OY at 8,230 to 9,480 t, 75% of equilibrium yield (ZY). To allocate OY, the Eastern Regulatory Area was repartitioned in 1983 into subareas east and west of 140° W. long. The subarea west of 140° W. long. consists of the western part of the INPFC Yakutat Area, and the subarea east of 140° W. long. consists of the eastern portion of the INPFC Yakutat Area and the portion of the INPFC Southeastern Area lying outside Alaskan jurisdiction. The subarea east of 140° W. long., although considered as a single area in terms of OY allocation, is managed as two areas--East Yakutat and Southeastern (Fig. 1). The 1983 OY was maintained in 1984 and 1985. The OY was increased in 1986 to 15,000 t and allocated to the regulatory areas in proportion to the estimated biomass at depths >400 m: 2,850 t to the Western Regulatory Area, 6,150 t to the Central Regulatory Area, and 6,000 t to the Eastern Regulatory Area.

Table 2.--Domestic processed catch (t) of sablefish (Anoplopoma fimbria) by gear and NPFMC regulatory area, 1985.

Gear	Area: Western	Central	Eastern	Total
Longline	1,236	2,835	5,368	9,439
Trawl	15	532[a]	34	581
Trap	704	577	860[b]	2,141
Other gear	0	0	55	55
Total	1,955	3,944	6,317	12,216

[a]Includes 174 t caught in Prince William Sound. This was not reported to PacFIN.

[b]Includes 675 t caught by freezer boats and landed in Washington State. This was not reported to PacFIN.

Sources: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201, except for catches referred to in footnotes a and b. These were obtained via personal communication with Fritz Punk, Alaska Department of Fish and Game, P.O. Box 3-2000, Juneau, AK 99802.

Table 3.--Domestic catch (t) of sablefish (<u>Anoplopoma fimbria</u>) in the Gulf of Alaska, by gear and NPFMC regulatory area, 1986.

Gear	Area			Total
	Western	Central	Eastern	
Longline	1,794	5,100	8,629	15,523
Trawl	695	1,764	765	3,224
Trap	787	1,193	21	2,001
Total	3,276	8,057	9,415	20,748

Source: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201 (report no. 124, 16 February 1987).

Table 4.--Year-end optimum yield (OY) of sablefish (Anoplopoma fimbria) domestic annual harvest (DAH), and total allowable level of foreign fishing (TALFF) for the Gulf of Alaska, be NPFMC regulatory area, 1977-86.

Year		Area: Western	Central	Eastern		Total
1977	OY					22,000
	DAH					2,500
	TALFF					19,500
1978	OY					15,000
	DAH					4,000
	TALFF					10,200
1979	OY	2,100	3,800	7,100		13,000
	DAH	100	100	3,800		4,000
	TALFF	1,965	3,570	3,270		8,805
1980	OY	2,100	3,800	7,100		13,000
	DAH	25	171	4,812		5,008
	TALFF	2,075	3,629	2,288		7,992
1981	OY	2,450	4,433	7,466		14,349[ab]
	DAH	115	423	3,805		4,343
	TALFF	2,335	4,010	3,661		10,006
				Yakutat	SE	
1982	OY	2,100	3,800	3,400	3,000	12,300[b]
	DAH	270	750	1,380	2,910	5,310
	TALFF	1,830	3,050	2,020	90	6,990
				West 140° W.	East 140° W.	
1983	OY	1,670	3,060	1,680	1,320-2,570[c]	7,730-8,980[b]
	DAH	270	400	266	1,320-2,570	2,256-3,506
	TALFF	1,400	2,660	1,414	0	5,474
1984	OY	1,670	3,060	1,680	1,320-2,570[c]	7,730-8,980[b]
	DAH	556	2,262	1,344	1,320-2,570	5,482-6,732
	TALFF + RES.	1,114	798	40	0	1,952
1985	OY	1,670	3,060	1,680	2,570	8,980[b]
	DAH	1,670	3,060	1,680	2,570	8,980
	TALFF + RES.	0	0	0	0	0
1986	OY	2,850	6,150	2,550	3,450	15,000[b]
	DAH	2,850	6,150	2,550	3,450	15,000
	TALFF + RES	0	0	0	0	0

[a]The OY was 13,000 t in 1981--12,300 t in the U.S. fishery conservation zone and 700 t for waters under Alaska jurisdiction. The 12,300 OY was increased (on a one-time basis) to 14,349 t to facilitate the transition of the foreign fishing year from a November to October basis to a January-December (calendar year) basis.

[b]An additional 700 t was allocated to waters under Alaskan jurisdiction in 1981-82 and 500 t in 1983-86.

[c]The OY in the area east of 140° W. Long. is further broken down into the following ranges: 850-1,135 t for east Yakutat and 470-1,435 t for the outer coast of southeastern Alaska.

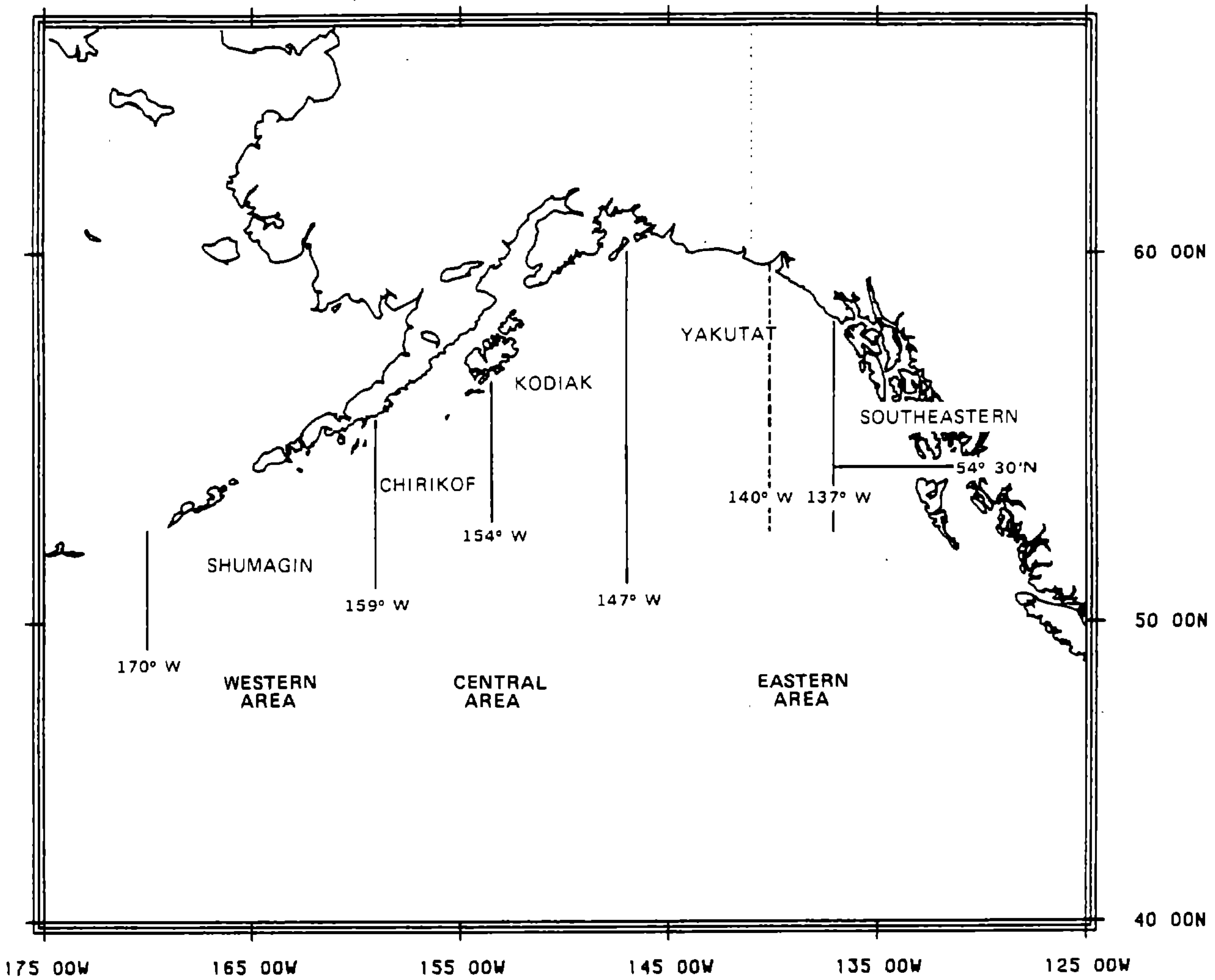

Figure 1.--Gulf of Alaska: International North Pacific Fisheries Commission (INPFC) statistical areas (Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern) and North Pacific Fishery Management Council regulatory areas (Western, Central, and Eastern). The INPFC Yakutat Area is divided at 140° W. long.

Annual landings averaged 72% of the OY each year for 6 years immediately following 1976. Domestic landings during this same period averaged 54% of the expected domestic annual harvest (DAH). Foreign landings exceeded the initial allocations of total allowable level of foreign fishing (TALFF) but, of the final allocations, averaged 87% and, in 1983, equaled 91%. The U.S. harvest exceeded the DAH for the first time in 1983 and exceeded the DAH, which had been increased, in 1984. The U.S. fishery received (and eventually exceeded) the entire OY in 1985 and 1986.

CONDITION OF THE STOCKS

Stock Structure

Experiments to identify sablefish stocks in the Gulf of Alaska continue. Scientists from the National Marine Fisheries Service (NMFS), the Alaska Department of Fish and Game (ADF&G), Japan, and Canada have released tagged sablefish over the past several years. There is disagreement on the degree of interchange of fish between regions. Wespestad et al. (1983) reported that interregional migration is small in comparison to stock size within each region, and agreed with previous reports (Low et al. 1976; Wespestad et al. 1978) that management of the resource is best conducted by geographic region. Bracken (1982), however, described an analysis of gulf-wide sablefish tagging data and suggested that sablefish move extensively throughout the Gulf of Alaska. His analysis showed that fish <60 cm fork length (FL) tended to move westward, whereas those 260 cm FL tended to migrate eastward.

Fujioka and Shaw (1985) also studied the movement of sablefish in the Gulf of Alaska. In a preliminary summary, the numbers of tagged fish released in each INPFC area in 1978-82 and recovered in the INPFC Southeastern Area in 1979-83 were adjusted by dividing the number recovered by the number (in 1,000s) released per area and year. These "release-adjusted" recoveries yielded an estimate of the composition of recoveries in the INPFC Southeastern Area that would have resulted if 1,000 tagged fish had been released annually in each INPFC area. On this basis, 54 to 69% of the recoveries in the INPFC Southeastern Area were from other INPFC areas.

Bracken (1982) also presented a conceptual model that identified southeastern Alaska and British Columbia as a pooling area for large fish and showed that much of the spawning is in that region. Small fish inhabit the shallow nearshore areas and then enter deep water in their third or fourth year. From there, a significant portion of the fish migrate to the open ocean and move westward until reaching maturity. A large portion of the mature fish then migrate back into the eastern gulf to spawn. Bracken (1982) concluded by recommending management of sablefish as a single gulf-wide stock with OY prorated over all regulatory areas, and suggested that lower harvest levels throughout the gulf would speed rebuilding of the depleted spawning population in the INPFC Southeastern Area.

Beamish and McFarlane (1983) concluded from their tagging studies that a large portion of juvenile sablefish reared in Queen Charlotte Sound and Hecate Strait, British Columbia, move north to Gulf of Alaska waters.

Conversely, most tagged adult sablefish were recovered close to the release area, indicating that the adult population is composed of subpopulations or groups. Based on these results, Beamish and McFarlane (1983) contended that adult sablefish in the Canadian zone should be managed separately and should not be managed as a part of one large stock off the west coast of North America. In a review of U.S. tagging studies, Dark (1983) found apparently similar northward movement of small (40-65 cm FL) sablefish released off Alaska and Washington but less movement of fish >65 cm FL.

Gharrett et al. (1983) reexamined electrophoretic data on sablefish. Their new interpretation suggested that some geographic separation of genetically distinct stocks exists. They separated eight Gulf of Alaska collections (excluding seamount samples) into groups with major divisions at Kodiak Island, about 140° W. long. in the INPFC Yakutat Area, and in the vicinity of Cape Addington in the INPFC Southeastern Area.

Tagged fish released by NMFS from southeastern Alaska inside waters in Chatham Strait and recovered in outside waters generally are not caught north of the entrance to Chatham Strait, but are caught south as far as the INPFC Charlotte Statistical Area off British Columbia.[3/]

Currently, management of sablefish in the Gulf of Alaska is by five management regions: the NPFMC Western and Central Regulatory Areas, the western and eastern portions of the Eastern Regulatory Area, and the portion of INPFC Southeastern Area not under Alaskan jurisdiction. Clearly, the questions of migration and stock structure, basic to rational management of sablefish, are yet unresolved.

Year-Class Strength

Year-class strength is an important consideration in studying the dynamics of fish populations. The examination of fish length data (mean fork lengths and length frequency distributions) is, in turn, one way of monitoring the strength of year classes. Several sources provided length data on the sablefish population in the Gulf of Alaska--the Japanese longline fishery, 1969-83; the NMFS trap indexing surveys in southeastern Alaska, 1978-86; the Japan-U.S. cooperative longline surveys, 1979-85; and the 1984 triennial survey (the U.S.-Japan cooperative bottom trawl survey in the central and western gulf and complementary surveys in the eastern gulf).

Several authors (Balsiger and Alton 1981; Sasaki 1982; McFarlane and. Beamish 1983; Funk and Bracken 1984) have reported strong recruitment from the 1977 year class. The 1979 NMFS trap indexing survey (Fig. 2) provided one of the first opportunities to observe the emergence of the 1977 year class--as a mode in the length frequency distribution at 45-50 cm FL. The mode moves to the right (increases) with time and, by 1983, either dominates

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3/ Personal communication with Michael Sigler, Auke Bay Laboratory, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, P.O. Box 210155, Auke Bay, AK 99821.

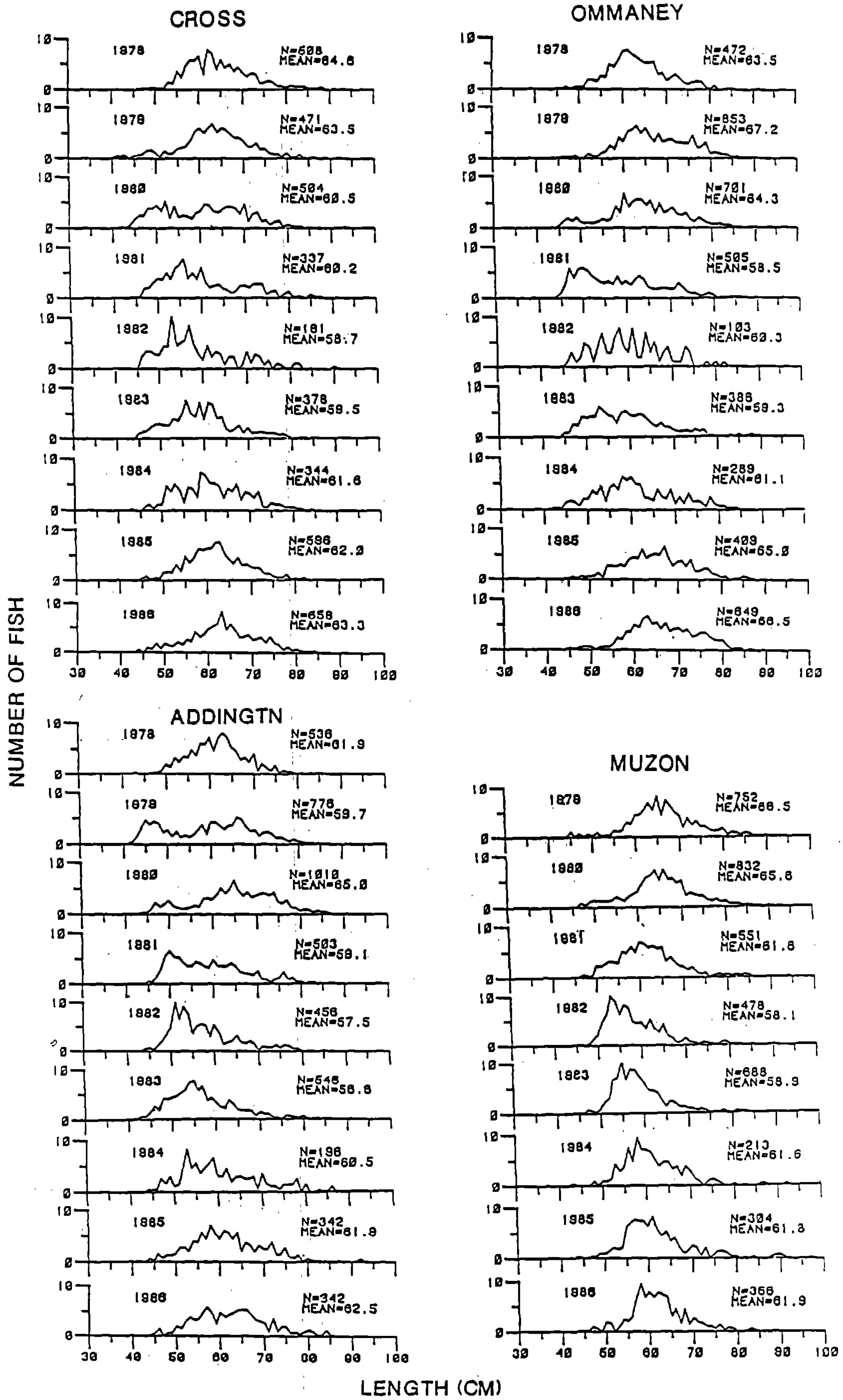

Figure 2.--Length frequency distribution of sablefish (Anoplopoma fimbria) in National Marine Fisheries Service trap-indexing surveys in the Gulf of Alaska, 1978-86.

or helps dominate the length frequency distribution at about 55-60 cm FL. The presence of a strong 1977 year class was first reflected in the Japanese longline data in 1980 by a decrease in mean length of fish at depths >500 m, a decrease that remained as long as the fishery existed.

Stauffer (1985) noted a higher percentage of fish t55 cm FL in the Japanese longline fishery in 1982-83 than in years prior to the appearance of the 1977 year class and surmised that post-1977 year class recruitment has been successful as well. Data from the NMFS trap indexing surveys indicate a similar difference between the length frequency distributions in 1983, 1984, and before the 1977 year class appeared in 1979. Further, the percentage of fish <55 cm FL in the 1983 and 1984 distributions was similar for the NMFS trap indexing surveys, the Japan-U.S. cooperative longline surveys, and the Japanese longline fishery.

Length frequency distributions, weighted by estimated biomass (Brown 1986), indicate that the abundance of fish 50-56 cm FL was high in the INPFC Kodiak Area in 1984. Fish of this size are presumably in their fourth or fifth summer, making them cohorts of the 1980 or 1981 year class.

A preliminary estimate of age composition in the 1984 population, based on otolith samples from the 1984 longline survey, indicates the presence of' strong year classes beginning in 1977 and continuing until 1981 (Fig. 3). Ageing sablefish is difficult, and the indication of five adjacent strong year classes may actually result from two or three strong year classes.

Small (30-40 cm FL) sablefish, presumably of the 1984 year class, were more abundant than usual in inside waters of southeastern Alaska in 1985.

U.S. Foreign Fisheries Observer Data

From data collected by U.S. foreign fisheries observers on the depth of the fishing gear, Japanese longline effort in the gulf was categorized as being' directed at either Pacific cod, Gadus macrocephalus, (<300 m deep) or sablefish (>500 m deep) (Balsiger and Alton 1981). These data cover 1977-83 and demonstrate trends similar to those of the longline survey. The catch per unit effort (CPUE) increased from the late 1970s, with a sharp increase from 1981 to 1982. Similar to the longline survey, the 1983 CPUE did not increase from 1982.

More detailed discussion of the foreign observer data and the foreign fishery is in Balsiger (1983) and Stauffer (1983 and 1985). With the removal of foreign directed effort on sablefish in the gulf in 1984, this time series of observations no longer provides up-to-date information on status of stocks.

Japan-U.S. Cooperative Longline Survey

Since 1978 Japan and the United States have cooperated to survey the Gulf of Alaska with longlines--an activity which has expanded in recent years to include the Bering Sea-Aleutian Islands region. The survey objective is to study the condition of the stocks of sablefish and other species caught by

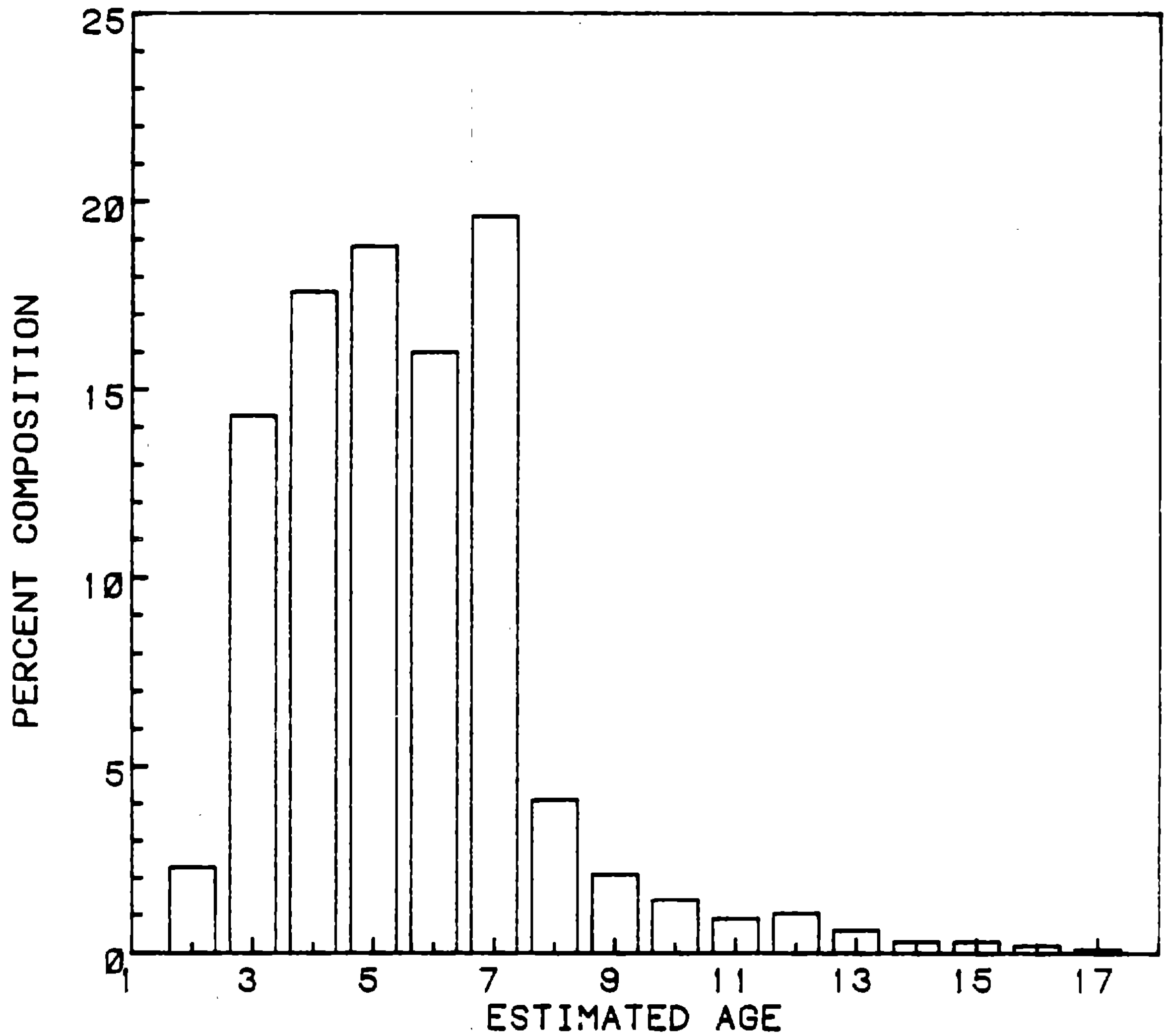

Figure 3.--Age composition of sablefish (Anoplopoma fimbria) in the Gulf of Alaska estimated from otoliths sampled during the Japan-U.S. cooperative longline survey, 1984.

longline. The relative abundance and size structure of sablefish in the northeastern Pacific Ocean and Bering Sea based on the results of these surveys have been updated by Sasaki (1983a, 1983b, 1984a, 1984b, 1985, and 1986) for 1979-85, including a comparison with a 1969 Japanese survey in the Gulf of Alaska. Sasaki presents two indices of population abundance: relative population number (RPN) and relative population weight (RPW). The RPW, an index of biomass, is a summation of the CPUE in units of catch weight for the longline gear for each of several depth categories, multiplied by the area of the fishing grounds that lie in those depth categories. Index values have been summarized by Sasaki (1986) by INPFC area and bottom depth strata 101-200 m and 201-1,000 m for 1979-85 (Table 5). The 1978 survey results were excluded because the fishing techniques were not standardized until 1979.

The 1985 RPW for the Gulf of Alaska (depths l0l-1,000 m pooled) reported by Sasaki (1986) was 2.8 times the 1979 RPW and 1.5 times the 1984 RPW. The 1985 RPW exceeded the 1984 RPW in each INPFC area and was the highest ever surveyed in each area except the Southeastern Area. Similarly, the 1985 RPN was 2.3 times the 1979 RPN and 1.4 times the 1984 RPN. Sigler and Fujioka (1987) extended the analysis by computing confidence intervals for the RPNs. They reported that the increase in RPN between 1979 and 1984 was significant gulf-wide and in the INPFC Shumagin and Kodiak Areas, but not in the INPFC Chirikof, Yakutat, and Southeastern Areas (Figs. 4 and 5). Further, the increase in RPN between 1984 and 1985 was significant gulf-wide, but not so in any of the individual areas.

Two-thirds of the increase in RPW reported by Sasaki (1986) was in the 101-200 m stratum--a stratum where indexing is highly variable (Sigler and Fujioka 1987). Also, the potential for a significant overestimate seems likely in the 101-200 m stratum because 1) this stratum is sampled only along its deeper perimeter and 2) sampling often covers less than half of the depth range. The area within the 101-200 m stratum (which is quite large) is therefore represented by catch rates obtained solely along the perimeter adjacent to the continental slope (customarily considered to be sablefish habitat). This concern about using catch rates obtained along the outer edge of the stratum to represent the entire stratum was borne out by the observation that catch rates obtained during the 1984 U.S.-Japan cooperative bottom trawl survey adjacent to the slope in the Shumagin, Chirikof, Kodiak, and Western Yakutat Areas at depths 101-200 m exceeded the catch rates in the corresponding flat and gulley areas[4]/. In the 1985 longline survey, the average beginning depth sampled in the 101-200 m depth stratum was 127 m in the Shumagin Area, 148 m in the Chirikof Area, 165 m in the Kodiak Area, 182 m in the Yakutat Area, and 155 m in the Southeastern Areas[5]/.

4/ Personal communication with Eric Brown, Resource Assessment and conservation Engineering Division, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE., Bin C15700, Building 4, Seattle, WA 98115.

5/ Personal communication with David Clausen, Auke Bay Laboratory, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, P.O. Box 210155, Auke Bay, AK 99281.

Table 5.--Relative population number (RPN) and relative population weight (RPW) of sablefish (Anoplopoma fimbria) on the Continental Shelf and continental slope of the eastern Bering Sea, Aleutian region, and Gulf of Alaska in summer, 1979-85. The values are shown as percentage of 1979 value in the Gulf of Alaska (from Sasaki 1986).

Region and area	Year	Shelf (101-200 m) RPN	Shelf (101-200 m) RPW	Slope (201-1,000 m) RPN	Slope (201-1,000 m) RPW	Total[a] RPN	Total[a] RPW
Eastern Bering Sea	1982[b]	3	3	14	15	17	18
	1983[c]	5	5	8	9	13	14
	1984[b]	2	1	18	19	20	20
	1985[b]	1	1	28	29	28	30
Aleutian region	1980	2	1	13	14	15	15
	1981	<1	<1	13	14	13	15
	1982	<1	<1	15	16	15	16
	1983	0	0	16	19	16	19
	1984	<1	<1	19	23	19	23
	1985	<1	<1	23	30	23	30
			Gulf of Alaska				
Shumagin	1979	3	-	4	-	6	6
	1980	6	4	4	5	10	9
	1981	9	8	6	7	15	15
	1982	9	10	10	12	19	22
	1983	14	13	11	14	25	28
	1984	8	8	11	15	19	23
	1985	10	10	14	21	24	30
Chirikof	1979	16	-	20	-	36	32
	1980	12	9	18	22	30	31
	1981	8	7	19	21	27	26
	1982	11	10	32	37	43	46
	1983	11	8	27	31	38	39
	1984	17	14	32	40	48	54
	1985	25	22	36	50	61	72
Kodiak	1979	11	-	18	-	28	29
	1980	18	13	16	18	34	31
	1981	11	9	16	18	27	27
	1982	20	18	21	25	40	42
	1983	21	16	25	28	46	44
	1984	35	31	25	30	60	61
	1985	69	74	28	42	97	116
Yakutat	1979	8	-	9	-	17	19
	1980	22	17	10	11	32	28
	1981	20	20	13	16	33	35
	1982	21	17	16	18	37	36
	1983	16	12	12	15	28	27
	1984	8	7	12	17	20	23
	1985	18	17	14	20	32	37

Table 5.--Continued.

Region and area	Year	Shelf (101-200 m) RPN	Shelf (101-200 m) RPW	Slope (201-1,000 m) RPN	Slope (201-1,000 m) RPW	Total[a] RPN	Total[a] RPW
Southeastern	1979	3	-	10	-	12	13
	1980	6	4	11	11	17	15
	1981	8	8	14	19	22	27
	1982	9	8	12	16	21	24
	1983	6	4	11	15	17	19
	1984	4	4	11	16	16	20
	1985	7	7	13	19	20	25
Gulf of Alaska total	1979	40	-	60	-	100	100
	1980	63	47	59	66	122	113
	1981	57	52	68	80	125	132
	1982	70	63	91	107	161	170
	1983	68	55	86	103	154	158
	1984	72	65	91	118	163	183
	1985	128	129	106	151	234	280

[a]Discrepancies between actual sums of component figures and totals given are due to rounding.

[b]Because killer whales (*Orcinus* spp.) were seen eating some hooked sablefish during sampling, RPN and RPW are believed to be moderately underestimated.

[c]Because killer whales (*Orcinus* spp.) were seen eating a great many hooked sablefish during sampling, RPN and RPW are believed to be considerably underestimated.

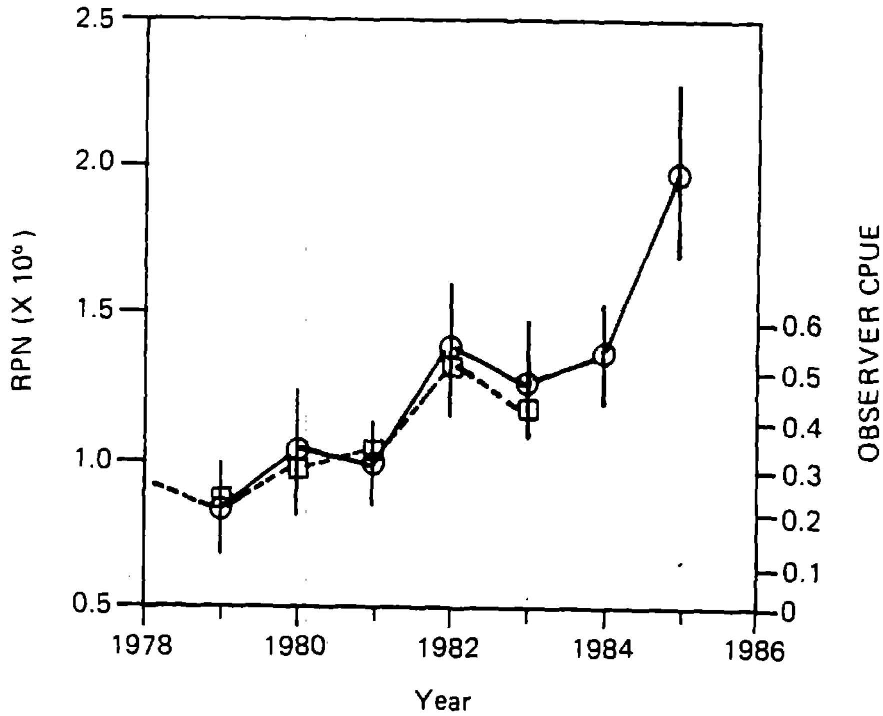

Figure 4.--Relative population number (RPN) of sablefish (<u>Anoplopoma fimbria</u>) caught at l0l-1,000 m depths in the Gulf of Alaska in the Japan-U.S. cooperative longline survey, 1979-85, and catch per unit effort (CPUE) in the Japanese longline fishery as estimated by U.S. foreign fisheries observers, 1978-83. The RPN (with the estimated 95% confidence interval) is depicted by a solid line (-) the CPUE by a broken line (---).

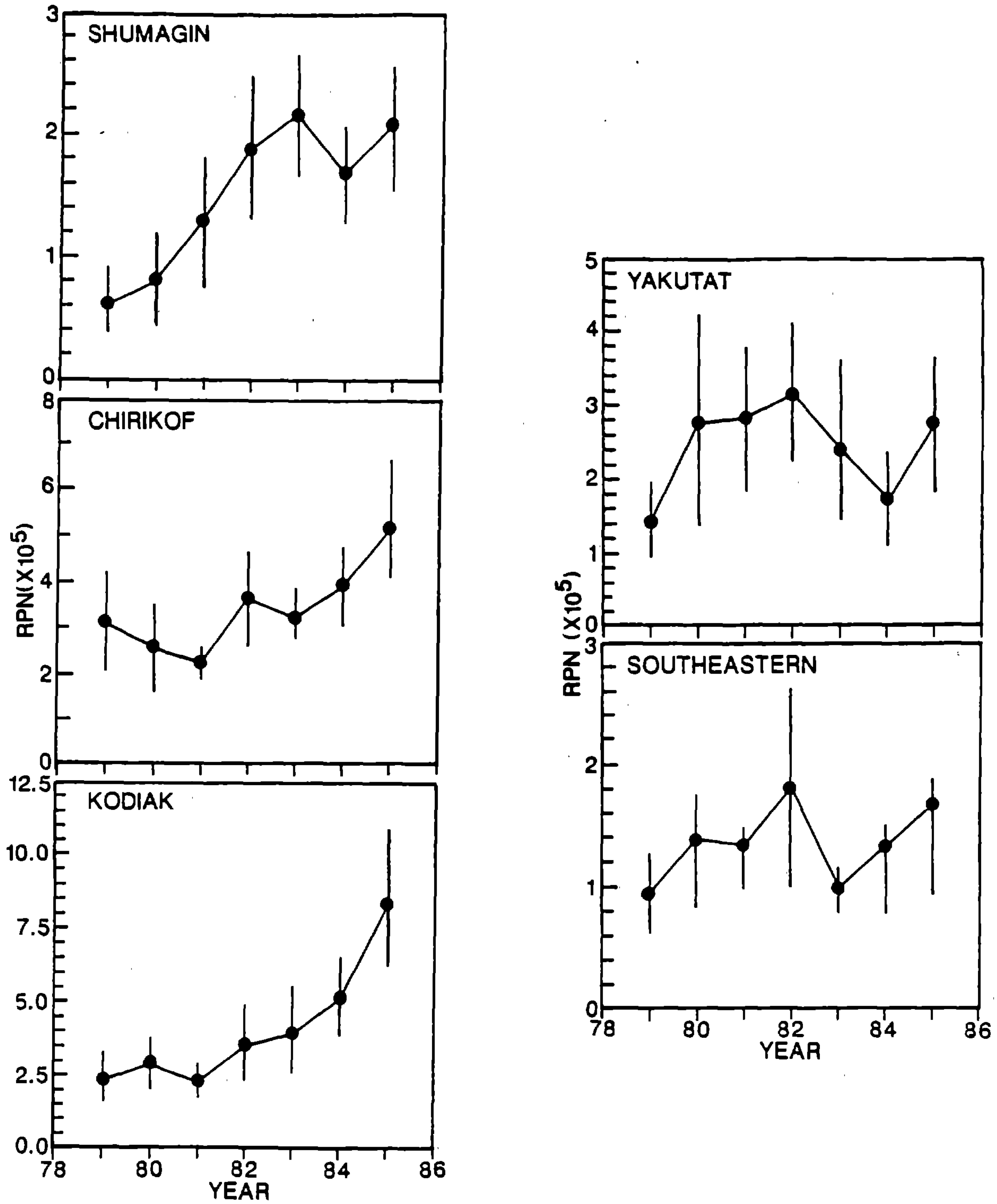

Figure 5.--Relative population number (RPN) and estimated 95% confidence interval of sablefish (*Anoplopoma fimbria*) caught at 101-1,000 m depths in the Gulf of Alaska in the Japan-U.S. cooperative longline survey, by International North Pacific Fisheries Commission statistical area, 1979-85.

In Table 6 the RPNs and RPWs are grouped into three strata--the 101-200 m stratum used by Sasaki (1986) is maintained, but Sasaki's 201-1,000 m stratum is divided into two strata: 201-400 and 401-1,000 m. In addition to the increase in the 101-200 m stratum (already discussed), Table 6 reveals that the 401-1,000 m stratum also contributed greatly to the overall increase in RPN and RPW between 1984 and 1985 (up 45 and 55%, respectively). The indices of population abundance did not increase as much in the 201-400 m stratum as in the 101-200 and 401-l ,000 m depth strata. The estimates in the 201-400 m stratum are tenuous however because much of the stratum is in Shelikof Strait, Amatuli Trough, and Marmot Gulley--areas where there was no sampling. When calculating the index, these areas were assumed to have the same density as the adjacent slope area within the stratum. Concern about the validity of the assumption 'has not been completely allayed by the observation that (in the 1984 U.S.-Japan bottom trawl survey) catch rates in these areas were similar to those on the adjacent slope (Brown 1986).

It may also be appropriate to examine the population increase in 1985 in terms of fish length. To achieve this the RPNs, pooled into two depth strata (101-400 and 401-1,000 m) were plotted by length in two ways: 1) using data collected in 1985 per se and 2) using data collected in 1984 and then projected to 1985 on the basis of expected growth. Note that in the 101-400 m stratum the observed RPN exceeded the projected RPN mostly in the smaller length categories (Fig. 61, while in the 401-1,000 m stratum the observed RPN exceeded the projected RPN over the entire range of lengths (Fig. 7).

1984 Triennial Trawl Survey

Sasaki (1984b) revised sablefish biomass estimates based on additional comparisons of area-swept biomass estimates from trawl surveys and 1983 RPW values, for the gulf. By various methods, three estimates (213,800, 509,700, and 643,200 t) were obtained. Because of the wide discrepancy in these estimates, yield estimates based on these biomass figures were considered to be tentative at best.

The 1984 triennial groundfish survey provided a basis for deriving new biomass estimates of sablefish in the gulf. First, Wakabayashi and Teshima (1985) used the results of part of the U.S.-Japan survey to estimate sablefish biomass in the central and western regions. By, applying the area-swept technique to the catches of the Japanese trawler, Japanese researchers came up with estimates of 79,900 t, 91,700 t, and 209,300 t for the INPFC Shumagin, Chirikof, and Kodiak Areas, respectively.

U.S. scientists extended the analysis (Brown 1986). They noted, from a study to measure the comparability of the two U.S. trawlers and the single Japanese trawler, that the Japanese trawler was more efficient at capturing sablefish than were the U.S. trawlers. Biomass estimates, therefore, are smaller if the catches by the Japanese trawler are converted to the efficiency of the U.S. trawlers. If, on the other hand, the efficiency of the Japanese vessel is used as a standard, biomass estimates by U.S. scientists are similar to those reported by Wakabayashi and Teshima (1985).

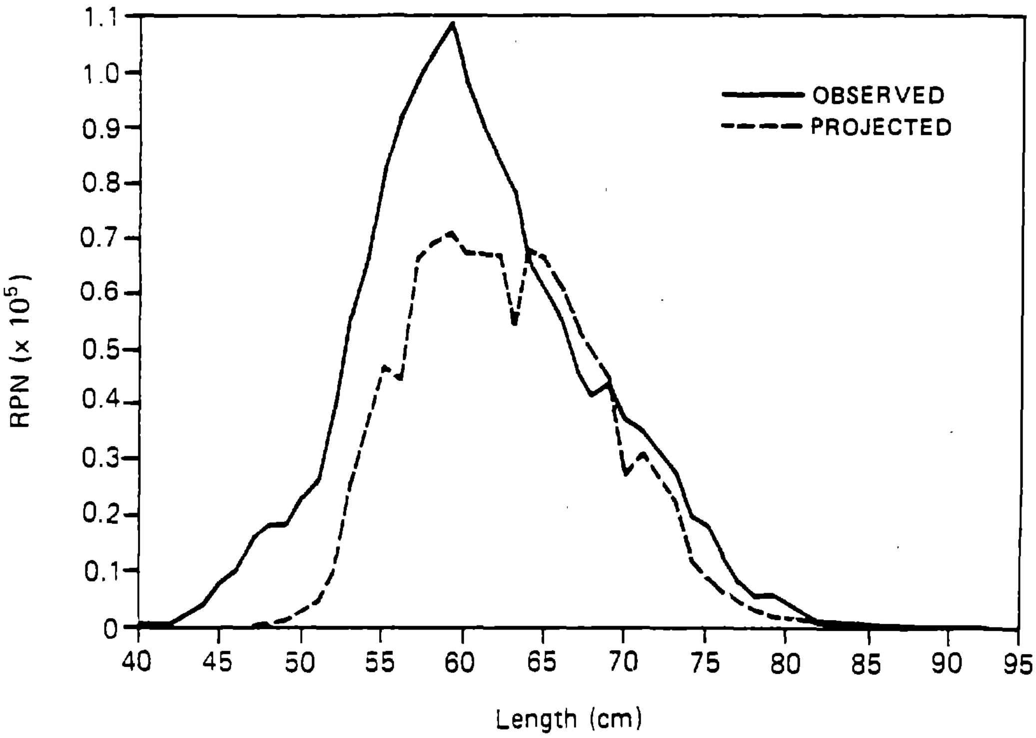

Figure 6.--Size composition of sablefish (Anoplopoma fimbria) at 101-400 m depths in the Gulf of Alaska, 1) observed in 1985 (-), and 2) estimated for 1985 from 1984 size composition (---).

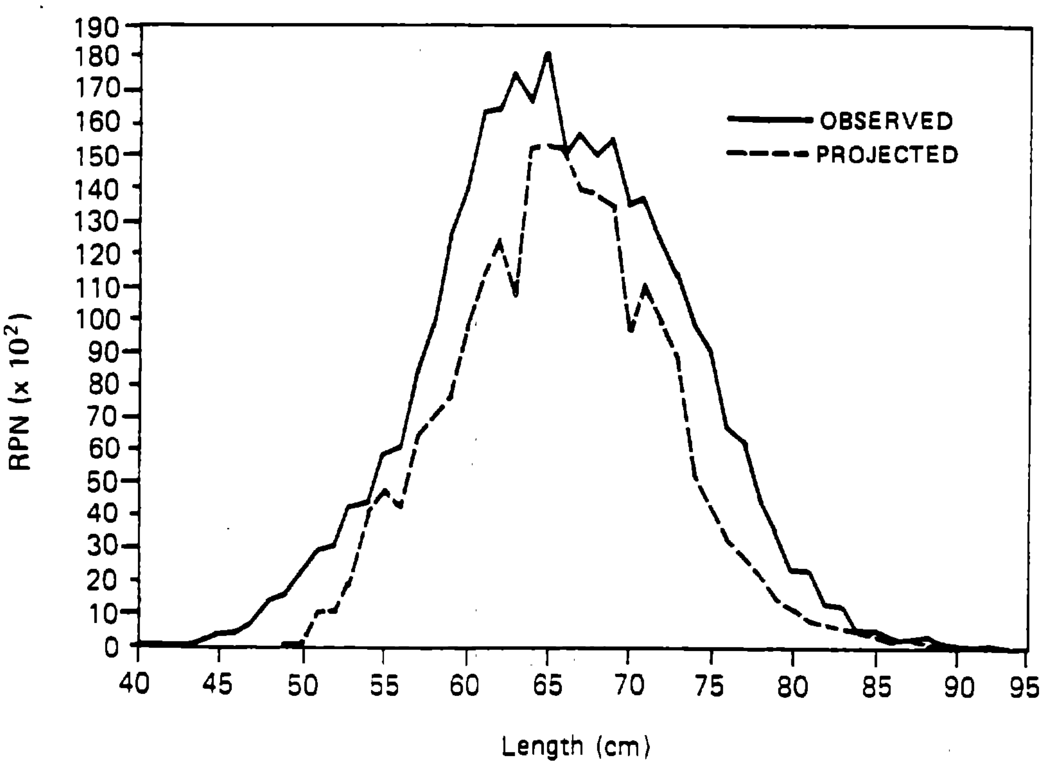

Figure 7.--Size composition of sablefish (Anoplopoma fimbria) at 401-1,000 m depths in the Gulf of Alaska, 1) observed in 1985 (-), and 2) estimated for 1985 from 1984 size composition (---).

Table 6.--Indices (100s) of the abundance of sablefish (*Anoplopoma fimbria*) in the U.S.-Japan cooperative longline survey, by depth, 1984 and 1985. (Numbers in parentheses are the percentage change from 1984 to 1985.)

Depth (m)	RPN 1984	RPN 1985		RPW 1984	RPW 1985	
101-200	6,236	11,012	(+77)	11,960	23,526	(+97)
201-400	5,138	5,608	(+9)	14,050	16,695	(+19)
401-1,000	2,369	3,284	(+39)	6,663	10,263	(+54)
101-1,000	13,743	19,904	(+45)	32,673	50,484	(+55)

Source: Personal communication with Michael Sigler, Auke Bay Laboratory, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, P.O. Box 210155, Auke Bay, AK 99821

An estimate of biomass resulting from preliminary analyses was reported last year (Fujioka 1986). This estimate incorporated net efficiency correction factors between nylon and polypropylene U.S. nets and the net used by the Japanese trawler. The biomass estimate assumed the most efficient net provides the most accurate result. The Japanese net was the most efficient, and its relative efficiency generally increased with depth (Brown 1986). When the U.S. catch rates were modified by the appropriate ratios, the resulting point estimate of the biomass of sablefish in the Gulf of Alaska was 536,416 t (since modified to 535,918 t)6/.

Much of the estimated biomass comes from the 101-200 m depth stratum, especially in the INPFC Kodiak and Southeastern Areas (60 and 69%, respectively). The 101-200 m stratum, provided 43% of the total biomass estimate for the gulf. Because, the areas within the 101-200 m stratum are large and the catch rates are highly variable, estimates of biomass must be viewed with caution.

Fish size was another element of the 1984 U.S.-Japan cooperative bottom trawl survey in the central and' western Gulf of Alaska. Of particular interest is the relation between depth and fish size. In the stratum <200 m, between 66 and 100% of the sablefish were <57 cm FL, whereas in the deeper strata, only 15-58% were <57 cm FL (Brown 1986). The prevalence of smaller fish in the stratum <200 m has also been detected by longline surveys (Sasaki 1985).

Another objective of the 1984 surveys was to make preliminary investigations into supplementing biomass estimates with longline observations. Rose (1986) compared trawl catch rates with longline catch rates from the 1984 surveys and found that the relative catch rates varied with fish size. The trawl-to-longline catch ratio decreased as size increased, up to the 85-94 cm FL, but there were too few observations to estimate the ratio accurately. The catch rate ratio also appears to have varied between areas of the gulf, being lowest in the southeastern area7/.

NMFS Trap Indexing Survey

The NMFS trap indexing survey conducted annually since 1978 has provided another alternative to foreign longline statistics as a means of assessing sablefish stocks in the INPFC Southeastern Area. Clausen (1987) has summarized results from 1978 to 1986 for small (<57 cm FL), medium (57-66 cm FL), and large (>67 cm FL) sablefish at each of four indexing sites: Capes Cross, Ommaney, Addington, and Muzon (Fig. 8).

6/ The estimate was adjusted on the basis of new information provided by Eric Brown, January 12, 1987 (see footnote 4).

7/ Personal communication with Thomas Rutecki, Auke Bay Laboratory, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, P.O. Box 210155, Auke Bay, AK 99281.

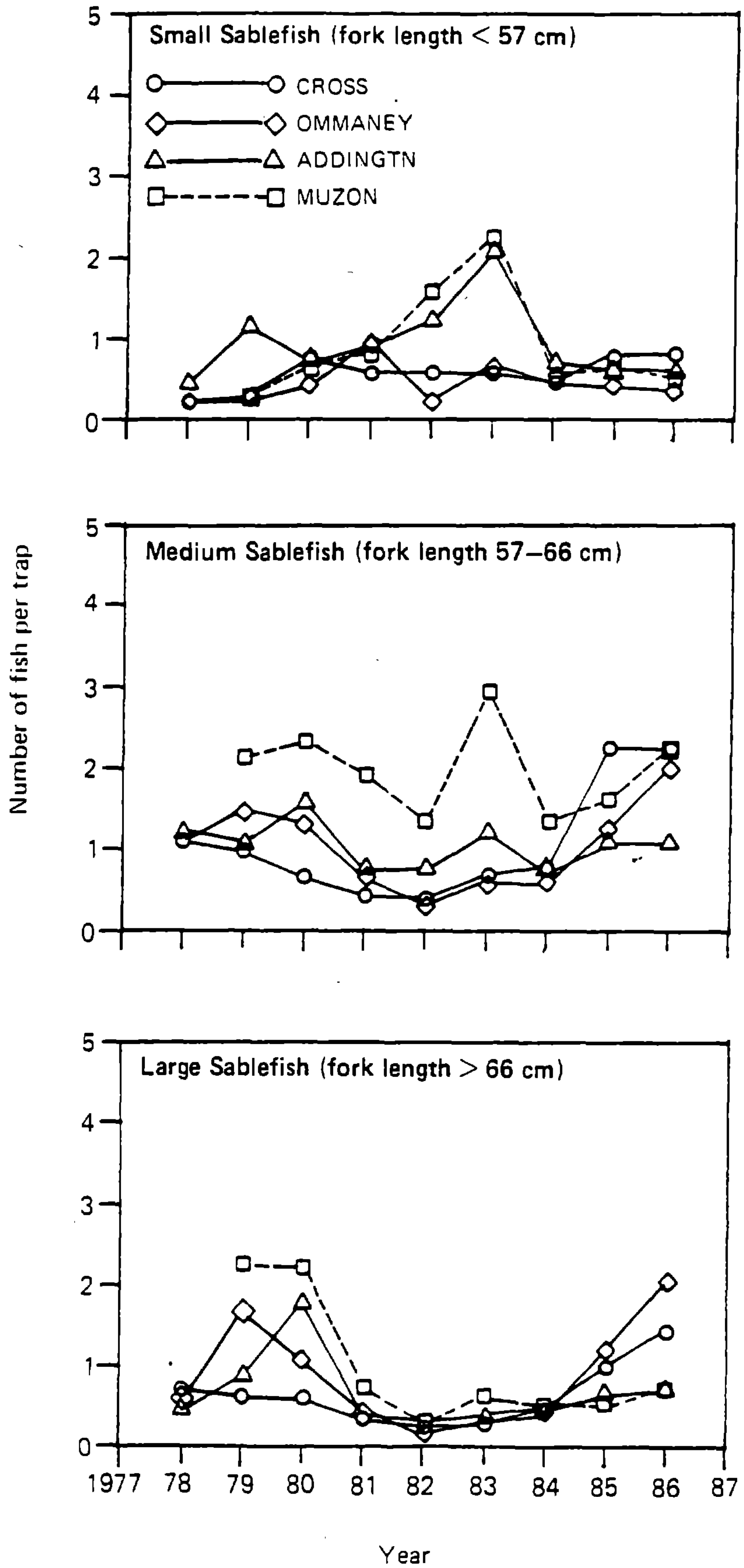

Figure 8.--Mean catch rates of small, medium, and large sablefish (*Anoplopoma fimbria*) at four index sites in the outside waters of southeastern Alaska, 1978-86. The Cape Muzon site was not fished in 1978.

Little or no net change occurred in the index of large sablefish in 1978-85, although in 1979 and 1980 the index was markedly above average at three of the four stations. The 1981 index decreased, however, to earlier levels. The index remained relatively stable at low levels in 1981-84 and slowly increased from a low index in 1982. The indices increased markedly at the Cape Cross and Cape Ommaney sites in 1985 and again in 1986 and reached the highest levels ever observed at these two stations. Meanwhile, the indices for the Cape Muzon and Cape Addington sites continue to increase slowly. As mentioned earlier, the RPW for the 401-l ,000 m depth stratum in the INPFC Southeastern Area remained stable in 1981-84, and the RPN values decreased slightly. The RPW for fish >58.1 cm FL, however, decreased sharply in 1981-83.

The index for small sablefish peaked moderately for 1 or 2 years at different times and in different areas. The Cape Addington and Cape Muzon sites peaked most noticeably in 1983, whereas the highest levels for the Cape Cross and Cape Ommaney sites were in 1980 and 1981, respectively. Interpretation of the time series of small fish is aided somewhat by reference to the length frequency distributions for each site. The distributions show that the 1977 year class appears at various levels and times at the different sites (Fig. 2). The index for small fish has remained fairly stable for the past 3 years (1984-86), at a level slightly above the 1978 level, indicating that no unusually large recruitment was occurring in southeastern Alaska.

The 1978-82 time series for medium-sized sablefish indices generally shows a pattern similar to that for large sablefish. In 1983, however, the indices peaked for medium- and small-sized fish, but not for large-sized fish, at the Cape Muzon site. The increases common to medium- and large-sized sablefish at several sites in 1985-86 were absent for small sablefish.

Although the 1977 year class apparently was abundant at the Cape Muzon and Cape Addington sites as small fish in 1982 and as small or medium fish in 1983, it was not abundant at those sites in 1984. Conversely, at the Cape Cross and Cape Ommaney sites the 1977 year class did not seem to be particularly abundant in 1982 or 1983, although it had been detectable in length frequency distributions compiled in earlier years. However, abundance of medium and large fish increased in 1985 at the Cape Cross and Cape Ommaney sites, apparently reflecting a resurgence of the 1977 year class at the two sites.

Size Composition and Catch Rates in. the Domestic Fishery

The ADF&G has summarized the market size composition of sablefish landings in the shore-based longline fishery for 1985 and 1986 (Fig. 9)[8/]. In 1985, the proportion of 273 lb sablefish landed in the Central Regulatory Area was above average. In 1986, the proportion of 3-4 lb fish landed in the Central Regulatory Area was above average, as were 5-7 lb and >7 lb fish landed in the Western Regulatory Area.

8/ Personal communication with Fritz Funk, Alaska Department of Fish and Game, P.O. Box 3-2000, Juneau, AK 99802.

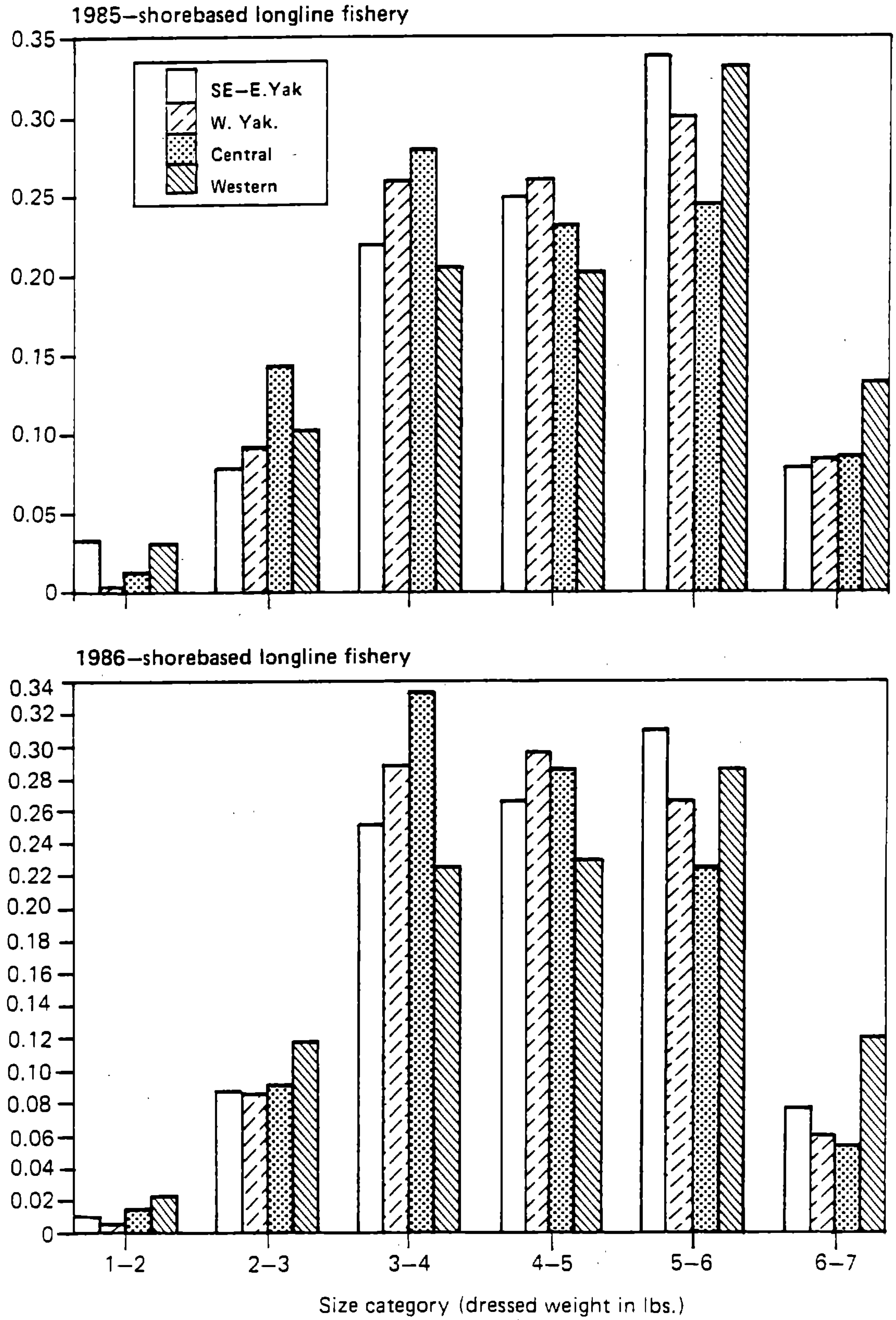

Figure 9.--Market size composition of sablefish (Anoplopoma fimbria) caught by the shore-based, domestic, longline fishery in the Gulf of Alaska, 1985 and 1986.

Bracken and O'Connell (1986) reported on longline fisheries monitoring in 1980-85 and recommended caution when using the fishery catch rates to indicate abundance. They noted that changes in any of several factors can confound the interpretation of this information: hook type, market demand for small fish, and preferred method of dressing fish.

POTENTIAL YIELD

Estimates of Maximum Sustainable Yield

Although the sablefish resource is managed by broad geographic region, the long-term productivity in each region is assumed to be related to the overall condition of the resource. Japanese and U.S. scientists have estimated maximum sustainable yield (MSY) of the resource as a whole, and apportioned MSY to each region based on historic production trends. The Japanese estimate of MSY for the entire resource! from California to the Bering Sea is 69,000 t. Using essentially the same general production model as the Japanese, but with a different weighting of data between regions, Low and Wespestad (1979) estimated MSY for the California to Bering Sea resource at 50,300 t.

By broad region, historical catches were categorized as being from the Bering Sea (25%), the Aleutian Islands (4%), the Gulf of Alaska (47%), and the British Columbia-Washington region (25%). (These percentages, which add up to 101, probably reflect a rounding error.) The apportioned MSY estimates were then compared to those de-rived from general production models applied region by region. The resulting mean and overall estimate of MSY was 25,100 t for the Gulf of Alaska (Low and Wespestad 1979). This estimate updated the MSY range of 22,000 to 25,000 t used in the FMP. Production models, however, are most appropriate for relatively short-lived species in which annual recruitment is relatively stable. It is questionable whether a time series of catch and effort data is appropriate for general production modeling of sablefish stocks, given that the life span of sablefish may be much longer than previously thought and the fishery apparently is supported by infrequent strong year classes (McFarlane and Beamish 1983).

Equilibrium Yield

The determination of EY values for past years is documented by Balsiger (1983) and Stauffer (1983). Annual adjustments in EY for the areas west of 140° W. long. have been based on changes in annual CPUE of the Japanese longline fishery and MSY estimates derived from surplus production models of the foreign longline fishery. For the areas east of 140° W. long., the EY was based on annual landings prior to 1980. In 1982, EY in the NPFMC Eastern Area was reduced by 50% because of the decline observed in the NMFS trap indexing surveys from 1980 to 1981. The EY established in 1982 was not modified for 1983 even though the condition of the resource appeared to be improving.

Funk and Bracken (1984) used an age-structured model to project future biomass levels and annual surplus production. Their model analysis is sensitive to initial age composition, biomass values, and projected average level of recruitment. They initiated the model with age composition determined by a length frequency analysis of the 1982 Japanese longline survey. Their assumed constant recruitment for age-3 fish was set at the average abundance of the

1976, 1978, and 1979 year classes that they estimated from the longline survey data. The model was run using biomass estimates of 171,240 t (derived from surplus production modeling of historic CPUE data) and 256,481 t (derived from a comparison of the 1982 RPW values to biomass estimates from trawl surveys in the Aleutian Islands reported by Sasaki (1983b)). Using the biomass estimates (171,240 and 256,481 t), they forecasted annual surplus production values for 1984 at 19,200 t and 26,100 t, respectively. These values are approximately double the EY range of 10,965 to 12,630 t for 1982 and 1983.

A preliminary estimate of biomass projections is shown in Figure 10. These projections are based on the estimated 1984 size composition of the gulf population obtained from the cooperative longline survey, the von Bertalanffy growth parameters K = 0.249 and Linf = 73.62 obtained from otolith samples from the 1984 longline survey, the observed catches in 1985 and 1986, the preliminary biomass estimate from the 1984 trawl survey, and mortality rates applied equally to all sizes. The results show that the instantaneous growth rate of the fish recruited to the surveyed population by 1984 would have gone from g = 0.130 for 1984 to 1985, g = 0.103 for 1985 to 1986, and g = 0.081 for 1986 to 1987. Then, the EY for 1987 would be approximately equal to (0.081 - M) times B(86) (the biomass at the end of the 1986 fishing season). For trial values of M = 0.00, 0.05, and 0.10, population biomass was projected from a 1984 value of 535,000 t to B(86) = 642,000, 580,000, and 524,000 t, respectively, with corresponding EY estimates of 52,000, 18,000, and (0 t, respectively.

These estimates apply only to fish recruited to the survey gear by 1984; any recruitment or increase in availability since then is not included. In 1985, however, significant recruitment as well as an increase in availability or catchability or both to the longline survey gear apparently occurred as suggested by the increase in RPN at all sizes and depths. To partially account for the increased recruitment, the 1985 size composition is projected back to an estimated 1984 size composition which is then equated to the 1984 trawl survey biomass estimate. The reasoning for this is based on an assumption that the 1980 or 1981 year class had fully recruited to the trawl survey by 1984 but not to the longline survey until 1985. Projecting this estimated population forward results in only slightly higher growth rates and EY estimates.

Ignoring recruitment in these projections seems reasonable for these years because there has been little indication that strong year classes will recruit to the longline gear by 1987. If a strong 1984 year class should result, it is likely that the year class would be evident in any 1987 surveys conducted on the shelf but would not recruit strongly to the longline fishery until 1988. This delay in recruitment would allow projections to be made for a 1988 fishery. If significant unexpected changes should occur in the 1986 longline survey, analysis will be completed in time for revised recommendations, if necessary, for the 1987 fishery.

Although an estimate of EY cannot be determined with useful accuracy, the sablefish population in the gulf is apparently well above any threshold level that may exist and is large relative to catch levels. Thus, the short-term biologically acceptable catch would apparently allow a much larger

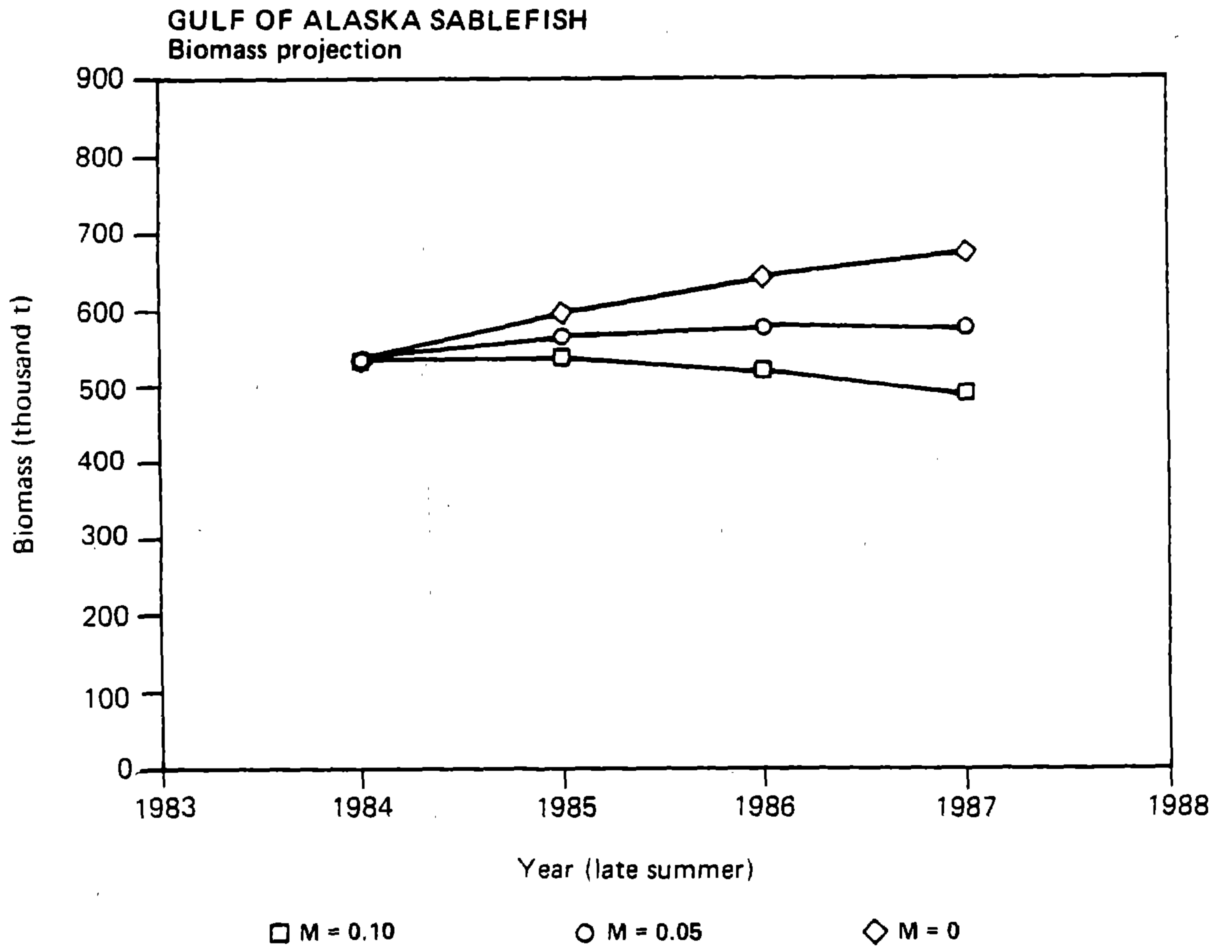

Figure 10.--Projected biomass of sablefish (Anoplopoma fimbria) in the Gulf of Alaska for 1984-87 based on the actual commercial catches of 1984 and 1985 and the projected commercial catches for 1986 and 1987.

increase than prudent management should allow to occur in 1 year. It is recommended that OY levels be allowed to rise slowly above current catch levels and the status of stocks be monitored carefully.

In past years, the apportionment of EY among INPFC areas was based on historical catch patterns. A more appropriate criterion for apportioning EY would consider the available biomass in each area, the size composition of the harvest in each area, and size-related growth and mortality rates. The OY in 1986 was apportioned approximately to the distribution of biomass in the 401-1,000 m depth stratum as estimated hastily from results of the 1984 longline survey and preliminary results of the 1985 longline survey. The biomass in the shallower depth was not considered as a criterion for apportionment because 1) the biomass in the shallower depth was composed of smaller fish, 2) the biomass estimates there were highly susceptible to error, and 3) the major target fishery operates at greater depths. Subsequent analysis of the 1985 survey reestimated the 1985 RPW distribution (Table 7) and showed that fish in the 101-200 m depth stratum were smaller than average, whereas fish in the 201-400 m depth stratum were similar in size to those in the 401-1,000 m stratum; their potential growth rates were 16, 9, and 8%, respectively (Sigler 1986). As pointed out earlier, within the 101-200 m and the 201-400 m depth strata, much of the bottom lies away from the slope, where the longline survey does not sample and where potentially large errors could go undetected.

Table 7.--The relative population weight (RPW) of sablefish (*Anoplopoma fimbria*) in the Gulf of Alaska, by NPFMC regulatory area and depth, 1985 (expressed as a percentage of the gulf-wide RPW for the same depth).

	Area			
			Eastern	
Depth (m)	Western	Central	(West[a])	(East[b])
101-1,000	11	67	8	14
201-1,000	14	61	10	15
401-1,000	17	48	16	19

[a]West of 140° W. long.

[b]East of 140° W. long.

Source: Sigler (1986).

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PACIFIC COD-

by

Harold H. Zenger, Jr. and James E. Blackburn[2/]

INTRODUCTION

In North American waters, Pacific cod (Gadus macrocephalus) occur on the Continental Shelf and upper slope from Santa Monica Bay, California (34° N. lat.) through the Gulf of Alaska, Aleutian Islands, and eastern Bering Sea to Norton Sound (Bakkala et al. 1981).

Since the Magnuson Fishery Conservation and Management Act (MFCMA) of 1977 went into effect, various regulations have been implemented by the North Pacific Fishery Management Council (NPFMC) that affected cod fisheries in the Gulf of Alaska and allowed catches to reach their historic highs in 1980-83. Amendment 2 to the Fishery Management Plan (FMP) for groundfish in the Gulf of Alaska allowed a year-round directed foreign longline fishery for Pacific cod west of 157O W. long. beyond 12 miles, beginning in 1979. Amendment 4 permitted foreign longlining for Pacific cod from 140 to 157° W. long. beyond 12 miles except that fishing would be closed within the 400 m isobath during the U.S. Pacific halibut, (Hippoglossus stenolepis), season. Those regulations allowed more intensive foreign exploitation of one or two unusually large year classes of Pacific cod which have now passed peak production.

Since 1977, the importance of Pacific cod in Gulf of Alaska groundfish catches has grown and receded. After increasing from 2,256 metric tons (t) in 1977 to 36,401 t in 1983, the annual total catch dropped to 14,307 t in 1985 (Table 1). The decreases in 1984 and 1985 were mostly due to reductions in catches by the Japanese, who limited their longline operations for Pacific cod to the International North Pacific Fisheries Commission (INPFC) Shumagin and Chirikof Statistical Areas to reduce the incidental catch of sablefish (Anoplopoma fimbria).

At this time, management of Pacific cod in the Gulf of Alaska has not reached a critical point because the stocks are relatively large in relationship to the optimumyield (OY). Recent harvest levels have been well below OY, and it is likely that they will remain so in all but the NPFMC Western Regulatory Area because of regulations imposed to protect sablefish stocks. (The Western Regulatory Area is the INPFC Shumagin Area, the Central Regulatory Area is composed of the INPFC Chirikof and Kodiak Areas, and the Eastern Regulatory Area refers to the combined INPFC Yakutat and Southeastern Areas.)

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[1]/This report is an update of Zenger and Blackburn (1986).

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Table 1.--Catch (t) of Pacificcod in the Gulf of Alaska, by fishery category, 1971-85[a].

Year	Japan	U.S.S.R.	ROK[b]	Poland	Mexico	Joint venture	U.S.	Total
1971	461	176	--	--	--	--	44	681
1972	830	2,696	--	--	--	--	66	3,592
1973	2,590	3,395	--	--	--	--	59	6,044
1974	2,951	2,136	--	--	--	--	145	5,232
1975	3,252	2,551	--	--	--	--	130	5,933
1976	3,291	2,995	--	--	--	--	222	6,508
1977	1,243	744	--	--	--	--	270	2,257
1978	8,846	1,141	1,369	14		7	785	12,162
1979	10,429	835	844	127	939	711	985	14,870
1980	30,582	1,942	1,666	55	--	466	612	35,323
1981	27,768	--	7,066	135	--	58	1,061	36,088
1982	24,451	--	2,486	--	--	193	2,250	29,380
1983	28,531	--	1,246	--	--	2,426	4,198	36,401
1984	15,250	--	636	10	--	4,649	2,672	23,217
1985	9,061	--	25	--	--	2,266	2,954	14,307

[a]Foreign catches 1971-76 are foreign-reported catches; foreign catches 1977-85 are best-blend estimates.

[b]Republic of Korea.

Sources: Foreign catches 1971-76: Forrester et al. (1983). Foreign catches 1977-84 and joint venture catches 1978-84: Berger et al. (1986). Foreign and joint venture catches ,1985: personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE., BIN C15700, Building 4, Seattle, WA 98115. U.S. catches 1971-80: Rigby (1984). U.S. catches 1981-85: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201.

Pacific cod are primarily taken with longlines and trawls. Foreign trawl catches of cod are usually incidental to directed fisheries for other species, and longlines catch most of the total allowable level of foreign fishing (TALFF) allocation. In direct contrast, the vast majority of domestic and joint venture catches are by trawls. Directed trawl and longline fisheries for cod are expected to capture other species such as sablefish, walleye pollock (Theragra chalcogramma), rockfish (Sebastes spp.), Pacific halibut, and other flatfishes.

FISHERY STATISTICS

The catch of Pacific cod increased sharply in 1980 (from 14,870 to 35,323 t) and remained roughly at that level until 1984 when it fell to 23,217 t, and further to 14,307 t in 1985 (Table 1). Three nations--the United States, Japan, and the Republic of Korea--and a number of joint ventures harvested Pacific cod in the Gulf of Alaska in 1985. Landings by U.S. fishermen peaked at 4,198 t in 1983, the highest since the salt cod fishery closed over 30 years ago. The 1984 U.S. harvest was down to 2,672 t, possibly because some domestic effort may have been redirected to joint ventures. The 1984 joint venture catch was approximately twice that of 1983. In 1985 joint ventures took 2,266 t and the U.S. catch increased to 2,954 t. Japan harvested 63% of the all-nation catch in 1985 and 66% in 1984, down from 78% in 1983. The domestic annual harvest (DAH), which combines joint venture and U.S. domestic catches, was 5,220 t, down 2,101 t from 1984. Pacific cod made up 5.6% of the total 1984 Gulf of Alaska groundfish catch, half of the 1983 level and a third of the 16.5% portion in 1980 (Table 2). In 1985 the catch of Pacific cod was only 4.4% of the total groundfish catch in the gulf.

As in recent years, the bulk of the foreign catches came from the Shumagin and Chirikof Areas. Domestic and joint venture catches were concentrated in the Chirikof Area (Table 21, reflecting a westward movement of the DAH fisheries.

Most U.S. landings were trawl-caught, although longlines, hook and line, pots, and seines were used to harvest Pacific cod (Table 3). The Japanese continue to take the majority of their cod catch in the Gulf of Alaska with longlines, whereas the joint ventures and the Republic of Korea employ trawlers (Table 4). From 1979 to 1984 Japanese longliners took 91-93% of that nation's annual gulf-wide cod catch (Table 5). In 1985 longliners harvested nearly 100% of the Japanese cod catch.

The combined Shumagin and Chirikof Areas have produced from 68 to 85% of the total catch of Pacific cod in the Gulf of Alaska since 1978 (Table 6). The variation among years may be influenced more by fishing patterns and regulations than the actual species abundance distribution.

The optimum yield for Pacific cod in the Gulf of Alaska has varied somewhat since the concept was adopted by the NPFMC, particularly in the early years. In 1977 OY was established at slightly less than the previous year's total catch. From 1978 to 1981, OY varied between 34,800 and 70,000 t, settling at 60,000 t in 1982 (Table 7). Prior to 1981, OY was assigned for "fishing years" rather than calendar years. In 1981 OY was raised temporarily to

Table 2.-Catch (t) of Pacific cod in the Gulf of Alaska, by fishery category and International North Pacific Fisheries Commission (INPPCC) statistical area, 1977-85.

Fishery category and INPFC area	Year 1977	1978	1979	1980	1981	1982	1983	1984	1985
Japan									
Shumagin	358	4,073	3,068	6,624	9,032	6,491	8,102	10,564	7,320
Chirikof	286	3,537	5,598	17,403	14,807	12,318	14,600	4,544	1,741
Kodiak	353	971	1,414	4,551	2,334	3,572	3,870	142	<1
Yakutat	231	199	294	1,961	1,517	2,070	1,959	--	--
Southeastern	15	66	55	43	78	--	--	--	--
Total	1,243	8,846	10,429	30,582	27,768	24,451	28,531	15,250	9,061
U.S.S.R.									
Shumagin	315	86	6	361	--	--	--	--	--
Chirikof	56	995	165	906	--	--	--	--	--
Kodiak	373	60	663	675	--	--	--	--	--
Yakutat	--	--	1	--	--	--	--	--	--
Total	744	1,141	835	1,942	--	--	--	--	--
Republic of Korea									
Shumagin	--	1,361	788	1,627	2,241	539	533	279	19
Chirikof	--	8	--	--	4,069	1,850	706	357	6
Kodiak	--	--	--	--	25	97	4	--	--
Yakutat	--	--	49	39	731	--	3	--	--
Southeastern	--	--	7	--	--	--	--	--	--
Total	--	1,369	844	1,666	7,066	2,486	1,246	636	25
Poland									
Shumagin	--	--	9	9	41	--	--	--	--
Chirikof	--	--	118	46	94	--	--	5	--
Kodiak	--	14	--	--	--	--	--	5	--
Total	--	14	127	55	135	--	--	10	--
Mexico									
Shumagin	--	--	100	--	--	--	--	--	--
Chirikof	--	--	376	--	--	--	--	--	--
Kodiak	--	--	463	--	--	--	--	--	--
Total	--	--	939	--	--	--	--	--	--
U.S./Foreign joint ventures									
Shumagin	--	7	11	13	--	21	469	305	310
Chirikof	--	--	17	223	58	167	342	775	1,418
Kodiak	--	--	683	230	--	5	1,615	3,569	538
Total	--	7	711	466	58	193	2,426	4,649	2,266
United States									
Shumagin	53	64	--	71	265	292	74	54	777
Chirikof	17	167	267	49	87	26	27	160	59
Kodiak*	140	443	606	415	677	1,869	4,078	2,424	2,026
Yakutat	6	3	27	4	1	38	1	1	<1
Southeastern	54	108	85	73	31	25	18	33	92
Total	270	785	985	612	1,061	2,250	4,198	2,672	2,954
Grand total	2,257	12,162	14,870	35,323	36,088	29,380	36,401	23,217	14,307
Percent of total ground-fish catch	1.2	7.2	8.7	16.5	14.0	12.5	12.4	5.6	4.4

*May include small catches from lower Cook Inlet.

Sources: Foreign and joint venture catches: personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point Way NE., Seattle, WA 98115. U.S. catches 1977-80: Rigby 1984. U.S. catches 1981-85: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland OR 97201.

Table 3.--Annual U.S. landings (t) of Pacific cod in the Gulf of Alaska, by gear type, 1981-85.

	Year				
Gear type	1981	1982	1983	1984	1985
Groundfish trawl	735	2,048	4,002	2,282	2,560
Beam trawl	1	<1	--	--	--
Shrimp trawl	115	6	<1	--	--
Gill nets	13	27	106	127	--
Longline	194	164	63	260	362
Other hook and line	3	5	27	3	13
Pots	--	--	<1	<1	2
Seine	--	--	--	--	18
Gear unknown	--	<1	<1	<1	--
Total	1,061	2,250	4,198	2,672	2,955

Source: Pacific Fishery Information Network (PacFIN), Pacific Marine-Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201.

Table.-4 Catch (t) of Pacific cod in the Gulf of Alaska, by fishery category and vessel type, 1978-85 (excluding the U.S. domestic catch.)

Fishery category and vessel type	1978	1979	1980	1981	1982	1983	1984	198
Japan								
Sm. trawler	433	312	1,525	1,033	702	530	164	
Lg. frz. trawler[a]	346	385	728	825	1,024	1,164	302	
Surimi trawler[b]	1,267	187	558	636	226	195	205	
Longliner	6,800	9,545	27,771	25,274	22,499	26,642	14,579	9,(
U.S.S.R.								
Lg. frz. trawler	1,141	835	1,942	--	--	--	--	
Republic of Korea								
Sm. trawler	--	--	--	988	237	68	50	
Lg. frz. trawler	1,369	844	1,657	6,074	2,249	1,127	586	
Longliner	--	--	9	4	<1	51	--	
Poland								
Lg. frz. trawler	14	127	55	135	--	--	10	
Mexico								
Sm. trawler	--	883	--	--	--	--	--	
Lg. frz. trawler	--	56	--	--	--	--	--	
Joint venture mothership	7	711	466	58	193	2,426	4,649	2,2
Total	11,377	13,885	34,711	35,027	27,130	32,203	20,545	11,3

[a] In 1978 and 1979, catches were reported as being from medium trawlers.

[b] In 1978 and 1979, catches were reported as being from large trawlers.

Source: Personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin 15700, Sand Point Way NE., Building 4, Seattle, WA 98115.

Table 5.--Japanese longline catch (t) of Pacific cod by International North Pacific Fisheries Commission statistical area, and the percentage of Japanese all-gear catch that was taken by longline, 1978-85.

Year	Area				Total longline catch	Percentage of Japanese all-gear catch
	Shumagin	Chirikof	Kodiak	Yakutat		
1978	3,812	2,972	15	2	6,800	77
1979	2,592	5,467	944	182	9,545	92
1980	5,958	17,061	3,228	1,525	27,771	91
1981	8,509	13,847	1,870	1,048	25,274	91
1982	5,582	11,631	2,945	2,070	22,499	92
1983	7,600	13,568	3,515	1,962	26,642	93
1984	10,304	4,275	--	--	14,579	92
1985	7,320	1,741	<1	--	9,036	>99

Source: Personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point Way NE., Seattle, WA 98115.

Table 6.--Catch (t) of Pacific cod in the Gulf of Alaska by International North Pacific Fisheries Commission statistical area, 1977-85.

Year	Area					Total
	Shumagin	Chirikof	Kodiak	Yakutat	Southeastern	
1977	726	359	866	237	69	2,257
1978	5,591	4,707	1,488	202	174	12,162
1979	3,982	6,541	3,829	371	147	14,870
1980	8,705	18,627	5,871	2,004	116	35,323
1981	11,579	19,115	3,036	2,249	109	36,088
1982	7,343	14,361	5,543	2,108	25	29,380
1983	9,178	15,675	9,567	1,963	18	36,401
1984	11,202	5,841	6,140	1	33	23,217
1985	8,426	3,224	2,564	<1	92	14,306

Sources: Foreign and joint venture catches: personal communication with Jerald Berger, U.S. Foreign Fishery Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point Way NE., Seattle, WA 98115. U.S. catches 1977-80: Rigby 1984. U.S. catches 1981-85: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201.

Table 7.--Allocations (t) of Pacific cod for the North Pacific Fishery Management Council Western, Central, and Eastern Regulatory Areas in the Gulf of Alaska, 1977-86.

Year and Allocation	Initial West.	Initial Central	Initial East.	Initial Total	Final West.	Final Central	Final East.	Final Total
1977								
OY[a]								6,300
DAH								4,000
RES								--
TALFF								2,300
1978								
OY				40,600				40,600
DAH				15,500				15,500
RES				8,120				0
TALFF				16,980				25,100
1979								
OY	9,600	19,400	5,800	34,800	9,600	19,400	5,800	34,800
DAH	4,300	8,600	2,600	15,500	240	3,480	280	4,000
RES	2,730	5,570	1,700	10,000	500	850	150	1,500
TALFF	2,570	5,230	1,500	9,300	8,860	15,070	5,370	29,300
1980								
OY	16,560	33,540	9,900	60,000	16,560	33,540	9,900	60,000
-DAP	240	3,480	280	4,000	740	1,588	230	2,558
-DNP	600	1,200	1,200	3,000	100	1,200	200	1,500
-JVP	1,040	1,370	590	3,000	1,040	1,370	90	2,500
DAH	1,880	6,050	2,070	10,000	1,880	4,148	520	6,558
RES	3,312	6,708	1,980	12,000	0	0	0	0
TALFF	11,368	20,782	5,850	38,000	14,680	29,382	9,380	53,442
1981[b]								
OY	19,320	39,130	11,550	70,000	19,320	39,130	11,550	70,000
-DAP	280	4,060	327	4,667	480	1,060	127	1,667
-DNP	700	1,400	1,400	3,500	700	1,400	1,400	3,500
-JVP	1,213	1,598	688	3,499	413	598	188	1,199
DAH	2,193	7,058	2,415	11,666	1,593	3,058	1,715	6,366
RES	3,864	7,826	2,310	14,000	0	0	0	0
TALFF	13,263	24,246	6,825	44,334	17,727	36,072	9,835	63,634
1982								
OY	16,560	33,540	9,900	60,000	16,560	33,540	9,900	60,000
-DAP	240	3,480	280	4,000	4,152	2,680	70	6,902
-DNP	600	1,200	1,200	3,000	--	--	--	--
-JVP	1,040	1,370	590	3,000	1,040	370	0	1,410
DAH	1,880	6,050	2,070	10,000	5,192	3,050	70	8,312
RES	3,312	6,708	1,980	12,000	0	0	0	0
TALFF	11,368	20,782	5,850	38,000	11,368	30,490	9,830	51,688

Table 7.--Continued.

Year and Allocation	Initial				Final			
	West.	Central	East.	Total	West.	Central	East.	Total
1983								
OY	16,560	33,540	9,900	60,000	16,560	33,540	9,900	60,000
-DAP	840	4,680	80	5,600	552	4,680	80	5,312
-JVP	1,040	1,370	590	3,000	1,040	2,712	0	3,752
DAH	1,880	6,050	670	8,600	1,592	7,392	80	9,064
RES	3,312	6,708	1,980	12,000	0	0	0	0
TALFF	11,368	20,782	5,850	38,000	14,968	26,148	9,820	50,936
1984								
OY	16,560	33,540	9,900	60,000	16,560	33,540	9,900	60,000
-DAP	500	11,700	120	12,320	500	8,700	120	9,320
-JVP	250	14,600	0	14,850	3,562	14,600	0	18,162
DAH	750	26,300	120	27,170	4,062	23,300	120	27,482
RES	3,312	3,708	1,980	9,000	0	0	0	0
TALFF	12,498	3,532	7,800	23,830	12,498	10,240	9,780	32,518
1985								
OY	16,560	33,540	9,900	60,000	16,560	33,540	9,900	60,000
-DAP	2,539	19,901	7,920	30,360	2,539	19,901	7,920	30,360
-JVP	3,209	4,431	0	7,640	3,209	4,431	0	7,640
DAH	5,748	24,332	7,920	38,000	5,748	24,332	7,920	38,000
RES	3,312	6,708	1,980	12,000	3,212	6,608	1,980	11,800
TALFF	7,500	2,500	0	10,000	7,600	2,600	0	10,200
1986[c]								
OY	29,951	33,049	12,000	75,000				
-DAP	9,800	19,600	5,600	35,000				
-JVP	2,521	2,959	4,000	9,480				
DAH	12,321	22,559	9,600	44,480				
RES	5,990	6,610	2,400	15,000				
TALFF	11,640	3,880	0	15,520				

[a]OY = optimum yield; DAH = domestic annual harvest; RES = reserve; TALFF = total allowable level of foreign fishing; DAP = domestic annual processing; JVP = joint venture processing; DNP = domestic nonprocessed catch.

[b]"Fishing year" 1981 was extended to 14 months in order that subsequent fishing years would coincide with calendar years.

[c]Initial allocation as of January 1, 1986.

70,000 t and the fishing year was extended until December 31 to allow subsequent OY's to cover calendar years. In 1986 the total OY was raised to 75,000 t and the geographic distribution was changed to 40, 44, and 16% in the Western, Central, and Eastern Regulatory Areas, respectively. Previously that distribution had been 28, 56, and 16%.

Proportional distribution of catches in the respective regulatory areas was relatively steady from 1979 to 1983, although in 1984 and 1985,the vast majority of cod catches came from the Western and Central Regulatory Areas (Table 8). This was due in large part to the absence of Japanese longliners in the INPFC Yakutat and Kodiak Areas after 1983. (Japanese longliners fishing for Pacific cod voluntarily limited their activities to the INPFC Shumagin and Chirikof Areas during those years.) Japanese longline vessels were permitted to target Pacific cod only in waters shallower than 350 m in order to reduce incidental catches of sablefish. Catches of Pacific cod in all three regulatory areas were well below the final total OY allocations, especially in the Eastern Regulatory Area (Tables 7 and 8).

Total initial allocations of Pacific cod for 1985 reflected a continuing trend toward increasing the domestic catch and a gradual phasing out of foreign fishing. The initial TALFF on 1 January 1985 was 10,000 t, less than half of the 23,830 t initial TALFF allocation on 1 January 1984, and less than a third of the 32,518 t final allocation for 1984 (Table 7). Two hundred t of additional TALFF were allocated by the end of 1985. The initial 1986 TALFF was increased to 11,640 t.

CONDITION OF THE STOCKS

Because the population structure of Pacific cod is poorly understood, the resource is primarily managed by geographic subdivision. Thus, the Washington-to-California, British Columbia, Aleutian Island, Bering Sea, and Gulf of Alaska regions are each considered to have separate stocks. As tagging studies in the Gulf of Alaska, Aleutian Islands, and Bering Sea progress, more informationon the validity of this assumption will become available. Discussions here concerning the condition of the Gulf of Alaska stock are developed along two lines: 1) resource assessment surveys and port sampling, and 21 size composition and catch per unit effort (CPUE) of the Japanese longline fishery based on data collected by the U.S. Foreign Fisheries Observer Program. Effort data for domestic and joint venture fisheries are not yet available to facilitate the use of production models. Growth and natural mortality rates for Pacific cod from the Gulf of Alaska are not well-defined.

Resource Assessment Surveys

The 1984 U.S.-Japan Cooperative Bottom Trawl Survey

The 1984 U.S.-Japan cooperative bottom trawl survey was conducted by personnel from the Northwest and Alaska Fisheries Center in Seattle, Washington, with extensive cooperation from the Fishery Agency of Japan,

Table 8.--Catch (t) of Pacific cod in the Gulf of Alaska, by North Pacific Fishery Management Council regulatory area, 1977-85.

Year	Area			Total
	Western	Central	Eastern	
1977	726	1,225	306	2,257
1978	5,591	6,195	376	12,162
1979	3,982	10,370	518	14,870
1980	8,705	24,498	2,120	35,323
1981	11,579	22,151	2,358	36,088
1982	7,343	19,904	2,133	29,380
1983	9,178	25,242	1,981	36,401
1984	11,202	11,981	34	23,217
1985	8,426	5,788	92	14,306

Sources: Foreign and joint venture catches: personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point Way NE., Seattle, WA 98115. U.S. catches 1977-80: Rigby (1984). U.S. catches 1981-85: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201.

which contributed a chartered research vessel and scientists from the Far Seas Fisheries Laboratory in Shimizu, Japan. The general objective of the work was to determine the abundance, distribution, and biological condition of groundfish stocks in the central and western Gulf of Alaska, June-October 1984. The survey was the most comprehensive ever completed in the region. Eight hundred and twenty-three demersal trawl stations ranging in depth from 27 to 823 m were sampled between Cape St. Elias (144° W. long.) and the Islands of Four Mountains (170° W. long.) by the chartered U.S. trawlers Morning Star and Ocean Spray and the chartered Japanese trawler Daikichi Maru No. 37. Subsequent to the above-mentioned survey, NMFS personnel from the Auk Bay Laboratory in Juneau, Alaska, surveyed the eastern Gulf of Alaska from Cape. St. Elias to Dixon Entrance (132° W. long.) aboard the Morning Star. Catches of Pacific cod by the three types of trawls employed were standardized by fishing power coefficients and adjusted to the most efficient trawl. The adjusted catches were used to calculate CPUE by INPFC area and 100-m depth interval (Table 9). The CPUE by depth was highest in the 101-200 m interval in each INPFC area, and by area (within the 101-200 m interval) was highest in the INPFC Shumagin Area. Beyond the 201-300 m interval, the abundance of cod was low.

Total biomass estimated from the results of the 1984 U.S.-Japan cooperative bottom trawl survey (between 144 and 170° W. long) was 538,820 t, with a 95% confidence interval of 389,623-688,016 t (Table 9). Of the five INPFC areas, biomass was greatest in the INPFC Kodiak Area. Biomass was estimated at 170,128 t in the INPFC Shumagin Area (Western Regulatory Area) and 343,747 t in the combined INPFC Chirikof and Kodiak Areas (Central Regulatory Area). This is very close to the 1:2 proportional allocation used to assign regional OY's prior to 1986. Biomass in the remaining area covered by the U.S.-Japan survey (the INPFC Yakutat Area west of 144° W. long.) was estimated at 24,945 t.

There is evidence, however, that computed biomass for the INPFC Yakutat Area as a whole may be less reliable. The estimated biomass of cod in the western half of the INPFC Yakutat Area (24,945 t) was much greater than in the eastern half (8,077 t). If one is willing to assume a more or less uniform distribution of Japanese longline effort in the east-central Gulf of Alaska during 1982 and 1983, the historical catch data (Zenger 1985) suggest that cod have been more or less equally abundant in the two subareas. It seems likely that lack of extensive sampling by the 1984 NMFS survey in the 101-200 m interval in the eastern Yakutat subarea (and the INPFC Southeastern Area) resulted in low biomass estimates. Until better data are available, it does not seem unreasonable to assume that biomass in the INPFC Yakutat Area as a whole was about 50,000 t--roughly twice that in the western subarea.

Neither the 1984 survey data nor the historical catch data provide a basis for generating a biomass estimate for the INPFC Southeastern Area. Lacking that, there can be no biomass estimate for the Eastern Regulatory Area (INPFC Yakutat and Southeastern Areas combined).

A first-order estimate of yield for the Gulf of Alaska Pacific cod stocks in the INPFC Shumagin, Chirikof, and Kodiak Areas as assessed in June-August 1984 can be derived using Gulland's (1975) equation:

Table 9.--Catch per unit effort (in kilograms per square kilometer (kg/km^2)) and biomass (t) of Pacific cod, by depth, in the International North Pacific Fisheries Commission (INPFC) Shumagin, Chirikof, and Kodiak Statistical Areas, and the western half of the Yakutat Statistical Area as estimated from results of the 1984 U.S.-Japan cooperative bottom trawl survey in the central and western Gulf of Alaska.

Depth (m)	Shumagin		Chirikof		Kodiak		Yakutat[a]	
	kg/km^2	t	kg/km^2	t	kg/km^2	t	kg/km^2	t
0-100	2,460	109,232	1,713	45,718	1,024	40,080	730	8,963
101-200	4,045	58,791	3,237	76,865	3,661	158,094	1,936	15,574
201-300	767	2,099	1,185	13,630	824	9,125	1,165	408
301-500	2	6	72	117	38	114	--	--
501-700	--	--	--	--	3	4	--	--
0-700[b]		170,128		136,330		207,416		24,945

[a]Western subarea, 144-147° W. long.

[b]Total biomass = 538,820 t with 95% confidence limits 389,623-688,016 t.

Source: Personal communication with Eric Brown, Resource. Assessment and Conservation Engineering Division, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point Way NE., Seattle, WA 98115. Biomass revised 12 January 1987.

$Y = 0.5\ M\ B_o$ where

Y = yield,

M = estimated force of natural mortality acting on the population, and

B_o = estimated virgin biomass (equated to the results of the 1984 triennial groundfish survey estimate of total biomass).

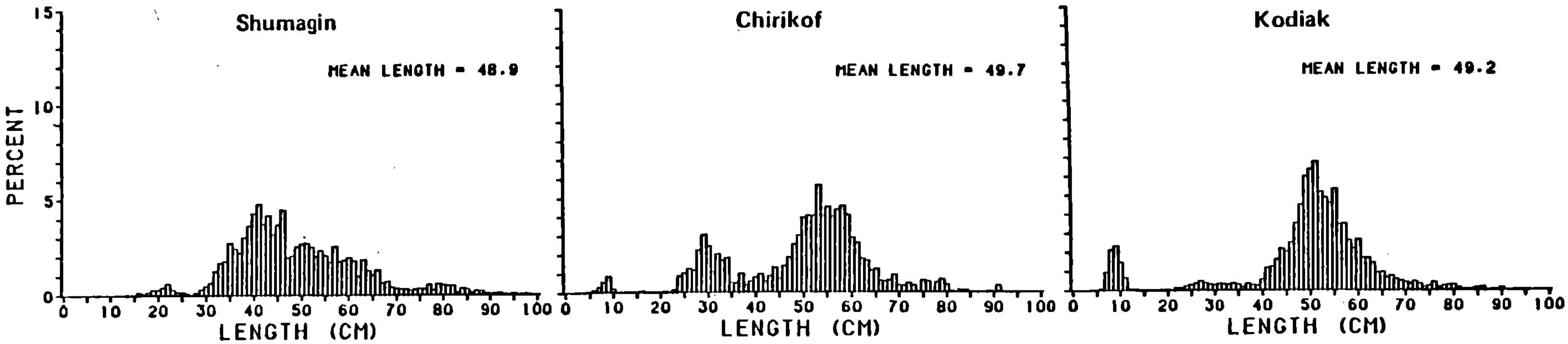
The force of natural mortality, estimated at 0.45 by Bakkala and Wespestad (1985), has been applied here. Yield estimates for the INPFC Shumagin, Chirikof, and Kodiak Areas are 38,279, 30,674, and 46,669 t, respectively. (These numbers were recalculated, and they reflect a small change from those reported last year in Zenger and Blackburn (1986).) Altogether, these three INPFC areas--which constitute the Western and Central Regulatory Areas--have an estimated yield of 115,025 t, which is approximately twice the OY for 1985 for the entire Gulf of Alaska.

Length frequencies from the 1984 U.S.-Japan cooperative bottom trawl survey of the central and western gulf provide a basis for examining other aspects of the Gulf of Alaska cod stock (size frequency modes can be used to estimate ages, especially for younger fish). The large 1977-78 year classes, for example, have largely lost their predominance in the population, although biomass-weighted size compositions show that they are probably still contributing a small amount to the total biomass in the largest size category (Fig. 1). In the INPFC Shumagin Area, age-2+ cod (frequency mode of approximately 40 cm) were relatively abundant and their biomass contributed a significant amount to survey catches. That mode should correspond to the 1982. year class. In the INPFC Chirikof and Kodiak Areas, on the other hand, the 2+ age group was not widely found in survey catches. Generally, it appears that post-1977 recruitment has been strong enough to maintain the Gulf of Alaska cod stock at a relatively high level, given its apparent underexploitation at this time. Age-O+ cod were found as a component of relatively dense semipelagic schools during the 1984 triennial survey along Shelikof Trough northeast of Chirikof Island and in lower Shelikof Strait near the Alaska Peninsula. The possibility of a strong 1984 year class of Pacific cod in the Gulf of Alaska was investigated during a late summer 1985 trawl survey of juvenile groundfish in the Kodiak Island to Shumagin Island region. Juvenile Pacific cod were rarely caught during the survey which was largely exploratory in nature. A similar trawl survey for juvenile groundfish was conducted in 1986.

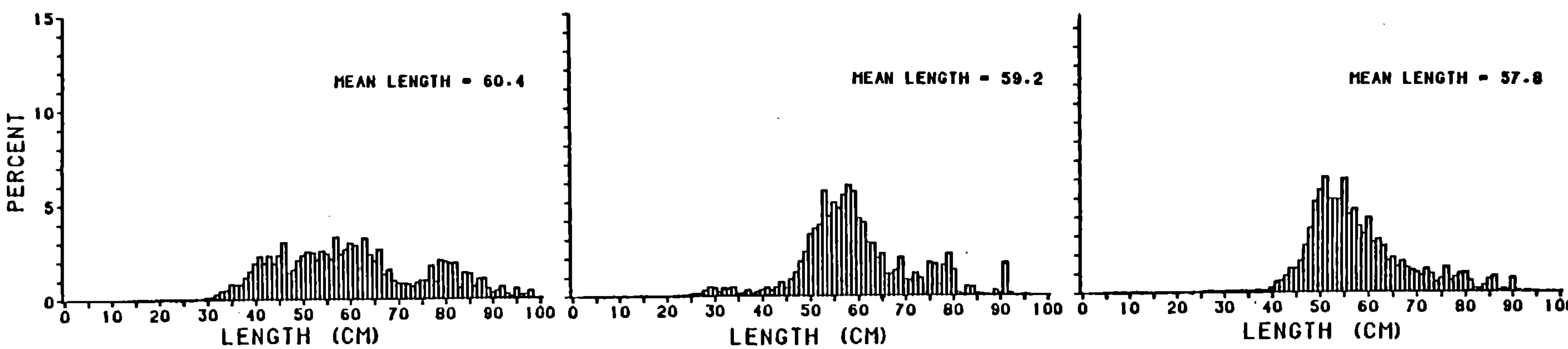
The next update of the status of Pacific cod stocks in the Gulf of Alaska will follow the triennial groundfish trawl survey to be conducted during the summer of 1987.

Alaska Department of Fish and Game Groundfish Trawl Surveys

The Alaska Department of Fish and Game (ADF&G) conducted summer groundfish trawl surveys in Shelikof Strait from 1980 to 1985, and in the Chignik area from 1981 to 1984. Size compositions indicate annual changes in the size-specific abundance indices of fish that were available to capture by trawl in



A. Size composition



B. Biomass-weighted size composition

Figure 1.--All-vessel size compositions and biomass-weighted size compositions for Pacific cod sampled in the INPFC Shumagin, Chirikof, and Kodiak Statistical Areas during the 1984 triennial Gulf of Alaska groundfish trawl survey.

each survey area. In 1981, newly recruited small cod (identified as age-l+) were taken in both areas (Fig. 2). They reappeared in both areas in 1982 with a frequency mode of about 40 cm. Since then comparable recruitment of age-l+ cod has not been detected, although during the 1983 survey in the Shelikof area a mode at 39 cm in the length freqency curve suggested that the 1981 year class may have been roughly comparable to that of 1980. It appears that in 1982 either the 1981 year class was in the area and went undetected, or that possibly it moved into the area after the survey. A mode in the 1985 frequency distribution that was located near 45 cm suggested that the 1983 year class may have been relatively large.

Since even the most basic information about cod spawning and migration patterns in the Gulf of Alaska is limited, the reliability with which data from an apparently localized concentration of cod can be projected as an indicator of abundance and biological condition of-the gulf-wide stock requires more study. For example, by comparing unweighted size compositions from the 1984 U.S.-Japan cooperative bottom trawl survey of the central and western gulf (Fig. 1) to those from the 1984 ADF&G groundfish surveys (Fig. 21, it is apparent that the more comprehensive U.S.-Japan survey took cod of a wider range of sizes--particularly the smaller age-O+ and age-l+ fish. How greatly the localization of the domestic and foreign fisheries and gear selectivity influence size composition data is best indicated by comparing the results of the 1984 U.S.-Japan survey to those from other sources. Note that in the Chignik area in the 1984 ADF&G survey, CPUE was highest for cod of around 50 cm (Fig. 21, whereas length frequencies collected from commercial vessels fishing in the vicinity of Kodiak Island during the fourth quarter of 1984 indicate a major mode near 58 cm (Fig. 3). Further, the size compositions of cod collected aboard Japanese longliners in the INPFC Shumagin and Chirikof Areas in 1984 show the predominant frequency mode at 63 cm (Fig. 4).

Although it was more limited in geographic coverage, the ADF&G groundfish survey was the only annual research program to update industry-independent estimates of groundfish stock condition. It was discontinued after 1985 due to budgetary restrictions.

U.S. Foreign Fisheries Observer Data

CPUE by Japanese Longline Vessels

Japanese longline CPUE indicates the relative abundance of Pacific cod, although as that fishery has been more closely regulated and areas more restricted, the scope of the data has been narrowed considerably. In this fishery Pacific cd are targeted in waters shallower than 300 m, and catches at greater depths are relatively infrequent and usually associated with the fishery for sablefish. Between 1978 and 1985 Japanese longline CPUE for Pacific cod has generally increased in the INPFC Shumagin and Chirikof Areas (Table 10). Part of that trend may have been associated with increased knowledge about the distribution and abundance of cod, especially in the earlier years when the Japanese began to transfer fishing effort from sablefish to cod. Although the significance of changes in CPUE in recent years is masked somewhat by the shifting of the fishery to shallower depths (Table 111, it can be ascertained by tracking CPUE in the key l00-199 m stratum that the abundance of cod has increased.

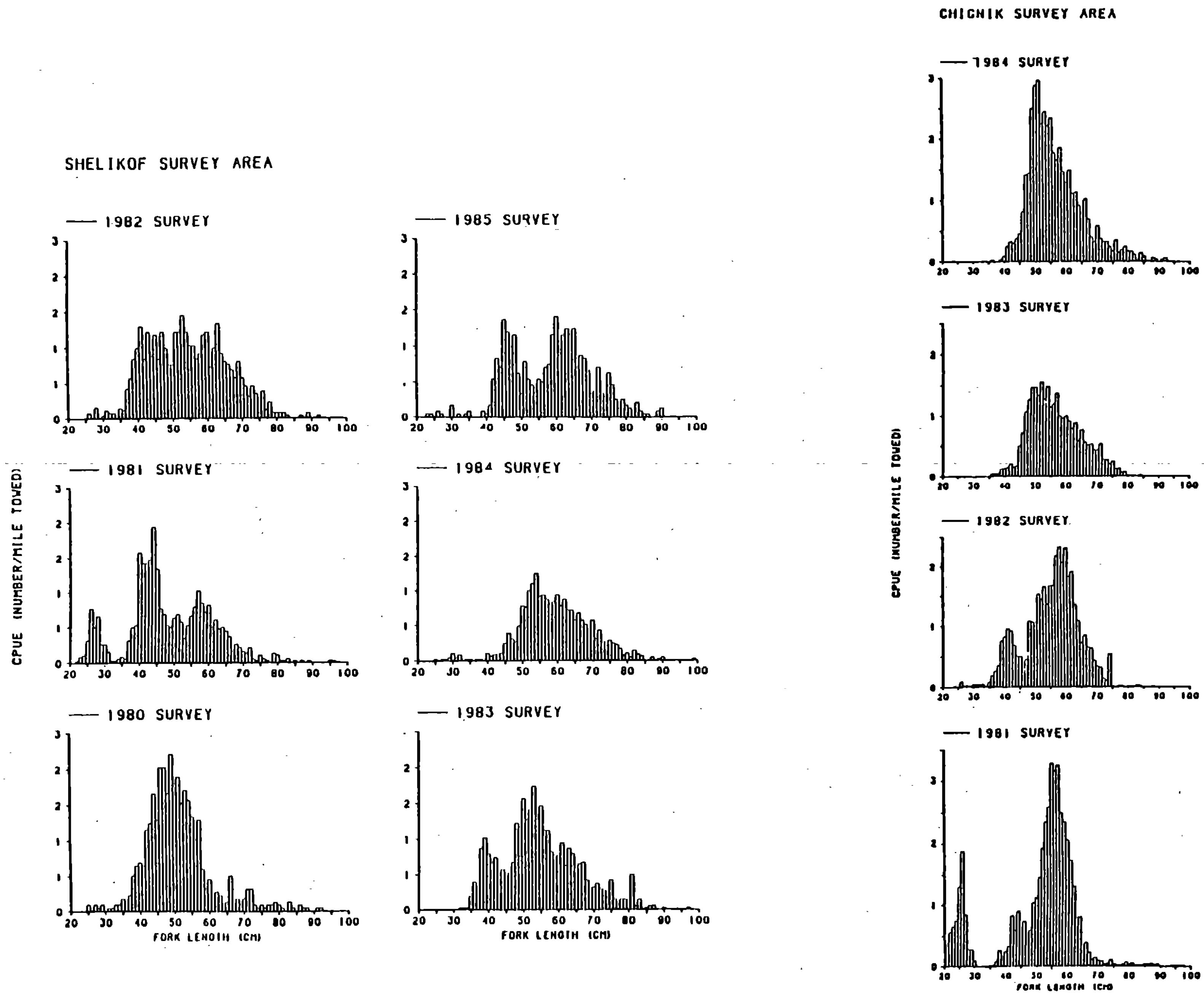


Figure 2.--Weighted length frequencies of Pacific cod sampled during annual Alaska Department of Fish and Game groundfish trawl surveys in the Shelikof Strait and Chignik areas, 1980-85.

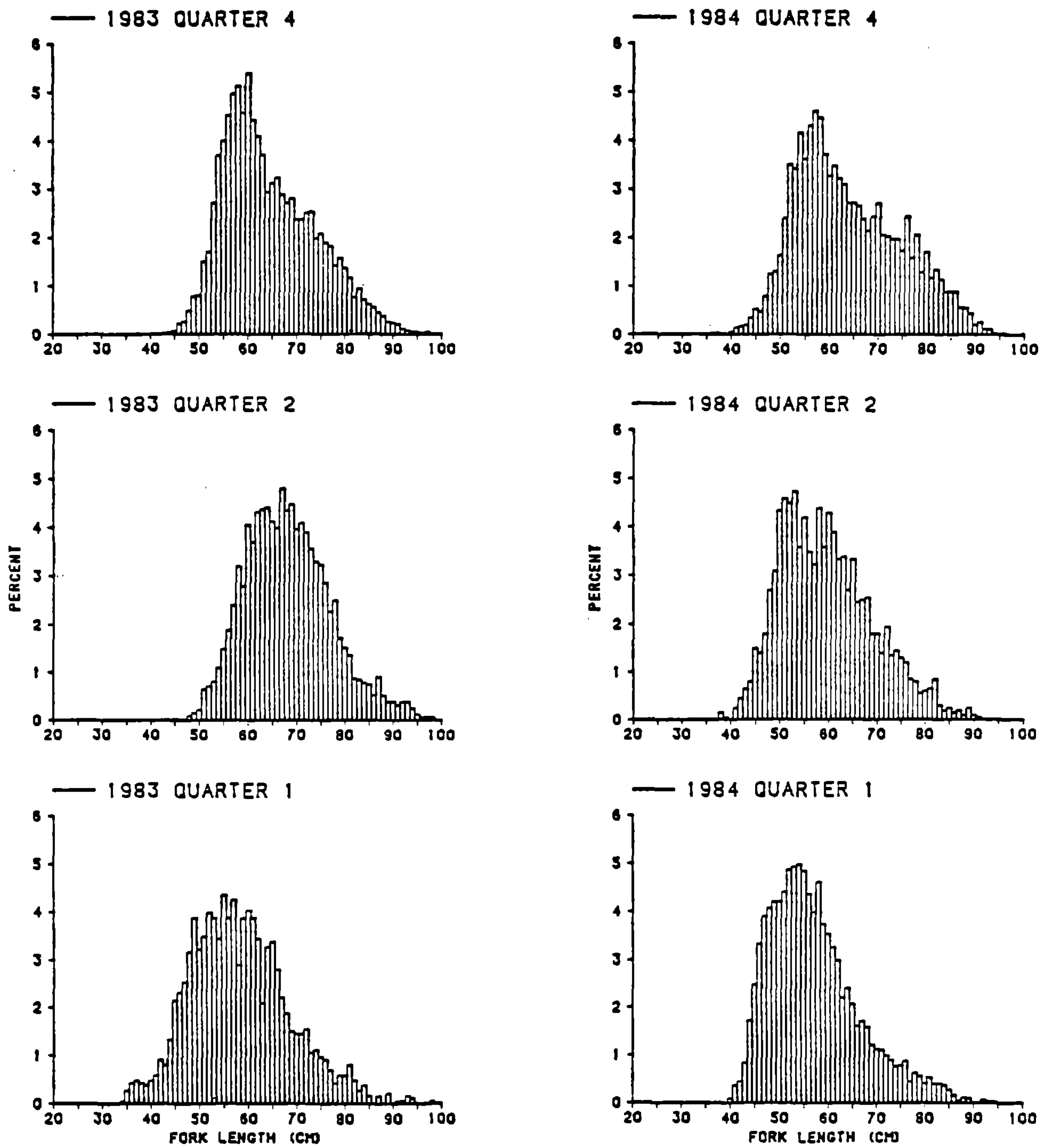


Figure 3.--Relative length frequencies of Pacific cod sampled by the Alaska Department of Fish and Game from commercial landings in Kodiak, Alaska, 1983-84.

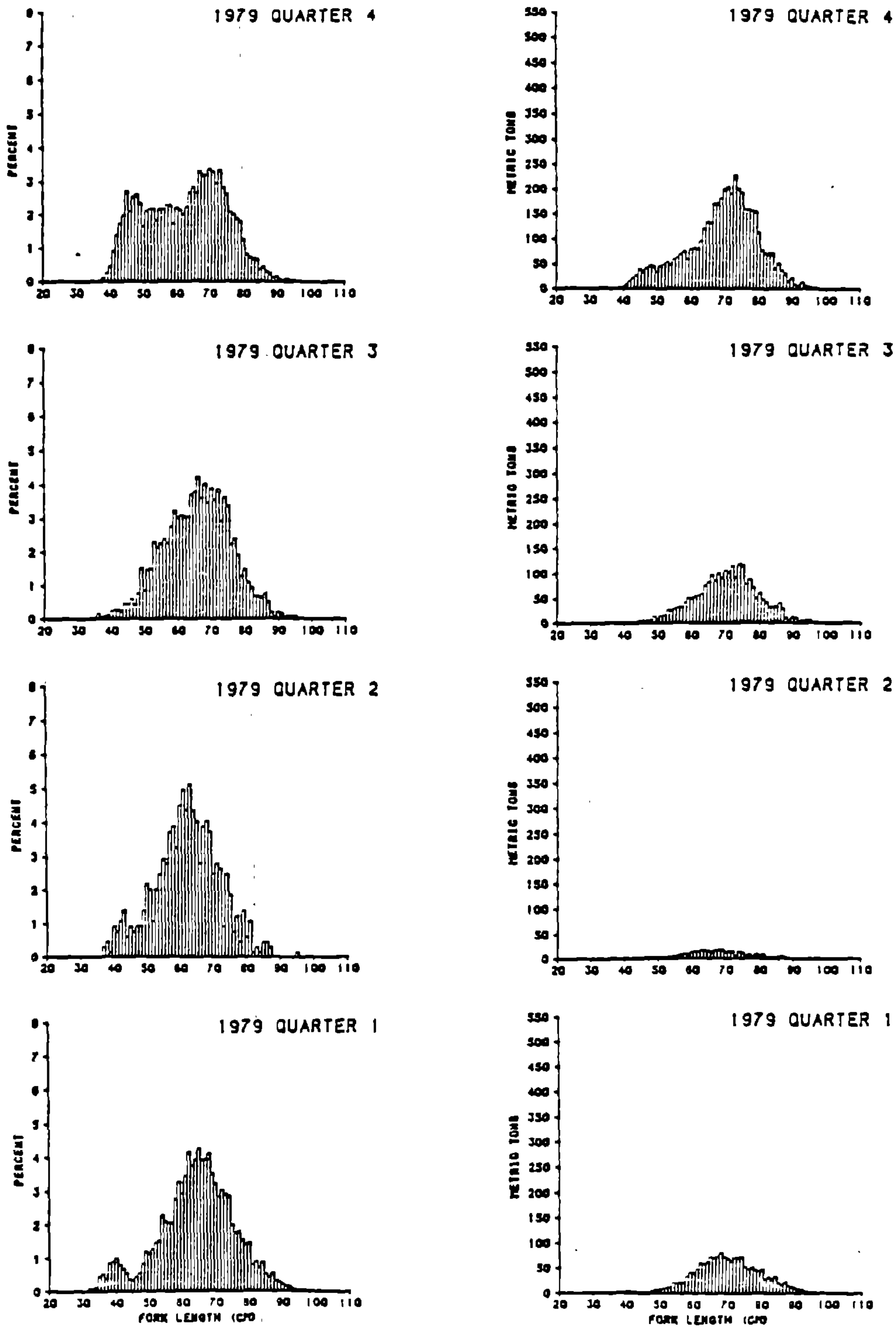
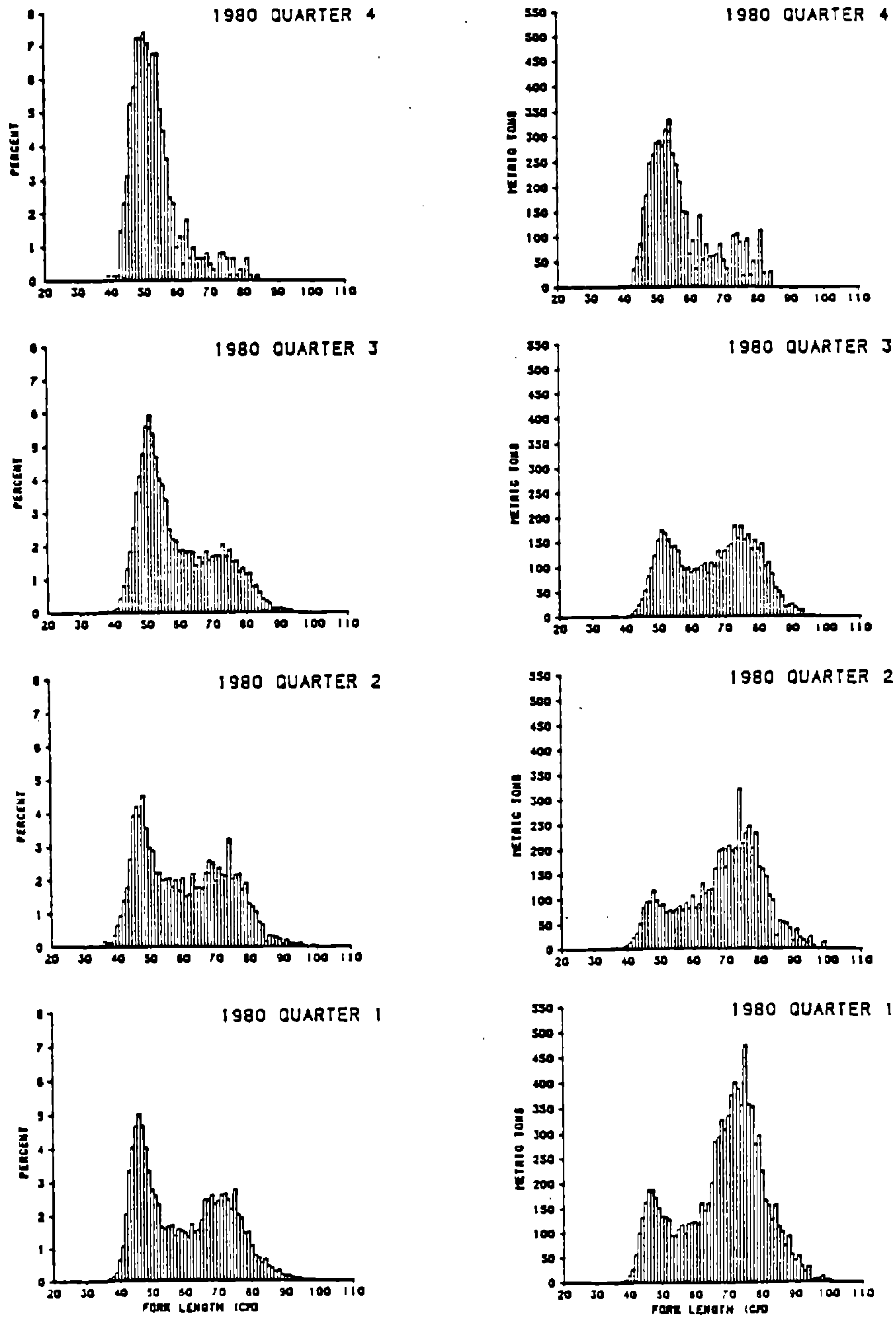


Figure 4.--Unweighted length frequencies and length frequencies expressed as metric tons of Japanese longline catches of Pacific cod per centimeter of fork length, by quarter, 1979-84. (Catch estimates and length frequencies furnished by the U.S. foreign Fisheries Observer Program, Seattle.)



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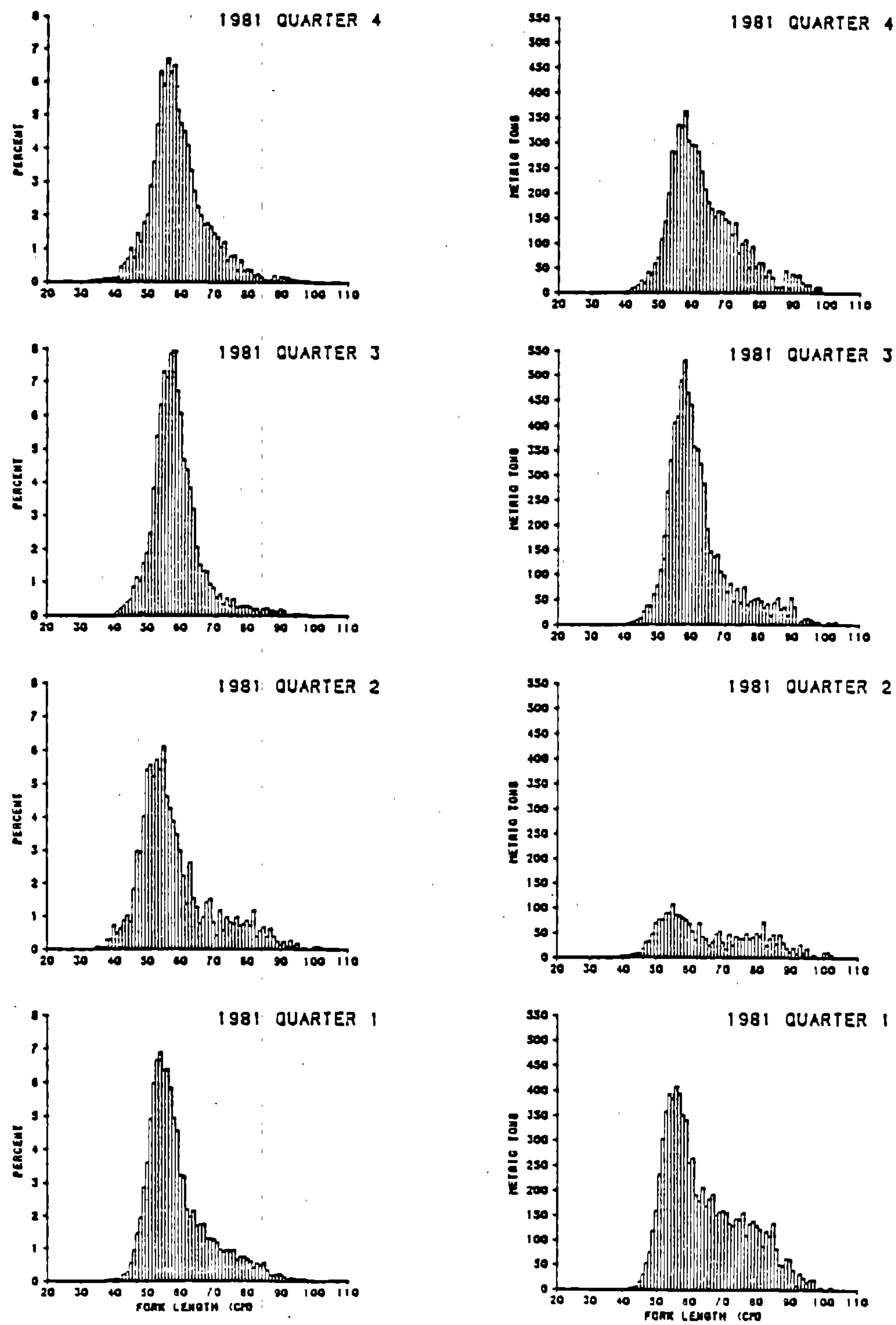

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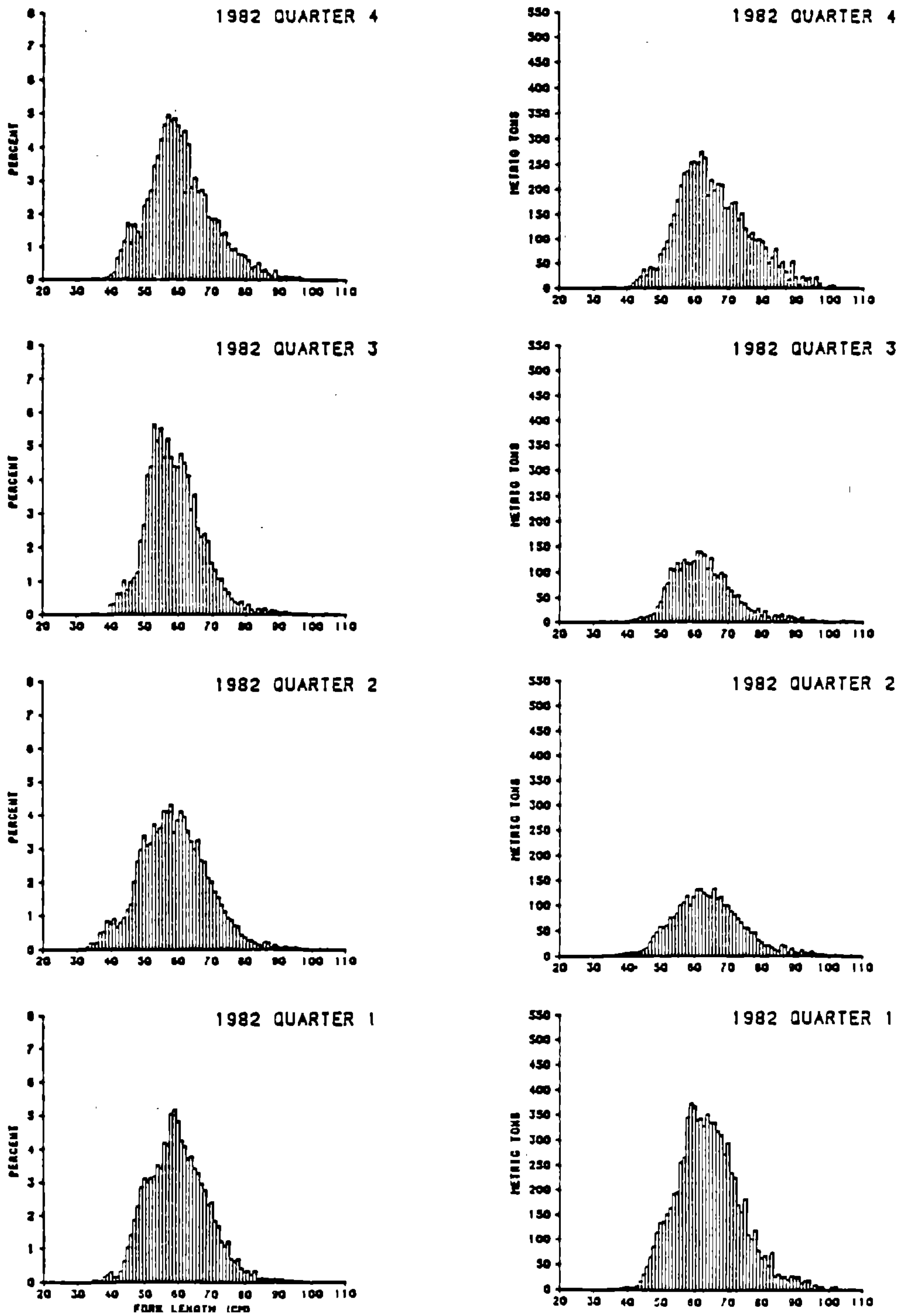

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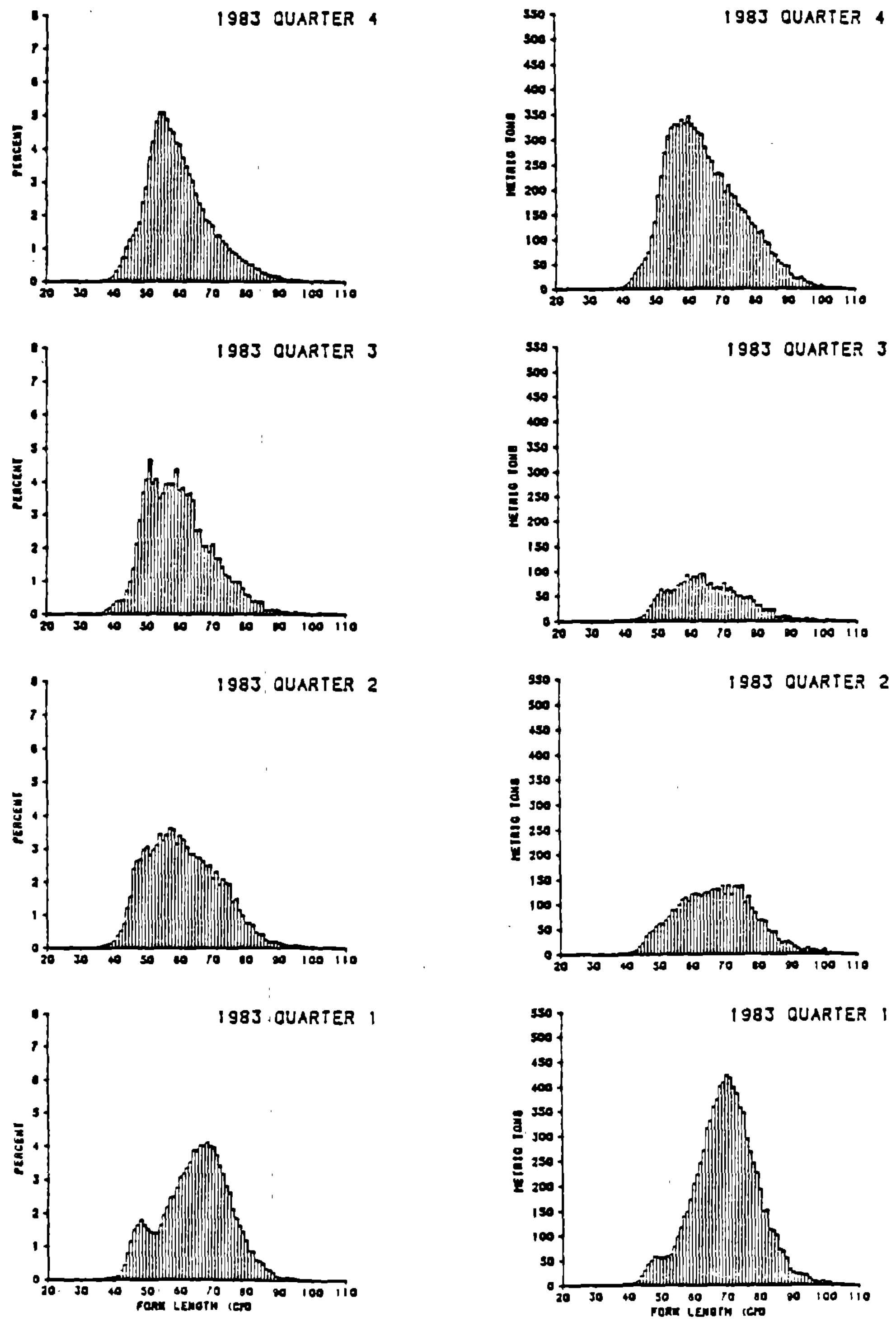

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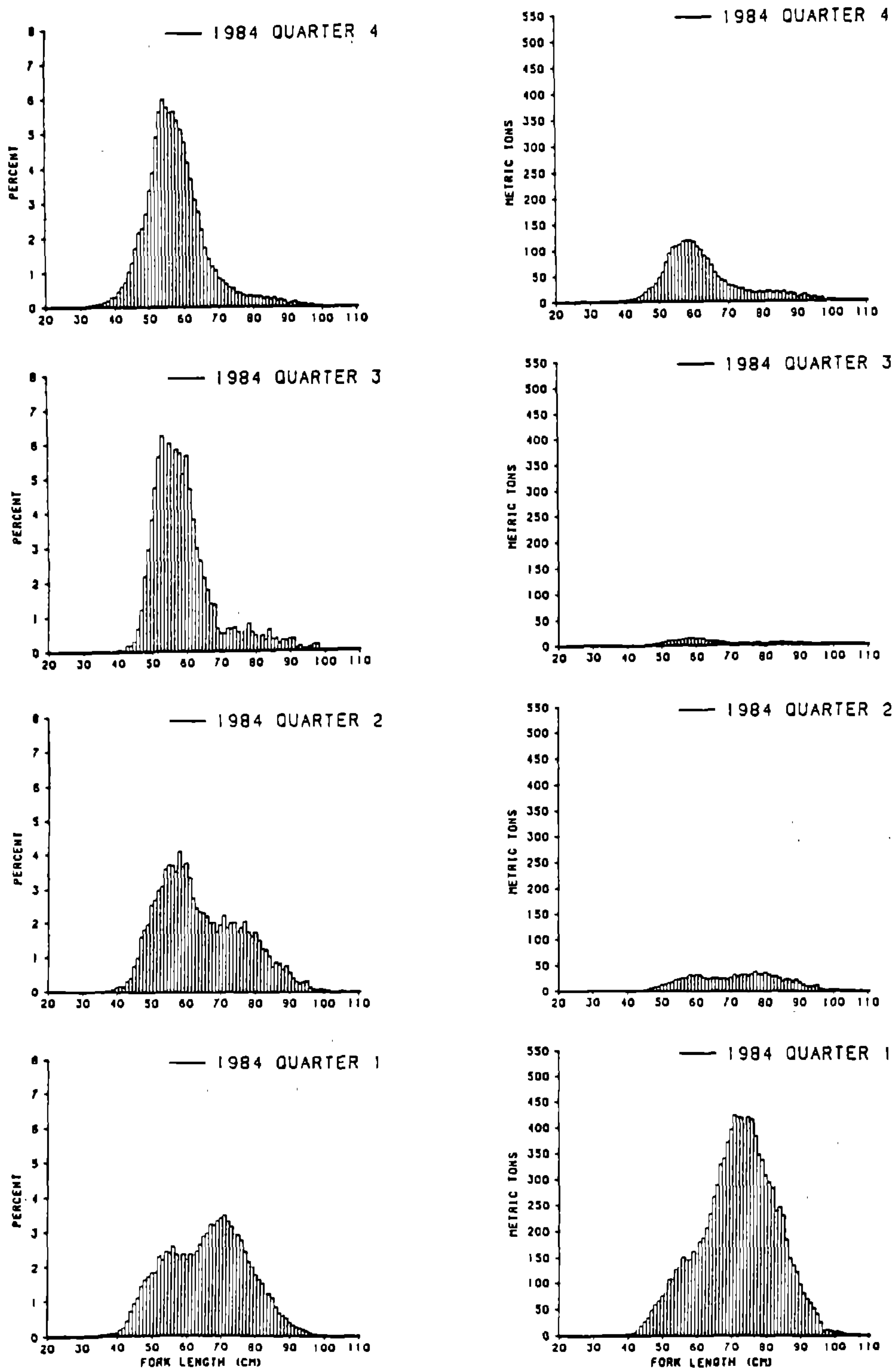

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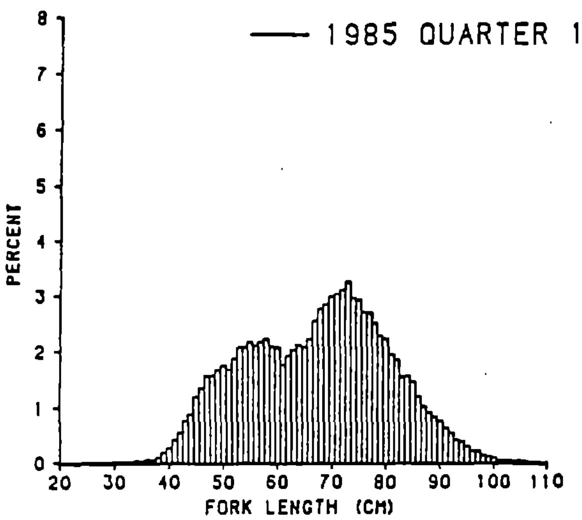

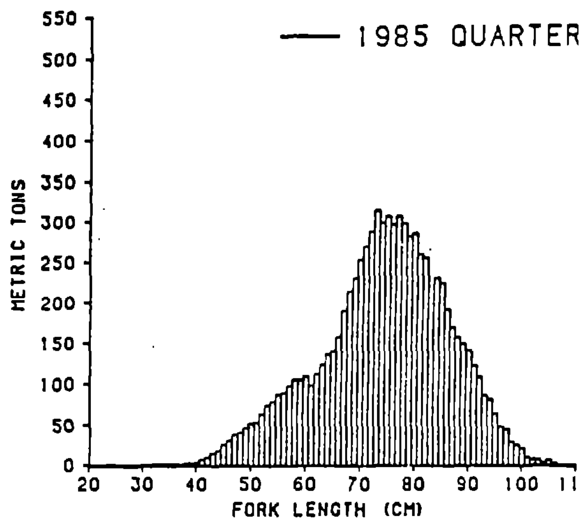

Figure 4.--Continued.

Table 10.--Catch per unit effort (t per 1,000 hooks) of Pacific cod for Japanese longliners, by depth and International North Pacific Fisheries Commission (INPFC) statistical area, 1978-85. (Based on samples collected by the U.S. Foreign Fisheries Observer Program.)

Year	Depth (m)	Area: Shumagin	Chirikof	Kodiak	Yakutat
1978	100-199	0.514	0.669	NS[a]	NS
	200-299	0.586[b]	0.521	NS	NS
	100-299	0.517	0.644	NS	NS
1979	100-199	0.572	0.581	0.833	0.193[b]
	200-299	0.610	0.737	0.413[b]	NS
	100-299	0.584	0.631	0.684	0.193
1980	100-199	0.623	0.547	0.404[b]	NS
	200-299	0.671	0.672	0.569[b]	NS
	100-299	0.641	0.628	0.504	NS
1981	100-199	0.688	0.646	0.354[b]	NS
	200-299	0.710[b]	0.554	0.412[b]	NS
	100-299	0.691	0.629	0.361	NS
1982	100-199	0.743	0.682	0.456	0.131[b]
	200-299	0.688	0.640[b]	NS	NS
	100-299	0.732	0.686	0.456	0.131
1983	0-99	0.845[b]	NS	NS	NS
	100-199	0.734	0.765	0.444[b]	NS
	200-299	0.445[b]	0.662	0.624	0.328[b]
	0-299	0.729	0.745	0.598	0.328
1984	0-99	1.608	0.946[b]	NS	NS
	100-199	1.012	0.734	NS	NS
	200-299	0.495[b]	0.184[b]	NS	NS
	0-299	1.018	0.735	NS	NS
1985	0-99	1.502	1.376	NS	NS
	100-199	1.410	1.217	NS	NS
	0-199	1.446	1.242	NS	NS

[a]NS: No sample.

[b]Relatively small sample.

Source: Personal communicaton with Jerald Berger, U.S. Foreign Fishery Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4. 7600 Sand Point Way NE., Seattle, WA 98115.

Table 11.--Catch per unit effort (CPUE) of Pacific cod for Japanese longliners derived from samples collected by the U.S. Foreign Fisheries Observer Program in the International North Pacific Fisheries Canmission (INPFC) Shumaqin, chirikof, and Kodiak Statistical Areas, for fishing depths shallower than 300 m, 1978-85.

Year/ INPFC area	Total estimated sample catch (t)	Total hooks fished (x1000)	CPUE for total sample (t/1000 hooks)	Mean depth per set (m)
1978				
Shumagin	465.9	900.9	0.517	166
Chirikof	1,106.8	1,717.5	0.644	183
Combined areas	1,572.7	2,618.4	0.601	
1979				
Shumagin	573.7	982.0	0.584	217
Chirikof	798.5	1,265.4	0.631	199
Kodiak	135.3	197.7	0.684	178
Combined areas	1,507.5	2,445.1	0.617	
1980				
Shumagin	580.6	905.7	0.641	193
Chirikof	1,031.9	1,644.2	0.628	210
Kodiak	126.6	251.0	0.504	213
Combined areas	1,739.1	2,800.9	0.621	
1981				
Shumagin	911.2	1,318.6	0.691	157
Chirikof	1,013.0	1,611.0	0.629	166
Kodiak	49.4	136.9	0.361	158
Combined areas	1,973.6	3,066.5	0.644	
1982				
Shumagin	672.0	918.0	0.732	107
Chirikof	1,149.1	1,693.2	0.686	137
Kodiak	129.4	284.0	0.456	99
Combined areas	1,950.5	2,895.2	0.674	
1983				
Shumagin	3,512.6	4,817.6	0.729	140
Chirikof	6,881.3	9,237.4	0.745	162
Kodiak	257.0	430.0	0.598	214
Combined areas	10,650.9	14,485.0	0.735	
1984				
Shumagin	7,967.8	7,830.0	1.018	130
Chirikof	3,941.7	5,365.0	0.735	128
Combined areas	11,909.5	13,195.0	0.903	
1985				
Shumagin	7,019.1	4,854.6	1.446	93
Chirikof	1,648.4	1,327.4	1.242	109
Combined areas	8,667.5	6,182.0	1.402	

Source: Personal communicaton with Jerald Berger, U.S. Foreign Fishery Observer Program, Northvest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point Way NE., Seattle, WA 98115.

Ranked CPUE (kg/day) for the most, common species captured by the Japanese longline fishery for Pacific cod shows that Pacific cod always ranks first, with Pacific halibut or sablefish second (Table 12). In 1983 and 1984 Pacific halibut catch rates increased, probably because of the trend toward fishing in shallower waters, and the recent increase in the abundance of halibut. In 1985 Japanese longliners fished only until early April and the CPUE of Pacific halibut decreased somewhat from the previous 2 years.

It is appropriate to note here that another longline activity (Japan-U.S. longline surveys, 1978-85) suggests that cod recruitment has occurred during each year. Indices of abundance derived from that survey suggest that the cod population found deeper than 100 m in the Gulf of Alaska has been relatively stable since 1980 (Teshima 1986).

Size Composition of Pacific Cod Taken by Longliners

The most consistent and relatively long-term source of Pacific cod size composition data from the Gulf of Alaska comes from the Japanese longline fishery. Length frequency data from that fishery collected by the U.S. Foreign Fisheries Observer Program from 1979 to 1985 are summarized by 3-month periods in Figure 4. Length frequencies are weighted by the catch of Pacific cod for each quarter year. Resulting histograms show the relative contribution to the total quarterly catch made by each centimeter size group. Also included with the weighted size composition figures are unweighted length frequencies, since the miniscule biomass represented by the small fish often masks their relative year-class strengths. During the fourth quarter of 1979 a relatively abundant group of fish appeared in the 40-50 cm interval, indicating the presence of the 1977 year class in the fishery. The recruitment of the 1977 year class (estimated as 3-year-olds from length-frequency modes) became more notable in 1980 and with time, as the mode moved to the right and strengthened, the 1977 and possibly the 1978 year classes became the major contributors to the Japanese longline fishery. (In the fourth quarter of 1980 there was once again a relatively large proportion of cod in the 40-50 cm range, suggesting that the 1978 year class was also strong--although the overwhelming size of the preceding (1977) year class was such that the 1977 and 1978 year classes could not be separated by inspection of the frequency histograms). Indications are that there has been recruitment every year except 1984, and that the 1977, 1978, and possibly the 1980 and 1982 year classes were relatively strong. The limited geographic distribution of the Japanese longline fleet and the early, abbreviated season may explain in part the lack of smaller fish in the 1984 and 1985 catches.

POTENTIAL YIELD

Maximum sustainable yield (MSY) was estimated at 88,000-177,000 t by Low et al. (1979) and at 95,000-190,000 t by Zenger and Cummings (1983) based on various Gulf of Alaska groundfish surveys that were conducted in 1980 and 1981. The results of the 1984 Gulf of Alaska triennial groundfish survey indicate that the potential yield for the Western and Central Regulatory Areas is 115,622 t with 95% confidence limits of approximately 87,000 to 154,000 t.

Table 12.--Banked catch per unit effort (CPUE) in kilograms/day for the four predominant species in Japanese longline catches from depths less than 300 m in the International North Pacific Fisheries Commission Shumagin, Chirikof, and Kodiak Statistical Areas, 1979-85.

	Area and CPUE					
	Shumagin	kg/d	Chirikof	kg/d	Kodiak	kg/d
1978						
	Pacific cod	7,509	Pacific cod	9,072		
	Sablefish	232	Pac. halibut	101	No fishing effort reported	
	Arrowtooth fl.	139	Sablefish	77		
	W. pollock	92	W. pollock	74		
1979						
	Pacific cod	6,039	Pacific cod	9,506	Pacific cod	2,706
	Pac. halibut	103	Sablefish	339	Pac. halibut	303
	Sculpin	66	Pac. halibut	143	Sablefish	101
	Sablefish	63	Arrowtooth fl.	96	Arrowtooth fl.	31
1980						
	Pacific cod	9,841	Pacific cod	10,117	Pacific cod	9,041
	Pac. halibut	434	Sablefish	709	Pac. halibut	1,326
	Greenland tur.	401	Pac. halibut	441	Sablefish	1,089
	Sablefish	257	Arrowtooth fl.	126	Arrowtooth fl.	238
1981						
	Pacific cod	10,595	Pacific cod	11,917	Pacific cod	4,937
	Sablefish	1,199	Sablefish	1,116	Sablefish	1,353
	Pac. halibut	444	Pac. halibut	917	Pac. halibut	795
	Arrowtooth fl.	124	Arrowtooth fl.	250	Sculpin	116
1982						
	Pacific cod	7,814	Pacific cod	9,738	Pacific cod	4,044
	Sablefish	625	Pac. halibut	702	Pac. halibut	699
	Pac. halibut	255	Sablefish	343	Sablefish	330
	W. pollock	77	W. pollock	102	Skates	101
1983						
	Pacific cod	9,597	Pacific cod	11,585	Pacific cod	6,947
	Sablefish	969	Pac. halibut	1,202	Sablefish	1,889
	Pac. halibut	778	Sablefish	651	Pac. halibut	1,649
	W. pollock	159	Arrowtooth fl.	276	Arrowtooth fl.	233
1984						
	Pacific cod	15,442	Pacific cod	13,639		
	Pac. halibut	882	Pac. halibut	1,303	No fishing effort reported	
	Sablefish	468	Sablefish	307		
	Arrowtooth fl.	126	Arrowtooth fl.	211		
1985						
	Pacific cod	22,460	Pacific cod	19,746		
	Pac. halibut	706	Pac. halibut	1,010	No fishing effort reported	
	Searcher	73	Sculpin	67		
	Arrowtooth fl.	52	Yellow Irish ld.	53		

Source: Personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point Way NE., Seattle, WA 98115.

Although estimates for the INPFC Yakutat and Southeastern Areas were not included, the contribution by those areas would be relatively small, probably an additional 10,000 t. The resulting estimate of mean yield (125,000 t) is somewhat smaller than the 1979 and 1982 estimates of 133,000 and 142,000 t. The current estimate was based on more cohesive data than the earlier estimates, with fewer unknown variables involved.

The OY has been maintained at about half of MSY in recent years. In 1986 the OY was increased to 75,000 t to accommodate requests from the fishing industry. This move was justified by the fact that the previous OY was low in relation to the current estimated potential yield and that the ability to monitor bycatches of Pacific halibut has improved greatly.

RESEARCH IN PROGRESS

Work is continuing to test the reliability of dorsal spines as age structures. Pacific cod are being tagged as secondary objectives to other programs, principally to study their movements. Predator-prey relationships are being studied to enhance the information available for ecosystem modelling.

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ATKA MACKEREL

by

Lael L. Ronholt

INTRODUCTION

Atka mackerel (Pleurogrammus monopterygius) are distributed throughout the Gulf of Alaska, but are primarily found in the International North Pacific Fisheries Commission (INPFC) Kodiak, Chirikof, and Shumagin Statistical Areas at depths of 50-350 m.

Foreign nations have historically been the principal harvesters of Atka mackerel. Soviet fleets dominated the fishery from 1972 to 1980, and those from the Republic of Korea (ROK) dominated in 1981-83. Joint venture operations, with U.S. fishermen delivering primarily to ROK processors in the INPFC Shumagin Area, began in 1983 and in 1984 the foreign catch--taken mostly by Japanese vessels--was slightly exceeded by this fishery. Also in 1984, Atka mackerel were reported in the U.S. domestic catch for the first time. Catches by nation and joint venture are presented in Table 1. Estimates of optimum yield (OY), the harvest level that provides the greatest overall benefit to the nation, are also presented for each year beginning with 1977 when the Magnuson Fishery Conservation and Management Act went into effect.

Catches of Atka mackerel have declined drastically over the past 10 years, and the distribution of the catches has shifted westward (Table 2). From a high of roughly 28,000 metric tons (t) in 1975, catches declined to a plateau of about 19,000 t yearly in 1976-78 and then declined sharply to the historic low of 1,152 t in 1984 before increasing slightly to 1,848 t in 1985. The INPFC Kodiak Area was the best producer in the early, most productive years of the fishery--providing two thirds of the catch in 5 of the 7 years from 1974 to 1980. In 1978, and more recently in 1981-83, the adjacent INPFC Chirikof Area was the primary producer. In 1984 and 1985, over 94% of the catch (even though very small) was taken in the INPFC Shumagin Area.

CONDITION OF THE STOCK

From the outset, the United States has managed the Atka mackerel resource on the premise that there are separate stocks in the Gulf of Alaska and Bering Sea-Aleutian Islands regions. The validity of this approach is supported by the conclusions of Levada (1979a), which tentatively showed that samples from the two regions are distinct morphologically and meristically.

Efforts to obtain a precise measure of the condition of the Gulf of Alaska stock using conventional methods are beset with difficulty. The series of catch per unit effort (CPUE) data from the Soviet commercial fisheries has been interrupted with the suspension of these fisheries, and CPUE data from resource surveys (another indicator of stock condition) are of limited use because of the variability introduced by the intensive schooling behavior of Atka mackerel.

Table 1.--Catch (t) of Atka mackerel (Pleurogrammus monopterygius) in the Gulf of Alaska, by fishery category, 1974-85. Optimum Yield (OY) is included for each year since the Magnuson Fishery Conservation and Management Act.

Year	U.S.S.R.	Japan	Republic of Korea	Mexico	Poland	JV	U.S.	Total	OY
1974	17,531	a	-	-	-	-	-	17,531	
1975	27,776	a	-	-	-	-	-	27,776	
1976	19,933	a	-	-	-	-	-	19,933	
1977	19,246	a	-	-	209	-	-	19,455	22,000
1978	18,387	1,136	63	-	-	-	-	19,586	24,800
1979	10,265	568	81	36	-	-	-	10,950	26,800
1980	10,473	1,896	736	57	-	-	-	13,162	28,700
1981	-	3,636	14,811	-	280	-	-	18,726	28,700[b]
1982	-	2,087	4,672	-	-	-	-	6,759	28,700
1983	-	2,806	8,664	-	-	790	-	12,260	28,700
1984	-	532	4	-	T	585	31	1,152	28,700
1985	-	T	2	-	-	1,846	-	1,848	5,278

[a]Reported in a category called "other species."

[b]Optimum yield (OY) for 1981 is sometimes given in other reports as 33,484 t. This figure (33,484) was computed on the basis that fishing year 1981 lasted 14 months. This, in turn, was done so that future fishing years would coincide with calendar years.

T: Trace; JV: Joint venture.

Sources: 1974-76: Forrester et al. (1983); foreign and joint venture catches 1977-84: Berger et al. (1986); foreign and joint venture catches 1985; personal communication with Jerald Berger, U.S. Foreign Fisheries observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE., BIN C15700, Building 4, Seattle, WA 98115; domestic catches: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201.

Table 2.--Catches (t) of Atka mackerel (<u>Pleurogrammus monopterygius</u>) in the Gulf of Alaska, by fishery category and International North Pacific Fisheries Commission statistical area, 1974-85.

Year		Area: Shumagin	Chirikof	Kodiak	Yakutat	Southeastern	Total
1974	U.S.S.R.	4,742	2,748	10,041	-	-	17,531
	Japan	-	-	-	-	-	*
							17,531
1975	U.S.S.R.	2,132	743	23,688	1,213	-	27,776
	Japan	-	-	-	-	-	*
							27,776
1976	U.S.S.R.	1,552	4,394	13,211	776b	-	19,933
	Japan	-	-	-	-	-	*
							19,933
1977	U.S.S.R.	69	2,057	17,120	-	-	19,246
	Japan	-	-	-	-	-	*
	Poland	-	-	209	-	-	209
							19,455
1978	U.S.S.R.	184	17,320	883	-	-	18,387
	Japan	243	265	338	125	165	1,136
	ROK	61	2	-	-	-	63
							19,586
1979	U.S.S.R.	5	708	9,552	-	-	10,265
	Japan	322	8	227	11	-	568
	ROK	81	-	-	-	-	81
	Mexico	11	4	21			36
							10,950
1980	U.S.S.R.	899	90	9,484	-	-	10,473
	Japan	35	179	1,511	171	T	1,896
	ROK	736	-	-	-	-	736
	Poland	48	9	-	-	-	57
							13,162
1981	Japan	699	1,331	1,369	212	25	3,636
	ROK	2,551	11,147	46	1,066	-	14,810
	Poland	221	59	-	-	-	280
							18,726
1982	Japan	1,922	77	87	1	-	2,087
	ROK	1,241	3,431	-	-	-	4,672
							6,759
1983	Japan	1,498	1,243	65	T	-	2,806
	ROK	1,096	7,568	-	-	-	8,664
	JV	789	-	1	-	-	790
							12,260
1984	Japan	476	56	T	-	-	532
	ROK	2	2	-	-	-	4
	Poland	-	-	T	-	-	T
	JV	578	2	5	-	-	585
	U.S	31	-	-	-	-	31
							1,152
1985	Japan	T	-	-	-	-	T
	ROK	2	-	-	-	-	2
	JV	1,843	3	T	-	-	1,846
							1,848

*Reported in a category called "other species."

T: Trace ROK: Republic of Korea, JV: Joint venture.

Sources: 1974-76: Forester et al. (19830, foreign and joint venture catches 1977-84: Berqer et al. (1986), foreign and joint venture catches 1985, personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE., BIN C15700, Building 4. Seattle, WA 98115, domestic catches: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201.

Catch Data

Even without accompanying effort data, catch data can be used--to assess the general condition of stock particularly when supported by associated biological data. Note, for example, the drastic decline of the catches in the INPFC Kodiak Area--from an average 12,326 t in the period 1974-80 to an average of just 393 t in 1981-85, including a historical low of "only a trace" in 1985 (Table 2 and Fig. 1). The recent catches are indicative of the reduced biomass reported from research cruises. In 1981 the Soviet research vessel Shantar, sampling on the usually productive Albatross Bank, was unable to locate any large concentrations of Atka mackerel. Similarly, in 1982 Soviet scientists working aboard the research vessel Mys Dalniy were unable to obtain samples of Atka mackerel at the usual locations. Corroborating information was obtained in 1984 during the U.S.-Japan cooperative bottom trawl survey of the central and western Gulf of Alaska (Brown 1986). Based on the small number of Atka mackerel taken in the INPFC Kodiak Area during the 1984 survey, biomass was estimated at only 516 t (Brown 1986). Further, an extensive U.S.-U.S.S.R. cooperative groundfish survey in 1985 produced no evidence of significant numbers of Atka mackerel in the INPFC Kodiak Area.

Catch data are too sporadic in the adjacent INPFC Chirikof Area to make similar long-term comparisons. Although landings in this area remained higher than in the INPFC Kodiak Area in 1982-83, they too decreased--to only 58 t in 1984 and 3 t in 1985. Moreover, the U.S. resourcement assessment survey took no Atka mackerel in the INPFC Chirikof Area in 1984, nor did the U.S.-U.S.S.R. survey in 1985.

Catches in the INPFC Shumagin Area were stable between 2,500 and 3,500 t in 1981-83, but this was assumed to be more reflective of the Total Allowable Level of Foreign Fishing (TALFF) for the area (roughly 4,000 t) than of stock abundance. In 1984, when the foreign commercial catch in the INPFC Shumagin Area decreased to 1,087 t, the U.S.-Japan survey found Atka mackerel to be more abundant there than in the other areas--with biomass being estimated at 35,548 t, mostly in waters 100 m deep or less (Brown 1986). Only modest catches of Atka mackerel were taken during the 1985 U.S.-U.S.S.R. cooperative survey.

Length

Fish length is another criterion for studying stock condition. For Atka mackerel in the Gulf of Alaska, data from the Soviet commercial fishery (collected either by the Soviet scientists or by the U.S. Foreign Fisheries Observer Program) and supplemented by data from U.S. research cruises are the most comprehensive in this regard. These data show that the proportion of larger Atka mackerel in the INPFC Kodiak Area increased substantially between 1971 and 1977, when 80% were 28-34 cm long, and 1981 and 1985, when at least 86% were 40 cm or longer (Figs. 2 and 3). During the early years of the fishery, mean length of the samples fluctuated between 27 and 34 cm, indicating that the recruitment of young fish was consistently good. It is also noteworthy that fish 40 cm and larger were absent from the earlier (fishery) samples. The gradual increase of the mean and modal lengths and the absence of yearclass pulses at the lower margin of the length frequency curve in

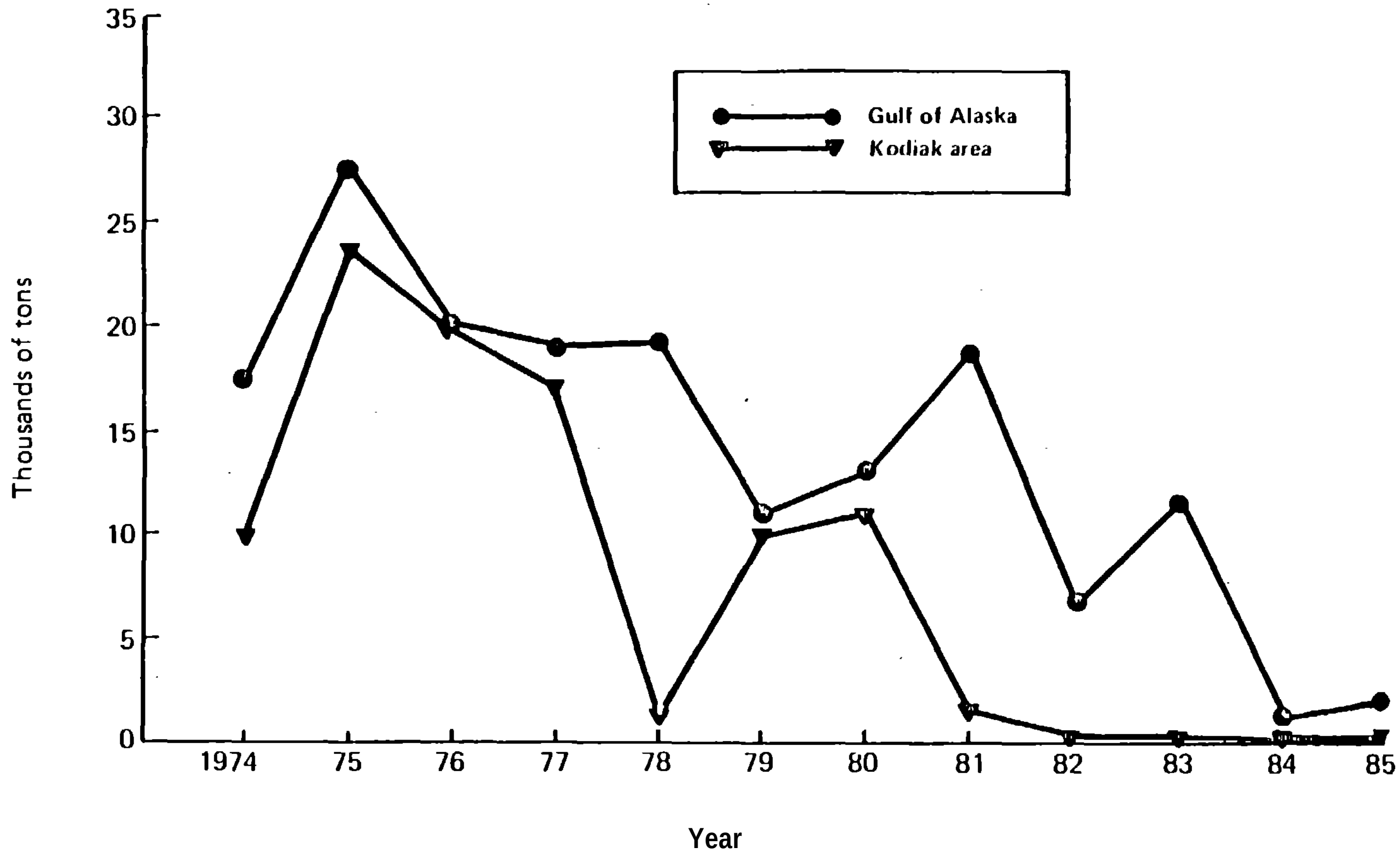

Figure 1.--Catch (t) of Atka mackerel *(Pleurogrammus monopterygius)* in the INPFC Kodiak Area and in the Gulf of Alaska as a whole, 1974-85.

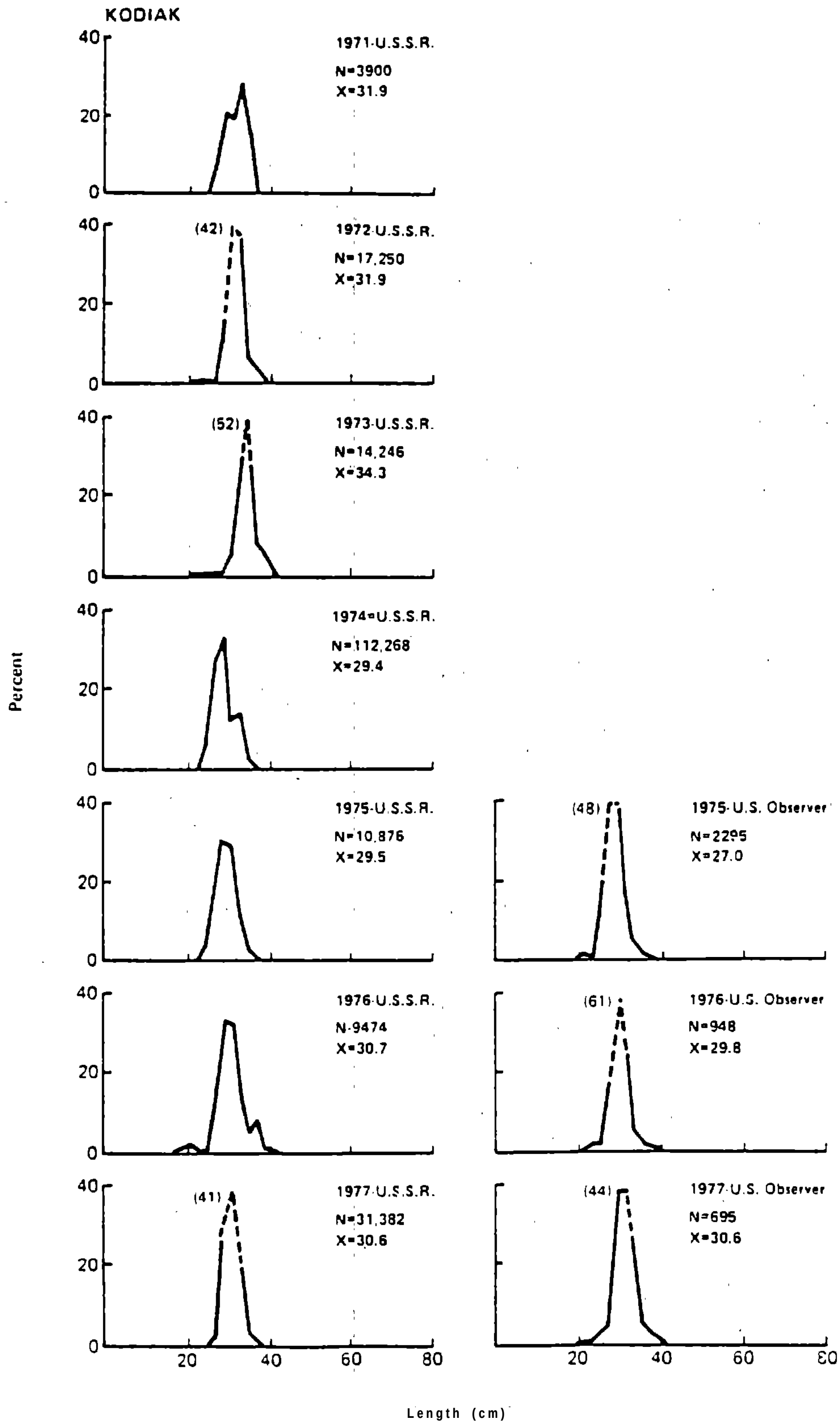

Figure 2.--Length frequency distribution of Atka mackerel (Pleurogrammus monopterygius) in the INPFC Kodiak Area, 1971-77 ~~(Soviet fishery~~ or U.S. Foreign Fisheries Observer Program data).

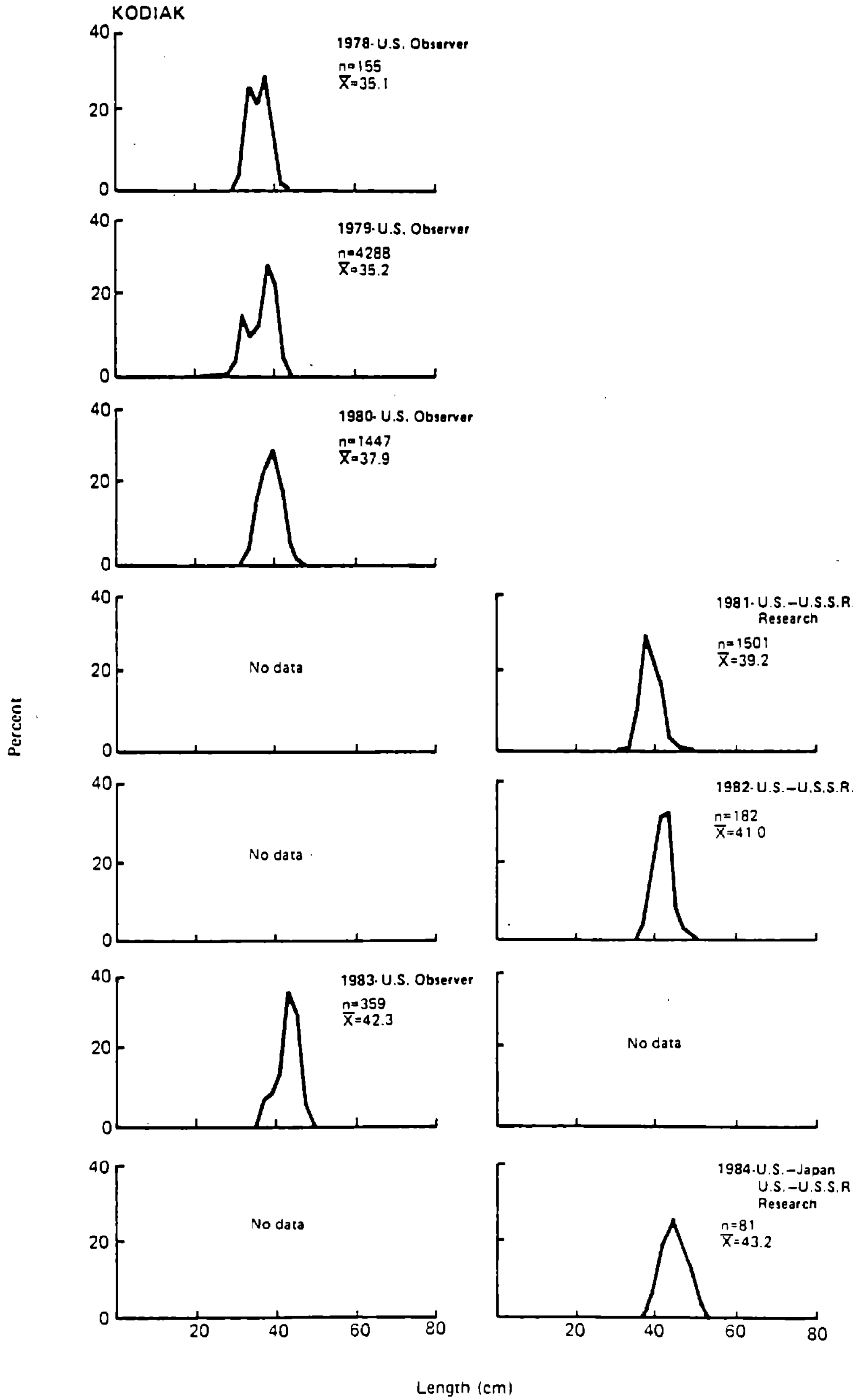

Figure 3.--Length frequency distribution of Atka mackerel (Pleurogrammus monopterygius) in the INPFC Kodiak Area, 1978-84 (U.S. Foreign Fisheries Observer Program or cooperative resource survey data).

recent years suggests that recruitment may be insufficient to maintain the stock at the high level once observed, or possibly that the recruitment processes or even the conduct of the fishery itself have changed. The weak showing of smaller fish in the 30 to 34 cm range was confirmed by data collected by U.S. scientists aboard the Soviet research vessels Shantar and Mys Dalniy in the INPFC Kodiak Area in 1981-82, data from the Japanese commercial fishery in 1983, data from the U.S. survey in 1984, and data from the U.S.-U.S.S.R cooperative survey in 1985.

Length frequency data from the INPFC Chirikof Area are available from the Observer Program for 1978 and 1981-84, from the ROK commercial harvest for 1981-84, and research surveys in 1984 (Fig. 4). In the INPFC Chirikof Area, as in the INPFC Kodiak Area, the mean length of samples taken in 1981-84 has increased. Limited recruitment is indicated in the Observer Program data in 1982 and 1983, but not in 1984, nor in the ROK fishery samples. In 1984, both the observer and research data show a bimodal length frequency distribution, with modes at 39-42 and 45-47 cm.

Samples for the INPFC Shumagin Area are available from the U.S. Foreign Fisheries Observer Program in 1980-84, the ROK commercial fishery in 1981-83 (Fig. 51, the U.S.-U.S.S.R research surveys in 1982-85, and the joint venture fisheries-- U.S.-ROK (1983 and 1985) and U.S.-U.S.S.R. (1985) (Fig. 6). These display increasing mean lengths from 1980 to present. The observer data and ROK commercial fishing data indicate some recruitment in 1982, while the research surveys and the joint venture fishery data indicate additional recruitment in 1983-85.

Age

Age composition is another commonly used indicator for studying stock condition. However, because ages determined by Soviet scientists using scales differ from those obtained by U.S. scientists using otoliths (Levada 1979a; Levada 1979b; and Fadeev and Kharin 1981), the data offer first approximations at best.

Limited age samples are available for Atka mackerel in the INPFC Kodiak Area. Observer samples were collected in 1978 and 1980 and resource assessment survey samples in 1982 and 1984.

Because most spawning in the Kodiak Area is completed by October (Fadeev and Kharin 1981) and the incubation period lasts 31-45 days, November 1 has been selected as the birthday for the cohorts. Based on this criterion, the available age data indicate that since 1979 the stock in the Kodiak Area has been dominated by the strong 1975 and 1977 year classes (Fig. 7).

Although the later samples,(1982 and 1984) are quite small because of the low abundance of Atka mackerel in the survey area, they show, nonetheless, that the 1975 and 1977 year classes are well represented. These data do not indicate that there has been any substantial recruitment in the Kodiak Area in recent years.

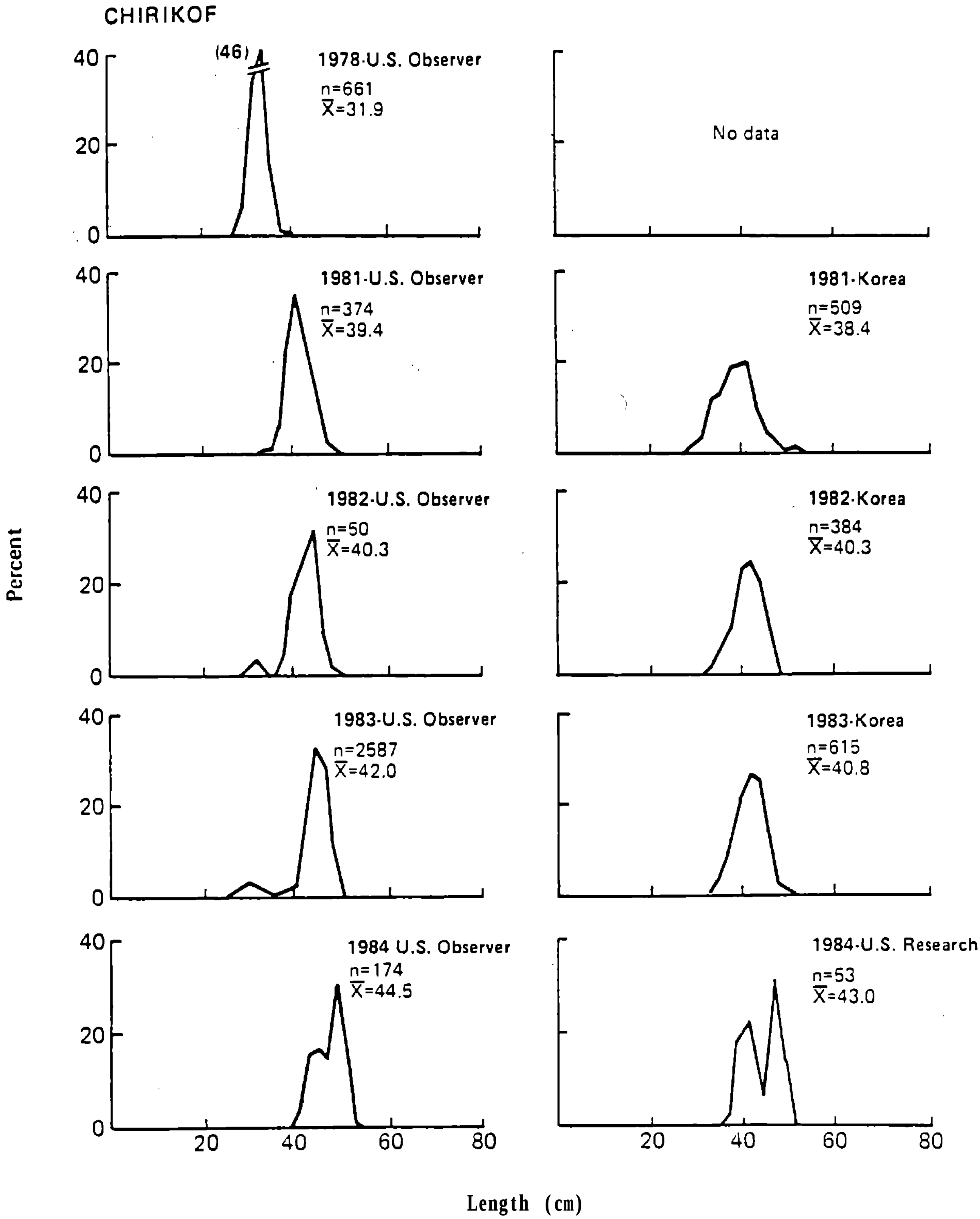

Figure 4.--Length frequency distribution of Atka mackerel (Pleurogrammus monopterygius) in the INPFC Chirikof Area, 1978-84 (U.S. Foreign Fisheries Observer Program or Republic of Korea fishery).

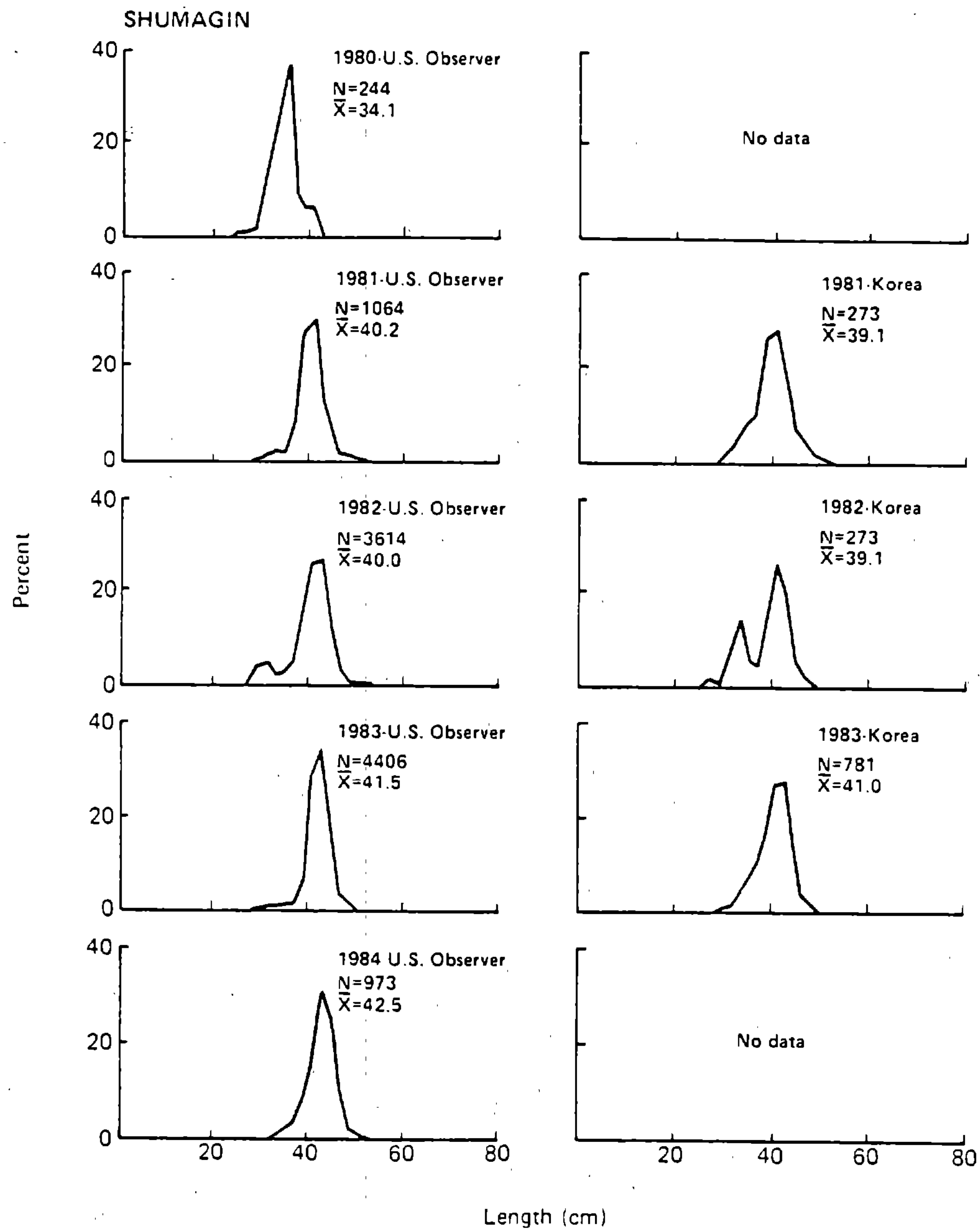

Figure 5.--Length frequency distribution of Atka mackerel (*Pleurogrammus monopterygius*) in the International North Pacific Fisheries Commission Shumagin Area, 1980-84 (U.S. Foreign Fisheries Observer Program or Republic of Korea fishery data).

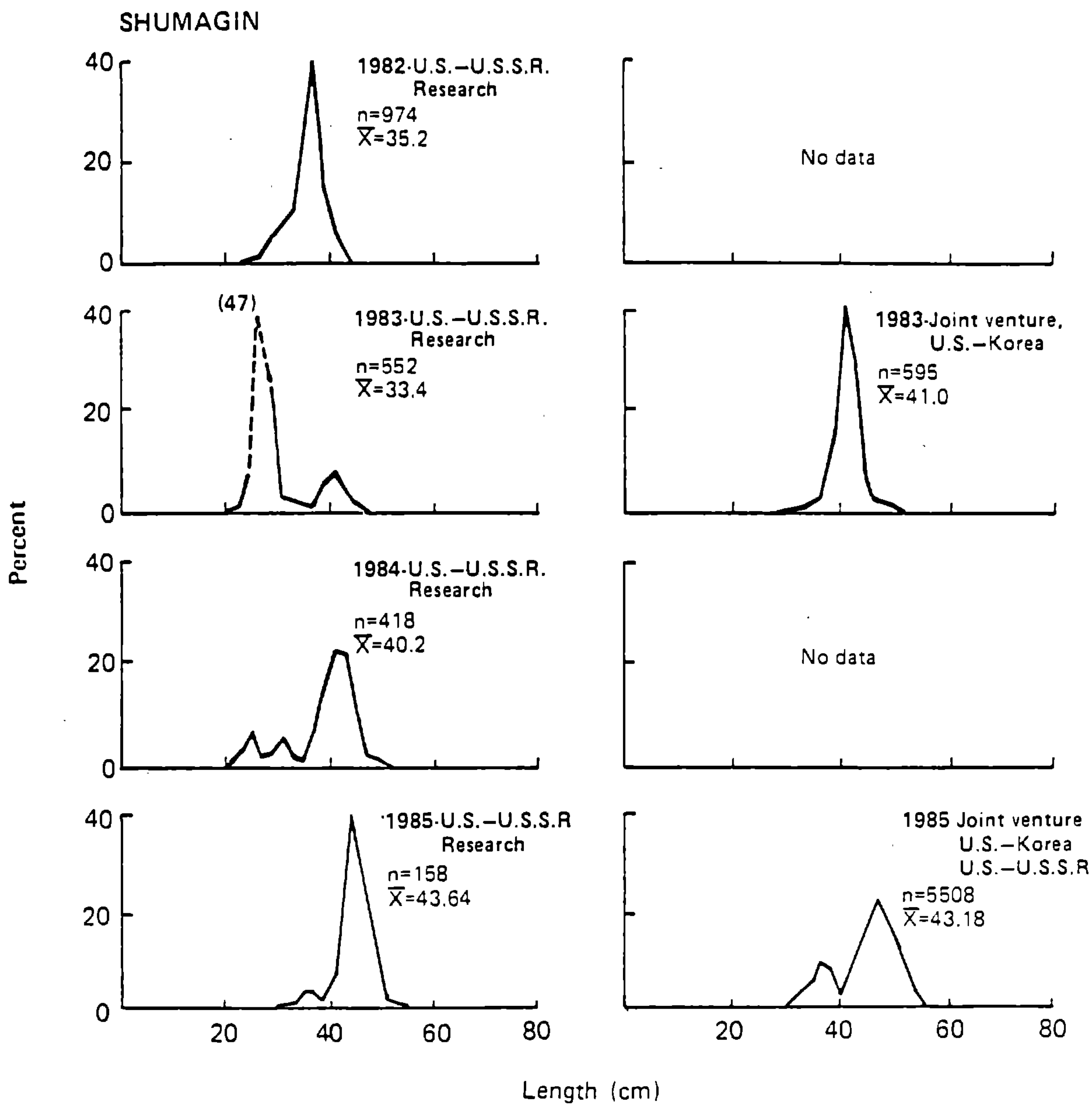

Figure 6.--Length frequency distribution of Atka mackerel (Pleurogrammus monopterygius) in the INPFC Shumagin Area, 1980-85. (U.S.-U.S.S.R research or joint venture fishery data.)

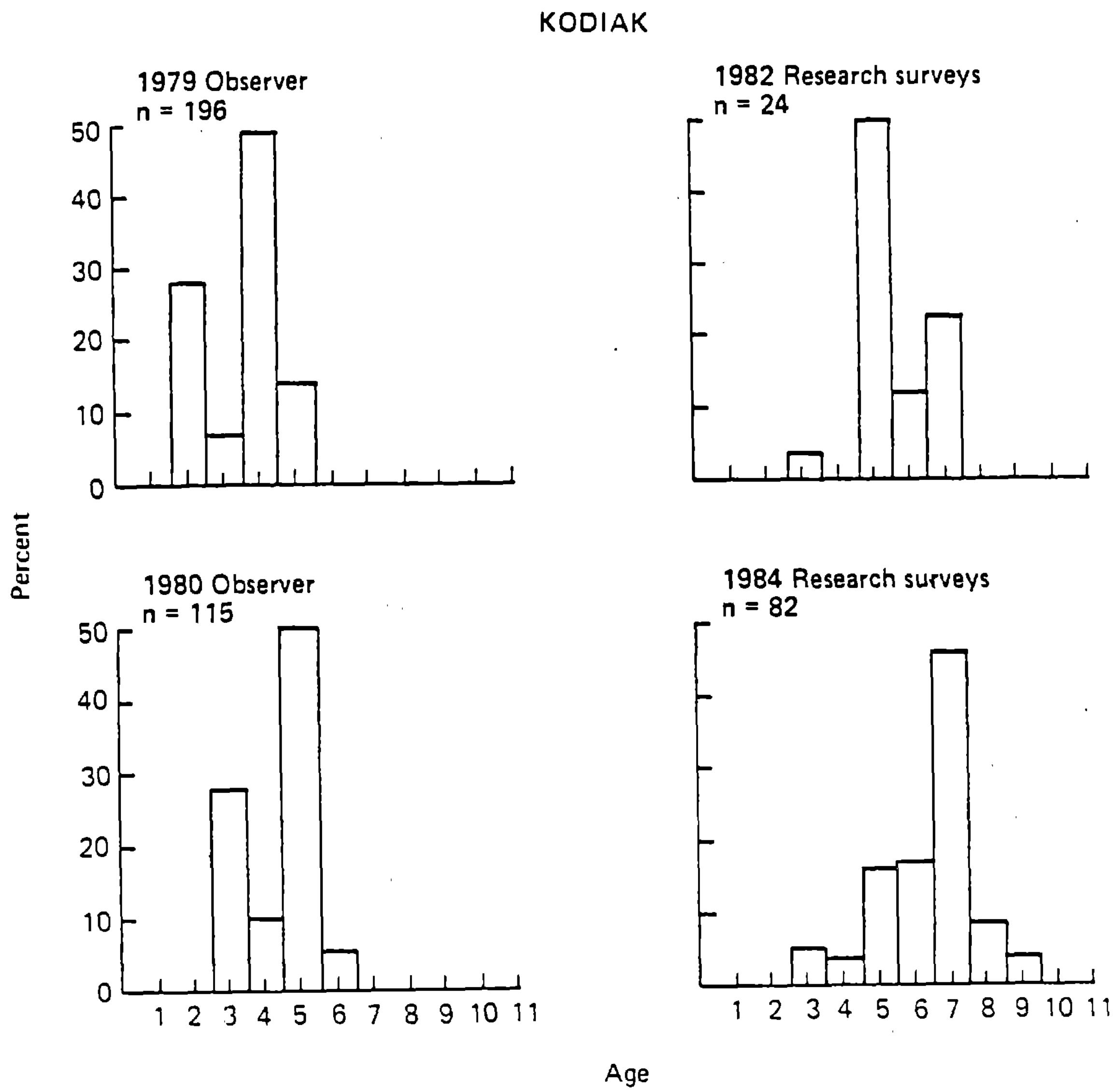

Figure 7.--Age composition of Atka mackerel (*Pleurogrammus monopterygius*) in the INPFC Kodiak Area, 1979, 1980, 1982, and 1984 (U.S. Foreign Fisheries Observer Program or cooperative resource survey data).

Only one age sample, resource survey 1984, is available for Atka mackerel from the INPFC Chirikof Area. These data show that, among the older age groups, the 1977 year class was also dominant in the Chirikof Area. Significantly, the data also indicate that there has been substantial recruitment in this area (Fig. 8).

There are two age samples from the INPFC Shumagin Area--one from the 1982 resource assessment surveys and another from the 1984 Observer Program collections. The data reveal that the 1977 year class was very dominant in the area and that, although recruitment has generally been low, the 1982 year class is well represented (Fig. 8).

POTENTIAL YIELD

Estimates of Maximum Sustainable Yield

Maximum sustainable yield (MSY) is an average, over a reasonable length of time, of the largest catch which can be taken continuously from a stock under current environmental conditions. It normally is presented with a range of values around its point estimate.

Early estimates of MSY necessarily were based on rather vague information and assumptions. Soviet hydroacoustic surveys in the Aleutian Islands area in 1977 found eight concentrations of Atka mackerel with an estimated biomass of 110,000 t. Trawl surveys indicated a biomass thought to be as large in the Gulf of Alaska. Most of the fish available to the trawls were 30 cm or longer-mature fish older than 3 or 4 years. On the basis of analyses of biological characteristics, Soviet scientists believed that 30% of the adult stock could safely be harvested. Accordingly, MSY for Atka mackerel in the Gulf of Alaska was set at 33,000 t (North Pacific Fishery Management Council 1984).

In 1979 Soviet scientists conducted the first hydroacoustic and trawl survey of the western Gulf of Alaska between 148 and 164° W. long. (Fadeev 1979). Their estimate of the biomass of Atka mackerel (32,447 t) became 95,552 t when extrapolated to the entire Gulf of Alaska, including the unsurveyed areas east of 148° W. long. This agreed reasonably well with the estimated biomass of 110,000 t that had been projected on the basis of the Aleutian survey. Subsequently, however, commercial fishing operations and resource assessment surveys have shown that Atka mackerel are not highly abundant in the Gulf of Alaska east of 148° W. long. as was assumed by the Soviet scientists. It is likely, therefore, that the 32,447 t estimated to inhabit the area west of 148° W. long; is closer to the gulf-wide biomass than the extrapolated estimate of 110,000 t.

Efimov (1984) tried a second approach. Employing a surplus production model based on fishery data to circumvent problems with age determination, he estimated that between 1976 and 1979 biomass ranged from 69,210 to 89,167 t (Table 3) and that the MSY of harvestable fish, age 3 to 8 years, was 28,300 t.

It is appropriate to note, however, that the MSY of 28,300 t calculated by Efimov was based on years when biomass was high, as indicated by the limited

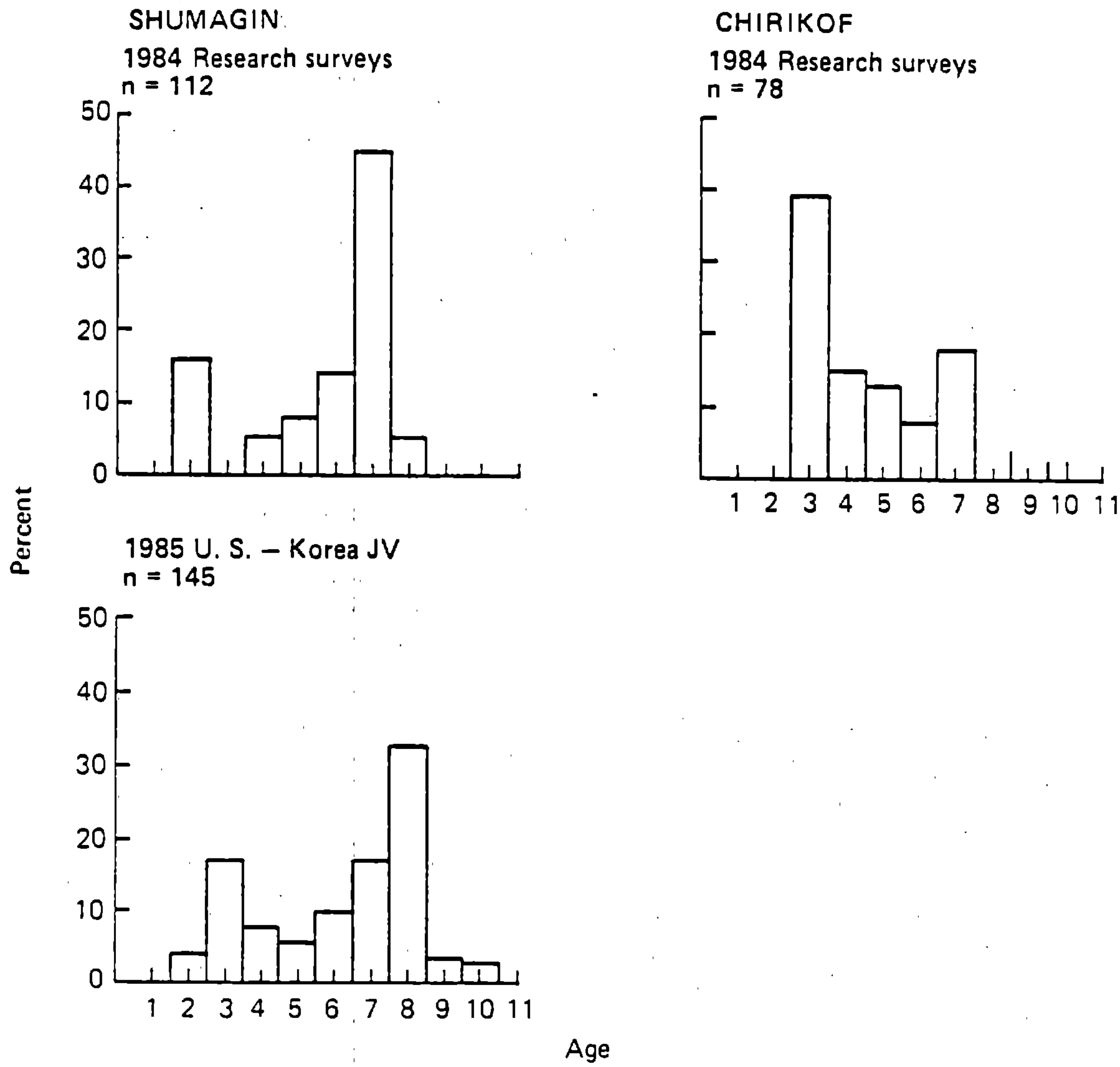

Figure 8.--Age composition of Atka mackerel in the INPFC Shumagin Area (1984-85) and the INPFC Chirikof Area (1984).

Table 3.--Mean catch per unit effort (CPUE), estimated biomass, and mean length of Atka mackerel (*Pleurogrammus monopterygius*) in the in the Gulf of Alaska, 1971-80.

Year	Mean CPUE (t/h)	Biomass (t)	Mean length (cm)
1971	-	-	31.9
1972	-	-	31.9
1973	-	-	34.3
1974	-	-	29.4
1975	1.5	69,210	29.5
1976	2.0	80,128	30.7
1977	2.2	84,354	30.6
1978	2.3	88,286	35.1
1979	2.5	89,167	35.2
1980	1.9	-	38.0

Sources: Mean CPUE 1975-79: Efimov (1984); 1980: Fadeev and Kharin (1981). Biomass: Efimov: (1984). Mean length 1971-77: Levada (1979b); 1978 and 1979: personal communcation with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE., Bin C15700, Building 4, Seattle, WA 98115; and 1980: Fadeev and Kharin (1981).

CPUE data available (Table 3) and the previously discussed stability of the mean and modal lengths of fish in the commercial catch, rather than over a long span of years.

The MSY also can be estimated using the equation developed by Alverson and Pereyra (1969) and modified by Gulland (1969):

$$MSY = a\ M\ B_o$$

where

a = constant 0.4 (Gulland) or 0.5 (Alverson and Pereyra),
M = instantaneous natural mortality rate, and
B_o = virgin biomass.

Using the values (a) = 0.4 and (M) = 0.6 (Efimov 1984) with Efimov's minimum biomass estimate (B_o) of 69,210 t, a conservative MSY of 16,610 t can be calculated for 3- to 5-year-old fish. Similarly, MSY of 26,750 t can be obtained using (a) = 0.5 and (M) = 0.6 with Efimov's maximum biomass estimate (B_o) of 89,167 t. The average of the two estimates is 21,680 t.

If, however, the biomass estimate (B_o) of the western gulf (36,100 t, rounded from Brown 1986) is used in conjunction with (a 1 values of 0.4 or 0.5 and (M) = 0.6, MSY is estimated at 7,220 and 8,664 t, respectively.

Levada (1979b) reported that Atka mackerel were only found in small numbers in the commercial catches of the Gulf of Alaska before 1970, and that they occurred only in small numbers on the important Albatross and Portlock Banks prior to 1976. Within a year, however, there were large commercial catches in these areas. One interpretation may be that Atka mackerel have not always occurred in commercial concentrations in the Gulf of Alaska and that the large catches and biomass estimates of the 1970's may reflect a "population explosion" and an accompanying geographic expansion of the stock. Based on this hypothesis, estimates of long-term MSY would be lower than any of those computed above.

Estimates of Equilibrium Yield

Equilibrium yield (EY) is the annual or seasonal harvest which maintains the resource at approximately the same level of abundance (apart from the effects of environmental variation) in succeeding seasons or years. It is usually less than MSY because abundance is normally not at the level which produces MSY.

From 1977 to 1984, the EY was set equal to the 33,000 t MSY that had, in turn, been derived from the early Soviet work (NPFMC 1984). By 1984, however, the decline of the catch in the historically important INPFC Kodiak Area and the apparent low recruitment indicated that MSY was no longer attainable and that EY should be set lower than MSY (Ronholt 1985). Based on updated information on the condition of the stock, MSY was reestimated at 7,800 t (the lower end of the range of estimates described earlier).

Estimates of Optimum Yield

The optimum yield (OY), after having been set at 87% of EY (28,700 t) in 1977-84, was determined by a new rationale for the 1985 fishing season. Noting the apparent-collapse of the stock based on information presented by Ronholt (1985)(specifically, sharply declining catches, the westward shift in distribution, and weak recruitment), the NPFMC sought to set OY as near to zero as was practical to allow the continued operations of the domestic, joint venture, and foreign fisheries. The OY was set at 4,678 t in the NPFMC Western Regulatory Area (INPFC Shumagin Area), the same as in previous years, but reduced to 500 t and 100 t in the Central and Eastern Regulatory Areas. The latter amounts were intended to provide enough Atka mackerel for by-catch to allow fisheries targeting on other species to continue.

RECOMMENDATION

Based on the latest data--the continued decline of the commercial catches, low abundance as indicated by the resource assessment surveys, and the apparent lack of recruitment --it is recommended that OY again be held at a low level for the 1987 fishing season.

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AGE COMPOSITION AND RECRUITMENT TRENDS OF
PACIFIC OCEAN PERCH OFF SOUTHEASTERN ALASKA
IN 1984 AND 1986

by

John F. Karinen[1/] and Bruce L. Wing[1/]

INTRODUCTION

The abundance of Pacific ocean perch (Sebastes alutus) was last estimated from data collected in the 1984 Gulf of Alaska triennial survey (Carlson et al. 1986). No systematic trawl surveys for groundfish (including S. alutus) were made in 1985 and 1986. The next major trawl survey in the Gulf of Alaska is scheduled for the summer of 1987.

An effort to determine age composition of S. alutus off southeastern Alaska was made from samples collected in April-May 1984 (Carlson et al. 1986). A sample of 1,148 otoliths from S. alutus aged by the "break and burn" method showed ages ranging from 5 to 74 years, with the 1976 year class (as 8-year-olds) constituting over 55% of the sample. This was the first indication of a strong year-class recruitment of 2. alutus in recent years. Therefore an effort, albeit small, was made in 1986 to determine whether the 1976 year class was still dominant in the S. alutus stock of southeastern Alaska.

METHODS

Rockfish were trawled at four locations in January-February 1986 by the NOAA research vessel Miller Freeman using an 83-112 otter trawl equipped with roller gear. Each tow was set for 0.5 hour bottom time at trawl depths varying from 190 to 527 m. The trawling sites off Cape Cross, Kruzof Island, Whale Bay, and Cape Onunaney were the approximate locations trawled in 1984 by Carlson et al. (1986). Only a limited effort was possible because of commitments to the sablefish (Anoplopoma fimbria) spawning and life history survey objectives. Sebastes alutus, a minor component of the rockfish catches, were separated from the catch, measured, and sexed, and otoliths were taken from each individual. Fork length was rounded to the nearest cm. Age determinations were done by the ageing unit at the Northwest and Alaska Fisheries Center, Seattle, Washington, using the "break and burn" method.

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RESULTS

Of 130 S. alutus collected, 124 yielded ageable otoliths: 86 wifhin the range of-interest (3-40 years); 38 at more than 40 years. Because these data showed some similarity to the age composition reported for the larger 1984 sample, and because some interesting correlations appeared to exist between strong year-class groups and periods of warming in the northeastern Gulf of Alaska, we elected to report on these few samples and compare them with the 1984 age data for S. alutus.

The length of S. alutus taken at the four trawl stations ranged from 23 to 40 cm. There-was a strong mode at 37 cm and minor modes at 28 and 31 cm (Fig. 1). These length modes may correspond to modes in the age distribution (Fig. 2). Fish aged as 6- and 8-year-olds may contribute most of the individuals in the 28 and 31 cm length modes, whereas fish over 10 years old probably contribute to the 37 cm mode. Length-age correlations within the rockfishes are highly variable, and within our samples length was a poor estimator of age for fish older than 10 years (Fig. 3). Sixty-three percent of the 1986 sample were 5-10 years of age and 25-36 cm in length.

DISCUSSION

Larger year classes of S. alutus in the 1984 catches (Table 1) and the 1986 catches (Table 2) are grouped over the same general range of years. The 1984 data have relatively strong year classes: 1945, 1948, 1950, 1952-56, 1958, 1972, and 1974-78. The 1986 data have a similar trend with some exceptions; relatively strong year classes represented were 1948, 1950, 1952-56, 1968-70, 1972, and 1976-81. The fact that many of the same year classes are represented in the small sample from 1986 lends support to the idea that these years supported relatively strong year classes of S. alutus.

Environmental data available from published literature are listed in Tables 1 and 2 opposite the years of occurrence. These data show: 1) positive, normal, or negative temperature anomalies of the near-surface water column (O-200 m) at index site GOA 1 since 1975 and from stations near the sampling sites for 1950-60; 2) positive, normal, or negative temperature anomalies of sea-surface temperature for the Bering Sea; 3) incidence of strong El Nino years in the North Pacific Ocean; and 4) years when the Sitka Eddy (Tabata Eddy) was noted to be absent or present. Where data are available, a positive correlation apparently exists between warm-water years and relatively strong year classes of S. alutus. The best correlation appears to be with the temperature anomaly of the upper 200 m of the water column in the eastern Gulf of Alaska. A detailed statistical analysis of this apparent correlation will be attempted following the collection and ageing of a large number of otoliths in 1987.

In recent years, especially 1977 and 1983, three factors--a strong El Nino, positive temperature anomalies, and the presence of a Sitka Eddy--co-occurred. Fish from the 1983 year class will not be available to nets of the trawl surveys until 1987 or 1988, but 1976 and 1977 both

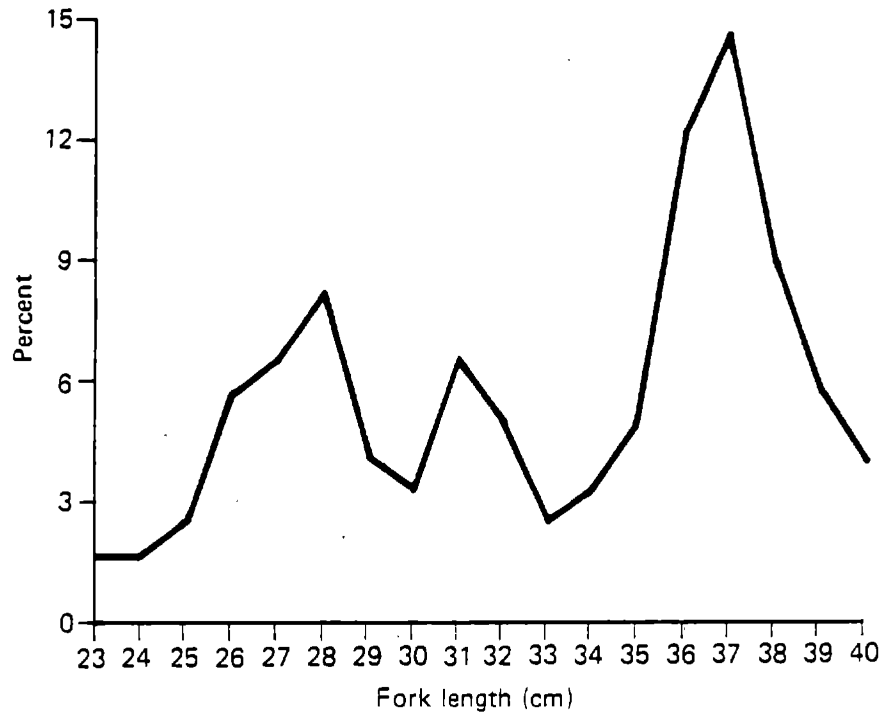

Figure 1 .--Length composition of Sebastes alutus collected January-February 1986 off the southeastern Alaska (N = 130).

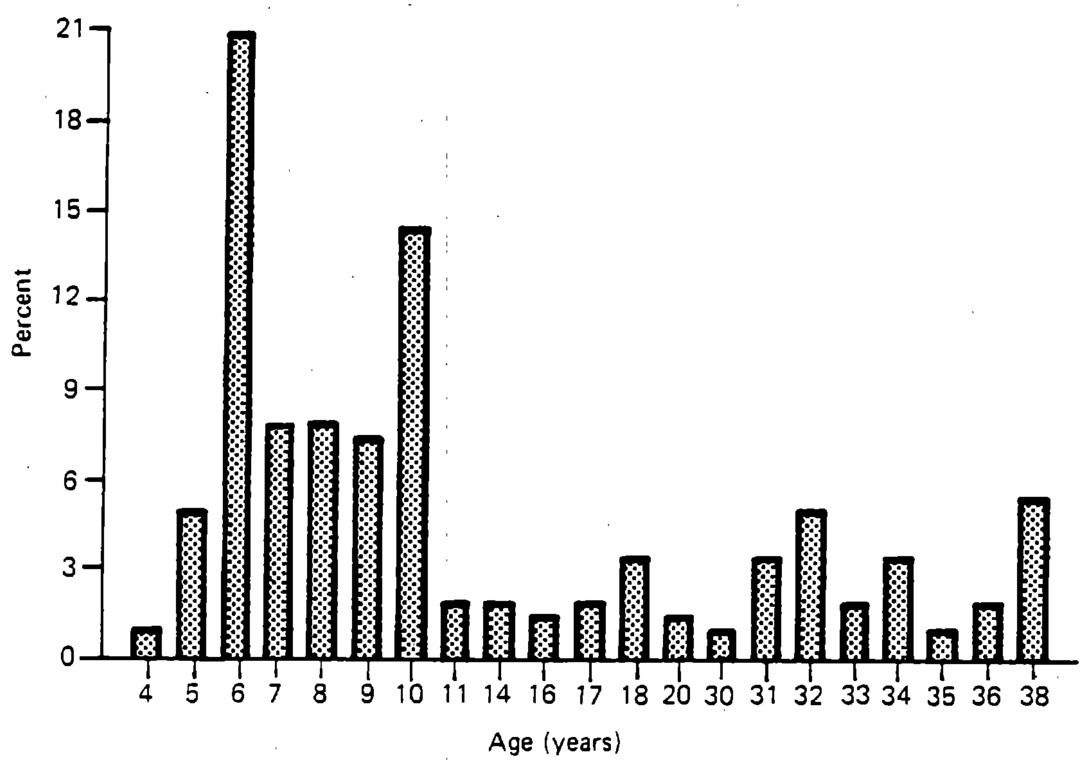

Figure 2.--Age composition of Sebastes alutus less than 40 years old collected January-February 1986 off southeastern Alaska (N = 86).

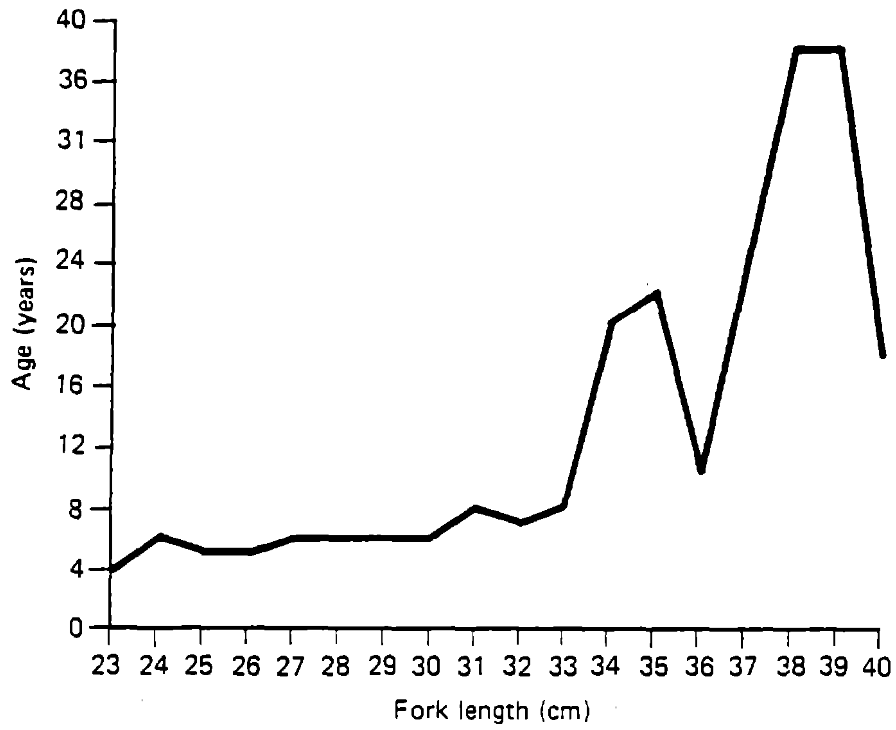

Figure 3.--Mean age at length of Sebastes alutus less the 40 years old collected January-February 1986 off southeastern Alaska (N = 86).

Table 1.--Age composition of S. alutus in the Gulf of Alaska (GOA) sampled April-May 1984 and environmental conditions of the year producing each year class. In the temperature anomalies, (+) equals above the long-term mean, (0) equals the mean, and (-)equals below the long-term mean.

				Temperature anomaly			
Year class	Age	No.	Percent of total	GOA	Bering	El Nino present	Sitka Eddy present
1979	5	5	0.4	+	+		
1978	6	10	0.9	+	+		
1977	7	125	10.9	+	+	yes	yes
1976	8	634	55.2	+	-		
1975	9	25	2.2	-	-		
1974	10	14	1.2	+*	-		
1973	11	5	0.4	-*	-		
1972	12	12	1.1	-*	-		
1971	13	5	0.4	-*	-		
1970	14	4	0.4	?*	+		
1969	15	3	0.3	-*	0		
1968	16	5	0.4	+*	+		
1967	17	6	0.5	+*	+		no
1966	18	5	0.4	?*	+		
1965	19	3	0.3	-*	+		
1964	20	0	-	+*			
1963	21	1	0.1	+*			
1962	22	2	0.2	?*			no
1961	23	0	-	+*			yes
1960	24	7	0.6	+*			yes
1959	25	5	0.4	+		yes	no
1958	26	13	1.1	+		yes	yes
1957	27	6	0.5	+			no
1956	28	10	0.9	-			no
1955	29	17	1.5	+			??
1954	30	15	1.3	+			yes
1953	31	22	1.9	+			
1952	32	22	1.9	+			
1951	33	6	0.5	-			
1950	34	13	1.1	+			
1949	35	9	0.8	-*			
1948	36	11	1.0	+*			
1947	37	4	0.4	+*			
1946	38	4	0.4	?*			
1945	39	11	1.0	?*			

Table 1 .--Continued.

Year class	Age	No.	Percent of total	Temperature anomaly GOA	Temperature anomaly Bering	El Nino present	Sitka Eddy present
1944	40	6	0.5	+*			
1943	41	5	0.4	+*			
1942	42	7	0.6				
1941	43	7	0.6			yes	
1940	44	4	0.4			yes	
1939	45	3	0.3				
1938	46	1	0.1				
1937	47	6	0.5				
1936	48	5	0.4				
1935	49	4	0.4				
1934	50	1	0.1				
1933	51	7	0.6				
1932	52	4	0.4				
1931	53	6	0.5				
1930	54	4	0.4				
1929	55	6	0.5				
1928	56	3	0.3				
1927	57	4	0.4				
1926	58	1	0.1				
1925	59	1	0.1	-*			
1924	60	3	0.3				
1923	61	6	0.5				
1922	62	1	0.1				
1921	63	0	-				
1920	64	1	0.1				
1919	65	3	0.3				
1918	66	1	0.1				
1917	67	2	0.2				
1916	68	1	0.1				
1915	69	3	0.3				
1914	70	1	0.1				
1913	71	0	-				
1912	72	1	0.1				
1911	73	0	-				
1910	74	1	0.1				

Total (all year classes and ages): No. = 1,148; percent = 100.5.

*Preliminary data based on Sitka sea-surface temperatures.

Sources: Age data: Carlson et al. (1986); GOA temperature anomaly data 1950-59: Favorite and McLain (1972); GOA temperature anomaly data 1975-79: Royer (1985); Bering Sea temperature anomaly data: Niebauer (1985); El Nino presence: Cannon et al. (1985); Sitka Eddy presence: Mysak (1985).

Table 7.--Age composition of S. alutus from the Gulf of Alaska (GOA) sampled January-February 1986 and environmental conditions of the year producing each year class. In the temperature anomalies (+) equals above the the long-term mean, (0) equals the mean, and (-) equals below the long-term mean.

Year class	Age	No.[a]	No.[b]	Percent of total[a]	Percent of total[b]	Temperature anomaly GOA	Temperature anomaly Bering	El Nino present	Sitka Eddy present
1983	3	1	1	1.2	0.8	+	-	yes	yes
1982	4	1	1	1.2	0.8	-	+		
1981	5	6	6	7.0	4.8	+	0		
1980	6	26	26	30.2	20.6	+	+		
1979	7	10	10	11.6	7.9	+	+		
1978	8	10	10	11.6	7.9	+	+		
1977	9	10	10	11.6	7.9	+	+	yes	yes
1976	10	3	18	3.5	14.3	+	-		
1975	11	1	2	1.2	1.6	-	-		
1974	12	0	0	-	-	+[c]	-		
1973	13	0	0	-	-	-[c]	-		
1972	14	1	3	1.2	2.4	-[c]	-		
1971	15	0	0	-	-	-[c]	-		
1970	16	1	2	1.2	1.6	?[c]	+		
1969	17	1	3	1.2	2.4	-[c]	0		
1968	18	2	4	2.3	3.2	+[c]	+		
1967	19	0	0	-	-	+[c]	+		no
1966	20	1	2	1.2	1.6	?[c]	+		
1965	21	0	0	-	-	-[c]	+		
1964	22	0	0	-	-	+[c]			
1963	23	0	0	-	-	+[c]			
1962	24	0	0	-	-	?[c]			no
1961	25	0	0	-	-	+[c]			yes
1960	26	0	0	-	-	+[c]			yes
1959	27	0	0	-	-	+			no
1958	28	0	0	-	-	+		yes	yes
1957	29	0	0	-	-	+		yes	no
1956	30	1	1	1.2	0.8	-			no
1955	31	2	4	2.3	3.2	+			??
1954	32	3	6	3.5	4.8	+			yes
1953	33	1	2	1.2	1.6	+			
1952	34	2	4	2.3	3.2	+			
1951	35	1	1	1.2	0.8	-			
1950	36	1	3	1.2	2.4	+			
1949	37	0	0	-	-	-[c]			
1948	38	1	7	1.2	5.6	+[c]			
Totals		86	126	100.3	100.2				

[a]Number aged by otolith.

[b]Number aged by otolith plus un-aged fish allocated to an age group on the basis of length.

[c]Preliminary data based on Sitka sea-surface temperatures.

Sources : GOA temperature anomaly data 1950-59: Favorite and McLain (1973): GOA temperature anomaly data 1975-79: Royer (1985), Bering Sea temperature anomaly data: Niebauer (1985), El Nino presence: Cannon et al. (1985), Sitka Eddy presence: Mysak (1965).

produced fairly strong year classes. The large numbers of fish captured from ages 5 to 10 could be an artifact of sampling and simply represent availability of these year classes before extensive fishing mortality and predation affect them; however, the group of fish in year classes 1952-58 and the correlationwith positive temperature anomalies appear to support the hypothesis that temperature is an influencing factor of S. *alutus* year-class strength and survival.

Earlier reports on oceanography and fish biology support the hypothesis that thermal conditions influence year-class strengths. Favorite and McLain (1973) reported a correlation between warm years and strong year classes 'of Pacific herring (*Clupea harengus pallasi*) between 1952 and 1958, and other researchers (e.g., Bailey and Incze 1985) have alluded to a positive correlation between positive temperature anomalies and S. *alutus* recruitment. If this correlation is real (which needs to be confirmed by further data collection), then one may expect that 1983 was a banner year for S. *alutus* recruitment. Hopefully, we will be able to discern this within 2 or 3 years.

The question of whether 1976 was a good recruitment year, as indicated by the 1984 data, is not succinctly borne out by the limited 1986 age data (only three fish were aged as being from the 1976 year class). However, when these three lo-year-old fish were supplemented by the 18 fish "aged" on the bases of length (Table 2) the 1976 year class appears to be strong. The inclusion of the 18 supplemental samples and the variability associated with the ageing process itself, and the desperate distributions of S. *alutus* suggest, however, that the conclusion that the 1976 year class is a-strong one be accepted with caution at this time. Clearly, additional sampling is required.

Nonetheless, it is suggested by the overall package of data presented in this report that if the present warming trend in the North Pacific Ocean (Royer 1985) continues, we may expect a sequence of relatively stronger year-class recruitments for S. *alutus* in the near future.

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PACIFIC OCEAN PERCH

by

John F. Karinen[1] and Bruce L. Wing[1]

INTRODUCTION

The last major trawl efforts to assess the condition of the Pacific ocean perch complex (Sebastes alutus and four congeneric species) in the Gulf of Alaska were the 1981 and 1984 triennial surveys (Shippen 1985). Data from these surveys were presented and discussed in status of stock documents (Shippen 1985; Carlson et al. 1986). Historical background is included in both documents.

The Pacific ocean perch complex remains in a depressed condition, but it is probable that recent recruitments will improve the stocks within a few years (Carlson et al. 1986; Karinen and Wing (another chapter, also on Pacific ocean perch) in this report). This paper summarizes and updates important portions of the discussions in Shippen's and Carlson's papers relating to fishery statistics, management actions, condition of the stock, and age composition. As the terms are used here, "Pacific ocean perch" and "Pacific ocean perch complex" refer to the five-species assemblage, while S. alutus refers to the single species.

FISHERY STATISTICS

History of the Fisheries

Commercial fishing for Pacific ocean perch began in the late 1940s in the Pacific Northwest (Major and Shippen 1970). Foreign trawl fisheries in the Gulf of Alaska began with Soviet fleets in the early 1960s, followed by those of Japan in 1963, and the Republic of Korea (ROK) in 1966 (Chitwood 1969). Massive efforts, primarily by the Soviets and Japanese, produced a peak catch of 348,598 metric tons (t) of rockfish in 1965--mostly 5. alutus. By 1977, annual catches were down to 23,453 t and, except for short-term increases, they continued to decline thereafter (Carlson et al. 1986).

Current Catches

The 1985 all-nation catch of Pacific ocean perch in the Gulf of Alaska was 1,087 t (Tables 1 and 2). This was 24% of the 1984 catch and reflects a continuing decline in Pacific 'ocean perch allocations by the North Pacific

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Table 1.--Catch, acceptable biological catch (ABC), and optimum yield (OY) (all t) of Pacific ocean perch in the Gulf of Alaska, by North Pacific Fishery Management Council regulatory area, 1977-85.

Year	Area				Gulf-wide management value	
	Western	Central	Eastern	Total	ABC	OY
1977	6,282	6,166	11,005	23,453	50,000	30,000
1978	3,643	2,024	2,509	8,176	50,000	25,000
1979	945	2,501	6,475	9,921	50,000	25,000
1980	841	4,012	7,618	12,471	50,000	25,000
1981	1,234	4,275	6,675	12,184	50,000	29,167
1982	1,746	6,228	17	7,991	50,000	11,475
1983	2,612	4,775	18	7,405	50,000	11,475
1984	1,771	2,678	3	4,452	6,944	11,475
1985	848	58	181	1,087	6,500	6,083

Sources: Catch data 1977-84: Carlson et al. (1986); 1985: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 308 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201.

Table 2.--Catch (t) of Pacific ocean perch in the Gulf of Alaska, by fishery category and North Pacific Fishery Management Council regulatory area, 1981-85.

Year	Fishery category	Area Western	Central	Eastern	Total
1981	Foreign	1,233	4,268	6,675	12,176
	U.S.	0	7	0	7
	JV	1	0	0	1
	Total	1,234	4,275	6,675	12,184
1982	Foreign	1,746	6,223	17	7,986
	U.S.	0	2	0	2
	JV	0	3	0	3
	Total	1,746	6,228	17	7,991
1983	Foreign	671	4,726	18	5,415
	U.S.	7	8	0	15
	JV	1,934	41	0	1,975
	Total	2,612	4,775	18	7,405
1984	Foreign	214	2,385	0	2,599
	U.S.	116	0	3	119
	JV	1,441	293	0	1,734
	Total	1,771	2,678	3	4,452
1985	Foreign	6	2	0	8
	U.S	631	13	181	825
	JV	211	43	0	254
	Total	848	58	181	1,087

JV: Joint venture.

Sources: 1981-84: Carlson et al. (1986); 1985: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201.

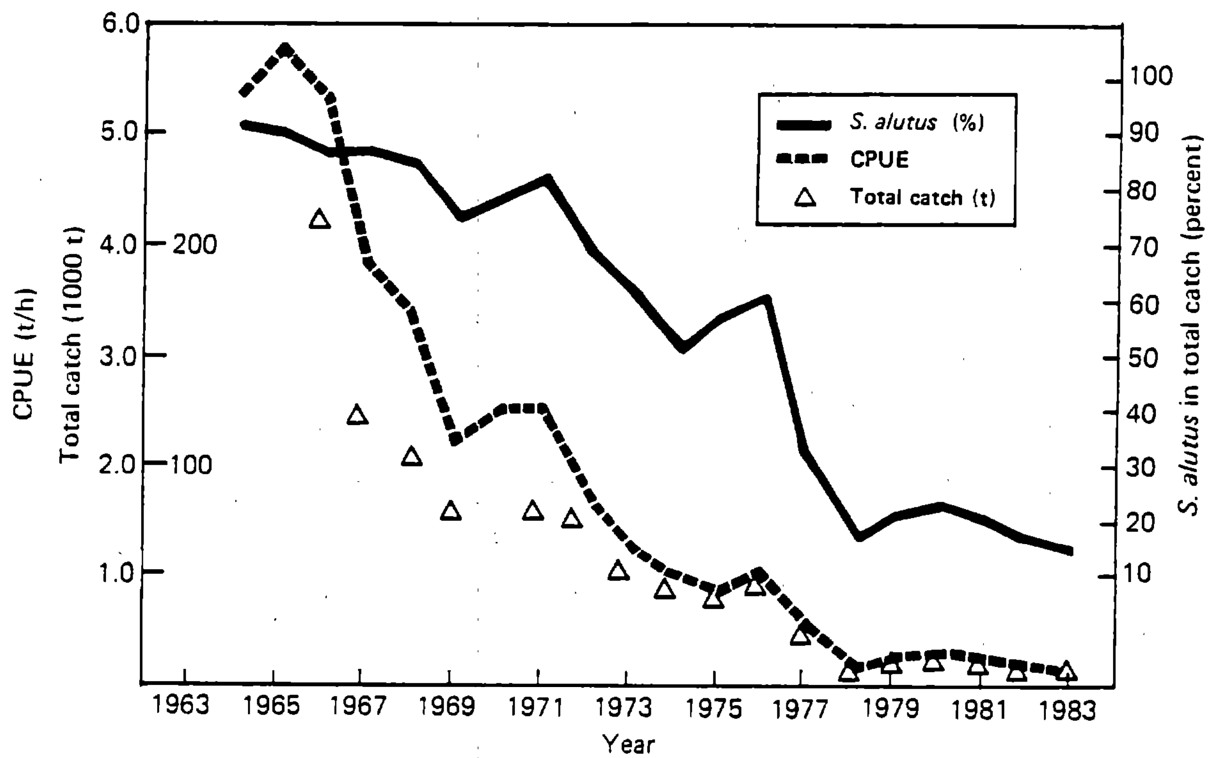

Figure 1 .--<u>Sebastes alutus</u> in the Japanese trawl fishery in the Gulf of Alaska, 1964-83; catch, percentage of the all-species catch, and catch per unit effort (CPUE).

Fishery Management Council (NPFMC). Foreign harvest was only 1% of the total catch in 1985, the remainder having been taken by the U.S. fishery (76%) and the joint venture fisheries (23%). The NPFMC Western Regulatory Area provided 848 t (78%) of the 1985 catch. The catch in the Eastern Regulatory Area, which had been very low in 1982-84, increased several-fold in 1985--to 181 t (17% of the gulf-wide total). This increase resulted mainly from the domestic trawl fishery for rockfish in the eastern gulf.

The small 1985 catch was probably more reflective of management action than of stock abundance. In 1982-84 the foreign catch ranged from 58 to 100% of the total catch (Table 2). In 1985, however, the foreign allocation was eliminated and optimum yield (OY) was simultaneously reduced (from 11,475 t in 1984 to 6,083 t in 1985). In contrast to 1982-84, when the all-nation catch ranged from 39 to 70% of the OY, only 18% of the substantially reduced OY was taken in 1985, despite the above-mentioned growth of the domestic trawl fishery for rockfish in the eastern gulf.

CONDITION OF THE STOCK

The evaluation of stock condition for the Pacific ocean perch complex in 1986 is based on three sources of data: historical Japanese catch data from 1964 to 1983 (Fig. 1); triennial trawl survey data from 1984 (Carlson et al. 1986); and age-size data from 1984 and 1986 (Carlson et al. 1986; Karinen and Wing (another chapter, also on Pacific ocean perch) in this report).

The data in Figure 1 provide evidence that S. *alutus* stocks (the largest component of the Pacific ocean perch complex) had declined to extremely low levels bv 1978. The total (all-nation) catch of S. *alutus* was down to about 5,000 t, the contribution of S. *alutus* to the Japanese all-species trawl catch had decreased to less than 15%, and the Japanese catch per unit effort (CPUE) for S. *alutus* had decreased to less than 0.2 t per hour. The close parallel between the Japanese CPUE and total catches of S. *alutus* from 1973 through 1983 is an indicator that the stocks continued in a depressed state over this period. However, because commercial CPUE data have become increasingly difficult to interpret since 1978 (because of low catches of S. *alutus*), the evidence is not conclusive.

Other sources (research data) indicate that the condition of S. *alutus* varies by region. Leaman and Nagtegaal (1986), using survey data From Dixon Entrance in the southeastern gulf, concluded that the biomass of S. *alutus* there had decreased between 1977 and 1983. In the eastern gulf, Kean CPUEs from trawl surveys in 1978, 1979, and 1981 (Carlson et al. 1986) agreed with the CPUE trend displayed by the Japanese data for the comparable period (Fig. 11, indicating some possible improvement in stock condition. The mean CPUE for the 1984 triennial survey in southeastern Alaska was about the same or slightly higher than the 1981 CPUE.

All these data have deficiencies which make it difficult to obtain reliable determinations of the condition of the S. *alutus* stocks. For example, the CPUE and biomass estimates derived from-trawl surveys have such large standard deviations that data from many consecutive years are required before even rough estimates of stock condition can be obtained. Also, trawl surveys are not always comparable from year to year. Finally, it is likely that trawl surveys generally underestimate S. alutus abundance (Leaman and Nagtegaal 1986). The need for revised procedures and the need to use other data sources (age, size, and year-class abundance) are obvious if we are to reliably estimate the stock condition of rockfish.

There is no evidence that the abundance of S. alutus has increased, although recent age-size data show a preponderanye of certain year classes. Based on age composition data presented by Carlson et al. (1986) from an April-May 1984 cruise, the 1976 year class appeared to be strong (over 55% of the 1,148 fish aged in 1984 were 8 years old). This (1976) year class recruited to the spawning stock for the first time in 1986. A strong 1976 year class for S. alutus in the western Gulf of Alaska was also detected in a small sample (in = 87) taken in 1982 (Blackburn 1986).

A plot of length versus age (Fig. 2) indicates that length is a very poor predictor of age for fish older than 10 years, but may be useful for fish less than 10 years old. Based on the mean growth rate of S. alutus during the first 10 years of life (Fig. 2) the series of length frequencies from a large sample of S. alutus from the foreign fishery (1981-84) suggests that the 1976 cohorts provided the major recruitment to the commercial stocks in the western and central gulf for these years (Carlson et al. 1986). Regional differences in recruitment strength and size and age composition within the gulf 2. alutus stock may occur, however, because in 1984 all index sites did not show the expected mode for the 34 cm size group for the 1976 year class (Carlson et al. 1986). Further studies of age composition in 1986 (Karinen and Wing 1987 (another chapter, also on Pacific ocean perch) in this report) neither strongly supported nor refuted the hypothesis of a strong 1976 year class, but provided circumstantial evidence that recent warming trends (1982-85) may abet strong year classes in the future. There is no evidence now, however, that the Pacific ocean perch stock has recovered sufficiently to allow relaxation of management controls now in force.

PROPOSED RESEARCH DIRECTIONS

Catches of S. alutus and related species in the Pacific ocean perch complex will be monitored through the reports of the Pacific Fishery Management Information Network (PacFIN). These data will be examined for catch trends, particularly the proportion of the total catch taken in the eastern Gulf of Alaska.

Adult stocks of the Pacific ocean perch complex will be assessed during the 1987 triennial trawl survey. Effort will be directed toward determining the age structure of the populations in each area, with specific emphasis on S. alutus in the eastern gulf--particularly the determination of year class strengths for fish less than 20 years old. Data analyses will concentrate on ages determined from otolith readings because ages estimated on the basis of associated fish lengths are, at best, first-order estimates.

Additional information is 'required on the early life phases of the species in the Pacific ocean perch complex, especially the possible relationships between oceanographic conditions and the recruitment from the pelagic

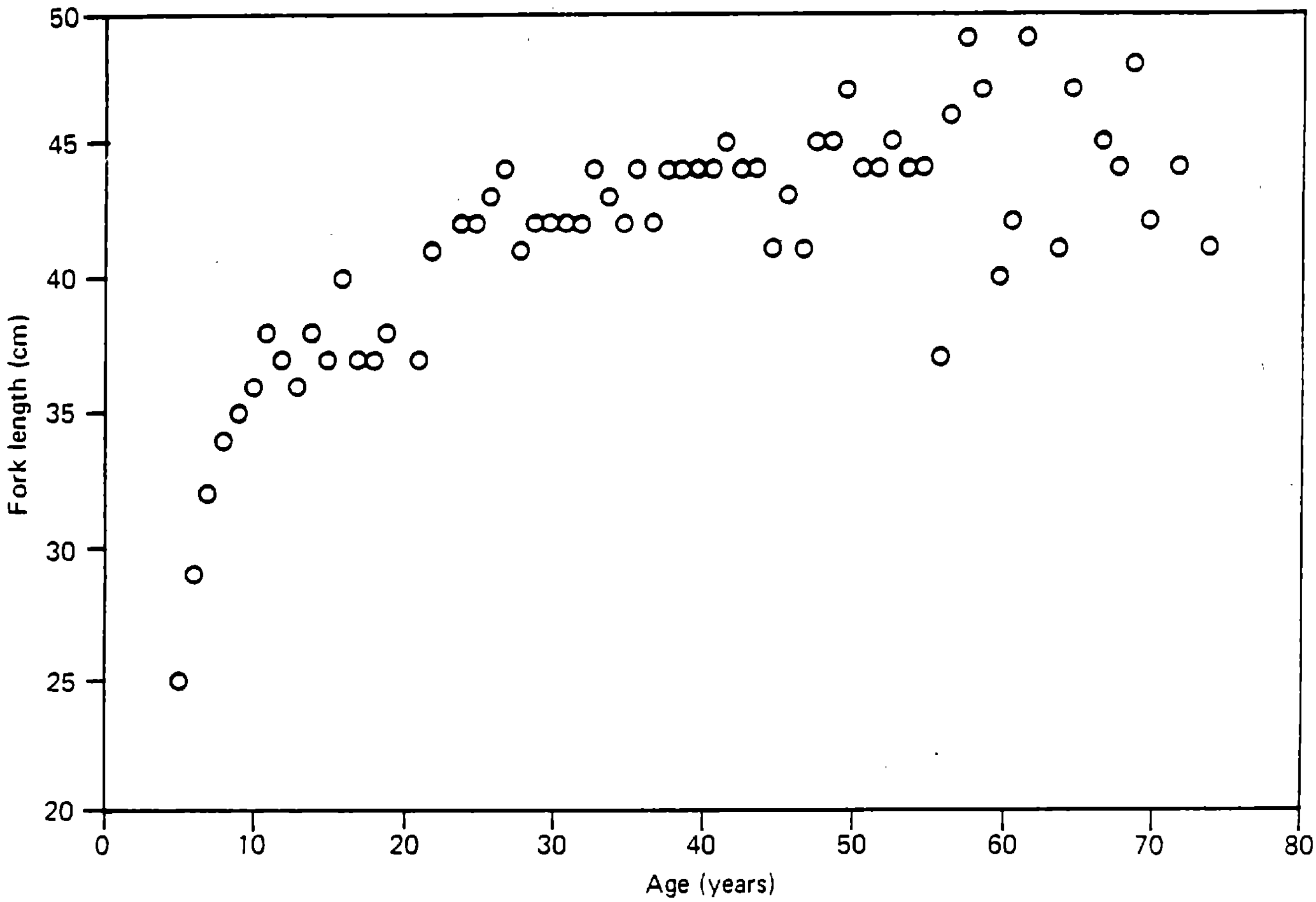

Figure 2.--Mean length at age of 1,148 Sebastes alutus sampled in the eastern Gulf of Alaska in April 1984. Seventy-two percent were less than age 13.

larval stage to the benthic juvenile stage. Water column thermal profiles will be monitored with expendable bathythennographs (XBTS) during the triennial trawl survey and the concordant sablefish survey studies. If opportunity arises, neuston net and bongo net samples will be taken to determine the distributon of Sebastes spp. larvae and the potential relationship of these larvae with the Sitka Eddy and the Alaska Coastal Current.

Hydroacoustic surveys constitute another effective tool for studying the biology and population levels of schooling fishes and zooplankton. In 1987 we intend to use hydroacoustic methods to examine the relationships of schooling Sebastes spp. to euphausiid distributions in the eastern Gulf of Alaska and determine the feasibility of monitoring 2. alutus in midwater with these techniques. Sebastes alutus may congregate to feed on discrete patches of euphausiids located on the Continental Shelf. Defining euphausiid-S. alutus relationships may lead to improved methods-for accurately assessing-the densities of Pacific ocean perch.

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THORNYHEADS

by

Herbert H. Shippen

INTRODUCTION

General Distribution

Two similar species are commonly referred to as thornyheads, thornyhead rockfish, or "idiots": the shortspine thornyhead (Sebastolobus alascanus) and the longspine thornyhead (Sebastolobus altivelis). They inhabit deep waters from the Bering Sea to Baja California--the shortspine from 92 to 1,460 m and the longspine from 370 to 1,600 m. Length ranges up to 75 cm for the shortspine variety and up to 38 cm for the longspine. Overall, the shortspines are the more abundant of the two species. In the Gulf of Alaska longspine thornyheads have rarely been taken in resource assessment surveys.

Multispecies Nature of the Fisheries

Although the flesh of thornyheads is highly regarded by fishermen, the species are ordinarily not the target objects of fisheries. They are taken, rather, in trawl and longline fisheries aiming at other species. According to Alverson et al. (1964), fishes commonly associated with thornyheads are arrowtooth flounder (Atheresthes stomias), Pacific ocean perch (Sebastes alutus), sablefish (Anoplopoma fimbria), rex sole (Glyptocephalus zachirus), Dover sole (Microstomus pacificus), shortraker rockfish (Sebastes borealis), rougheye rockfish (Sebastes aleutianus), and grenadiers (family Macrouridae).

FISHERY STATISTICS

Historical Catches

As an element of the deepwater community of demersal fishes, thornyheads have been fished in the northeast Pacific Ocean since the late 19th century, when commercial trawling by U.S. and Canadian fishermen began. In the mid-1960s Soviet fleets arrived in the eastern Gulf of Alaska (Chitwood 1969), where they were soon joined by vessels from Japan and the Republic of Korea (ROK).

There are no records of the catches of thornyheads in these early fisheries. The first data began to accrue as part of the U.S. Foreign Fisheries Observer Program in 1977, when the catch in the Gulf of Alaska (as a whole) was estimated at 1,163 t (Wall et al. 1978). From 1980 on, the observer program has generated annual estimates of the foreign catch of thornyheads by International North Pacific Fisheries Commission (INPFC) statistical area. Since 1982 the observer program has also estimated the catches of thornyheads in the joint venture fisheries. Finally (in 1984 for the first time), thornyheads were identified as a separate entity in the U.S. domestic catch statistics (Table 1).

Table 1 .--Catch (t) of thornyheads in the Gulf of Alaska by International North Pacific Fisheries Commission statistical area and fishery category, 1980-85.

Year	Nation	Area: Shumagin	Chirikof	Kodiak	Yakutat	South-eastern	Total
1980	Japan	129	197	391	355	144	1,216
	ROK*	99	-	-	33	-	132
	Poland	0	0	-	-	-	0
	U.S.S.R.	1	0	2	-	-	3
	Total	229	197	393	388	144	1,351
1981	Japan	203	138	235	365	179	1,120
	ROK	154	27	27	12	-	220
	Poland	0	0	-	0	-	0
	Total	357	165	262	377	179	1,340
1982	Japan	134	135	326	64	-	659
	ROK	32	12	19	65	-	128
	Total	166	147	345	129	-	787
1983	Japan	148	191	287	53	-	679
	ROK	10	3	20	4	-	37
	JV	12	0	1	-	-	13
	Total	170	194	308	57	-	729
1984	Japan	47	53	59	-	-	159
	ROK	3	2	-	-	-	5
	Poland	-	0	1	-	-	1
	JV	18	0	1	-	-	19
	U.S.	9	0	1	2	12	24
	Total	77	55	62	2	12	208
1985	Japan	4	0	0	-	-	4
	ROK	0	0	-	-	-	0
	JV	2	3	4	-	-	9
	U.S.	6	5	17	29	12	69
	Total	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

*Republic of Korea.

Sources: Foreign and joint venture catches: personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point Way NE., Seattle, WA 98115.
U.S. catches: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 SW. Fifth Avenue, Portland, OR 97201.

Current Catches

The catches of thornyheads in the Gulf of Alaska have declined markedly since 1983--continuing a trend that began at least as early as 1980. The declining catches appear to reflect U.S. management actions, which have reduced the amounts of target species available to foreign nations and restricted the foreign fisheries more and more to the west. Although only a relatively small quantity (69 t), the U.S. catch surpassed the foreign catch for the first time in 1985.

CONDITION OF THE STOCKS

The population structure of the thornyheads has not been defined. As a matter of practical convenience, those thornyheads inhabiting the Gulf of Alaska are managed as a single stock--independent of those in the Bering Sea-Aleutian region or the region to the south.

Because of the incidental nature of the catch of thornyheads in the foreign commercial fisheries, catch and catch per unit effort (CPUE) of thornyheads are functions of fisheries directed at the target species rather than at thornyheads themselves.

Resource assessment surveys provide what little information there is about changes in relative abundance of thornyheads over time. Results of bottom trawl surveys in 1979, 1981, and 1984 (expressed in kilograms of catch per square kilometer (kg/km^2)) are summarized in Tables 2 and 3. Comparisons are severely hampered by the lack of samples from deepwater areas which, according to Alverson et al. (1964), are the domicile for the greater part of the thornyhead populations. Even in the shallower regions, however, there are no well-defined trends in the relative abundance of thornyheads.

Longline surveys have been conducted jointly by the United States and Japan in the Gulf of Alaska each year to ascertain the abundance level and length composition of important groundfish species in depths from 101 to 1,000 m. For each species, Sasaki and Teshima (1986) used the catch rate for each depth stratum, the area of the depth stratum, and the size composition of samples from the depth stratum to determine the relative population weight (RPW) for the depth stratum. The RPWs for the various depth strata (201-1,000 m for thornyheads) were summed to obtain the following gulfwide totals:

Year	1979	1980	1981	1982	1983	1984	1985
RPW	5,696	6,726	6,793	4,254	4,148	3,115	4,362

In general, the stock had declined by 1984 to less than one-half of what it had been in plateau years 1980-81, before rebounding partially in 1985.

Change in the average length of fish in the catch was also examined as a possible indicator of changing stock condition. Note in Table 4 that thornyheads were smaller in 1982-84 than in 1980 and 1981, regardless of sex or area. The significance of the decreases is masked, however, by the fact that the

Table 2.--Thornyheads. in resource assessment surveys by bottom trawl in the International North Pacific Fisheries Commission's Shumagin, Chirikof, and Kodiak Statistical Areas of the Gulf of Alaska, 1979, 1981, and 1984. Catch per unit effort (kg/km^2) by area and depth.*

	Area								
	Shumagin			Chirikof			Kodiak		
Depth (m)	1979	1981	1984	1979	1981	1984	1979	1981	1984
101-200	37	-	28	26	-	47	55	165	79
(No. sta)	(20)	(0)	(76)	(22)	(0)	(83)	(25)	(5)	(136)
201-300	2,613	-	2,896	864	-	574	1,416	5,852	927
(No. sta)	(23)	(0)	(23)	(32)	(0)	(35)	(43)	(7)	(49)
301-500	-	-	2,507	2,657	-	3,289	1,160	4,019	2,523
(No. sta)	(0)	(0)	(17)	(15)	(0)	(11)	(5)	(5)	(20)
501-700	-	-	2,338	-	-	2,252	-	-	1,875
(No. sta)	(0)	(0)	(15)	(0)	(0)	(10)	(0)	(0)	(15)
701-1,000	-	-	1,151	-	-	3,274	-	-	2,275
(No. sta)	(0)	(0)	(5)	(0)	(0)	(6)	(0)	(0)	(6)

*To make the 1979 and 1981 survey results comparable to those of 1984, the 1979 and 1981 results have been converted from kg/h to kg/km^2 by assuming a towing speed of 3 knots during sampling, a trawl opening width of 18.3 m, and a fishing power coefficient of 1.00 in 1979 and 1981 as compared to 3.66 in 1984. The latter figure (3.66) was derived by means of comparative tests between U.S. and Japanese trawls as part of the the 1984 U.S.-Japan cooperative bottom trawl survey of the central and western Gulf of Alaska (Brown 1986).

Table 3.--Thornyheads in resource assessment surveys by bottom trawl in the International North Pacific Fisheries Commission's Yakutat and Southeastern Statistical Areas of the Gulf of Alaska, 1979, 1981, and 1984. Catch per unit effort (kg/km^2) by area and depth.[a]

	Area						
	Yakutat				Southeastern		
Depth (m)	1979	1981	1984[b]	1984[c]	1979	1981	1984
101-200	-	66	63	11	267	92	0
(No. sta)	(0)	(37)	(10)	(7)	(1)	(39)	(11)
201-300	190	1,091	6,036	38	1,940	2,053	0
(No. sta)	(7)	(41)	(4)	(6)	(5)	(36)	(8)
301-400	-	4,688	-	2,927	4,051	1,826	444
(No. sta)	(0)	(15)	(0)	(4)	(9)	(6)	(4)
401-600	-	-	-	1,238	-	-	0
(No. sta)	(0)	(0)	(0)	(4)	(0)	(0)	(1)
601-800	-	-	-	1,408	-	-	-
(No. sta)	(0)	(0)	(0)	(1)	(0)	(0)	(0)

[a]To make the 1979 and 1981 survey results comparable with those of 1984, the 1979 and 1981 results have been converted from kg/h to kg/km^2 by assuming a towing speed of 3.0 knots during sampling, a trawl opening width of 18.3 m, and a fishing power coefficient of 1.00 in 1979 and 1981 as compared with 3.66 in 1984. See Brown (1986) regarding the derivation of the figure 3.66.

[b]147-144° W. long.

[c]144-137° W. long.

Table 4.--Mean fork length (cm) of thornyheads in the Gulf of Alaska, by International North Pacific Fisheries Commission statistical area, as determined from samples measured by U.S. foreign fisheries observers, 1980-84. (No samples measured in 1985.)

Sex and area	Year									
	1980[a]		1981[a]		1982[b]		1983[b]		1984[b]	
	Length	No.	Length	No.	Length	No.	Length	No.	Length	No.
Males										
Shumagin	34.0	223	34.6	45	--	--	28.7	297	30.2	12
Chirikof	34.4	510	37.2	54	--	--	30.8	2410	30.8	411
Kodiak	33.5	516	35.6	18	27.9	498	29.6	15	--	--
Females										
Shumagin	35.0	293	35.1	28	--	--	28.3	202	30.9	40
Chirikof	35.7	416	39.0	73	--	--	30.3	1601	33.2	262
Kodiak	36.2	459	36.4	45	27.2	526	28.5	17	--	--

[a]Longline samples where bottom depth >500 m.

[b]Trawl samples where bottom depth >400 m.

Source: Personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, Building 4, 7600 Sand Point Way NE., Seattle, WA 98115.

samples in 1980 and 1981 were essentially from longline fisheries operating at bottom depths greater than 500 m, while those in 1982-84 were from trawl fisheries operating in areas where bottom depths were less than 400 m. In the longline surveys described by Sasaki (1985), no appreciable changes in the mean length of shortspine thornyheads were observed (mean body length in centimeters: 1980, 34.1; 1981, 33.9; 1982, 35.0; 1983, 34.7; and 1984, 34.5).

POTENTIAL YIELD

Estimates of Maximum Sustainable Yield

From the time the first Fishery Management Plan for groundfish in the Gulf of Alaska went into effect in 1979, maximum sustainable yield (MSY) for thornyheads has arbitrarily been set at 3,750 t. It was not until 1984, however, that it became possible to compare MSY to the estimated gulf-wide standing stock. The 1984 U.S.-Japan cooperative bottom trawl survey of the central and western Gulf of Alaska (which, together with a complementary survey by the National Marine Fisheries Service in the eastern gulf, is also referred to as the triennial survey) yielded the first information about the standing stock of thornyheads in the region. Samples were obtained throughout all three INPFC statistical areas in the central and western gulf--the Shumagin, Chirikof, and Kodiak Areas. Most tows were in waters where bottom depths were less than 700 m, although there were some tows in over 700 m. Taking into account the CPUE expressed as kilograms/square kilometer (Table 2) and the total area involved for each depth stratum, standing stock within the areas surveyed systematically during 1984 was estimated at 77,796 t (Table 5) (Brown 1986 (updated January 12, 1987) 1.

Sampling was less comprehensive in the INPFC Yakutat and Southeastern Areas. On the basis of limited samples available, however, the standing stock of thornyheads has been estimated at 5,231 t in the INPFC Yakutat Area and 267 t in the INPFC Southeastern Area (Table 5).

Thus, it turns out that the arbitrarily selected MSY for thornyheads in the Gulf of Alaska is roughly 5% of the total estimated standing stock (83,294 t) estimated from the 1984 triennial survey.

Estimates of Equilibrium Yield

Because it is felt that MSY is presently attainable, equilibrium yield (EY) is set at MSY.

Acceptable Biological Catch

As in the past, there are no compelling biological reasons to set acceptable biological catch (ABC) above or below EY. It is recommended, therefore, that ABC remain at 3,750 t.

Table 5.--Estimated standing stock (t) of thornyheads in the Gulf of Alaska in 1984, by International North Pacific Fisheries Commission statistical area and depth stratum. (Based on bottom trawl surveys by U.S. and Japanese research vessels.)

Depth (m)	Area					
	Shumagin	Chirikof	Kodiak	Yakutat (147°-144°W.)	Yakutat (144°-137°W.)	Southeastern
	-----Number of stations (top) and standing stock (bottom)------					
1-100	106 0	43 0	70 0	7 0	0 -	0 -
101-200	76 362	83 1,047	136 3,191	13 474	7 62	11 0
201-300	23 7,399	44 6,169	40 9,622	3 1,972	6 47	8 0
301-400					4 1,281	4 267
401-500	17 5,916	11 5,016	20 6,975	0 -		
501-600					4 715	1 0
601-700	15 4,387	10 3,989	15 2,711	0 -		
701-800					1 689	0 -
801-900	5 2,013	6 9,231	6 7,322	0 -		
Total	242 20,077	197 25,452	287 29,821	23 2,446	22 2,794	23 267

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OTHER ROCKFISH

by

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INTRODUCTION

Members of the family Scorpaenidae are distributed on or near the Continental Shelf throughout the world's oceans. In the Gulf of Alaska, the family is represented by over 30 species of the genus *Sebastes* and 2 species of the genus *Sebastolobus*. Beginning in 1980 and continuing to date (1987), these fishes have been divided into three management categories: the thornyheads (the two species of the genus *Sebastolobus*), the Pacific ocean perch (POP) complex (five species of the genus *Sebastes* with color and characteristics similar to Pacific ocean perch (*Sebastes alutus*), and "other rockfish" (all species of the genus *Sebastes* not included in the POP complex) (Table 1). Twenty-eight species of other rockfish have been identified in the Gulf of Alaska by fisheries observers and port samplers. Twenty species are caught regularly.

The species of the genus *Sebastes* can be divided into three groups, or assemblages (slope, shelf demersal, and shelf pelagic), on the basis of distribution and behavioral characteristics. Other rockfish of the slope assemblage have long been harvested in the foreign trawl fisheries along the continental slope primarily incidental to target fisheries on the POP complex (which are also members of the slope assemblage). The species of the shelf demersal assemblage are the target of an expanding longline fishery in the southeastern portion of the eastern gulf, while the shelf pelagic assemblage is largely unexploited at this time.

FISHERIES STATISTICS

Prior to the adoption of the current three-group management system (thornyheads; POP complex; other rockfish), the catch statistics for scorpaenid fishes were accrued and reported in a variety of ways, with the method varying by nation and frequently by year. Nonetheless, it is reasonable to assume that the POP complex comprised the bulk of the harvest. In recent years, estimates of the landings of the other two management groups, the thornyheads and the other rockfish, have been obtained from U.S. observers aboard foreign and joint venture fishing vessels and by shore-based samplers in Kodiak and in ports in southeastern Alaska. Fairly accurate catch estimates are available

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Table 1 .--Assemblages of rockfish in the Gulf of Alaska.

Common name	Scientific name	Current management group (assemblage)	Recommended management group (assemblage)
Longspine thornyhead	*Sebastolobus altivelis*	Thornyhead rock	Thornyhead rock
Shortspine thornyhead	*Sebastolobus alascanus*	Thornyhead rock	Thornyhead rock
Canary rockfish	*Sebastes pinniger*	Other rockfish	Shelf demersal
China rockfish	*S. nebulosus*	Other rockfish	Shelf demersal
Copper rockfish	*S. caurinus*	Other rockfish	Shelf demersal
Quillback rockfish	*S. maliger*	Other rockfish	Shelf demersal
Rosethorn rockfish	*S. helvomaculatus*	Other rockfish	Shelf demersal
Tiger rockfish	*S. nigrocinctus*	Other rockfish	Shelf demersal
Yelloweye rockfish	*S. ruberrimus*	Other rockfish	Shelf demersal
Redstripe rockfish	*S. proriger*	Other rockfish	Shelf demersal
Black rockfish	*S. melanops*	Other rockfish	Shelf pelagic
Blue rockfish	*S. mystinus*	Other rockfish	Shelf pelagic
Bocaccio	*S. paucispinis*	Other rockfish	Shelf pelagic
Dusky rockfish	*S. ciliatus*	Other rockfish	Shelf pelagic
Silvergray rockfish	*S. brevispinis*	Other rockfish	Shelf pelagic
Widow rockfish	*S. entomelas*	Other rockfish	Shelf pelagic
Yellowtail rockfish	*S. flavidus*	Other rockfish	Shelf pelagic
Pacific ocean perch	*S. alutus*	Pacific ocean perch	Slope
Northern rockfish	*S. polyspinis*	Pacific ocean perch	Slope
Rougheye rockfish	*S. aleutianus*	Pacific ocean perch	Slope
Sharpchin rockfish	*S. zacentrus*	Pacific ocean perch	Slope
Shortraker rockfish	*S. borealis*	Pacific ocean perch	Slope
Aurora rockfish	*S. aurora*	Other rockfish	Slope
Blackgill rockfish	*S. melanostomus*	Other rockfish	Slope
Chilipepper rockfish	*S. goodei*	Other rockfish	Slope
Darkblotched rockfish	*S. crameri*	Other rockfish	Slope
Greenstriped rockfish	*S. elongatus*	Other rockfish	Slope
Harlequin rockfish	*S. variegatus*	Other rockfish	Slope
Pygmy rockfish	*S. wilsoni*	Other rockfish	Slope
Redbanded rockfish	*S. babcocki*	Other rockfish	Slope
Shortbelly rockfish	*S. jordani*	Other rockfish	Slope
Splitnose rockfish	*S. diploproa*	Other rockfish	Slope
Stripetail rockfish	*S. saxicola*	Other rockfish	Slope
Vermilion rockfish	*S. miniatus*	Other rockfish	Slope
Yellowmouth rockfish	*S. reedi*	Other rockfish	Slope

for the other rockfish management group since 1980 (Table 21, but species definition within that management group remains a problem.

The recent-year catch of other rockfish peaked in 1981 at 4,585 metric tons (t) and then declined substantially through 1984 (Fig. 1). Most of the 1981 harvest of other rockfish (95%) was taken by foreign vessels, which have since been phased out of the Gulf of Alaska rockfish fisheries by regulatory changes. The slight increase noted in 1985 from 1984 is the result of an increase in domestic harvests. The foreign and joint venture harvests were largely displaced by domestic harvests in 1985.

Species breakdown of the other rockfish catch from the landing records is unreliable because most of the landings are entered in the unspecified rockfish category. It can generally be assumed, however, that most of the harvest in the foreign and joint venture fisheries were species in the slope assemblage, as the majority were landed in the deeper water trawl fisheries. In the domestic fishery, 754 t (75%) of the 1984 and 771 t (46%) of the 1985 landings in the other rockfish category were made by hook and line gear. The majority of species landed in the hook and line fisheries are in the shelf demersal rockfish assemblage, with two species--yelloweye rockfish and quillback rockfish--accounting for approximately 80% of the landed weight. The domestic trawl fisheries account for the remainder of the harvest, taking primarily slope-dwelling species as did the foreign and joint venture trawl fisheries.

CONDITION OF STOCKS

Stock Structure

As mentioned earlier, rockfish of the genus *Sebastes* can be separated into three assemblages according to habitat and behavioral characteristics. The slope assemblage, which includes the POP complex, is generally found in depths greater than 250 m. The other two assemblages, shelf demersal and shelf pelagic, are generally found in depths less than 200 m and are separated vertically in their habitat. The shelf demersal species spend all or nearly all of the time on bottom associated with rocky reefs or pinnacles, while the shelf pelagic species spend at least a portion of the time off bottom and, although frequently associated with prominent geological features, are often found offshore and not associated with definable submarine bottom structures.

Species diversity is highest in the eastern gulf and decreases to the west. All three assemblages occur in abundance in the eastern gulf, with substantial decreases in the abundance of the shelf-dwelling assemblages west of 140° W. long. For this reason, all assemblages are managed together west of 140° W. long., while a separate harvest level is assigned to the shelf demersal species in a portion of the International North Pacific Fisheries Commission (INPFC) Southeastern Statistical Area.

Fisheries which harvest shelf demersal and slope assemblages almost always land catches with mixed species composition. Fisheries which harvest the schooling shelf pelagic species are able to target on individual species

Table 2.--Catches (t), of other rockfish in the Gulf of Alaska, by fishery category, 1980-85.

Year	Fishery category			Total
	Foreign	Joint venture	Domestic	
1980	2,849	8	203	3,060
1981	4,341	0	244	4,585
1982	1,692	0	259	1,951
1983	1,712	289	349	2,350
1984	414	284	1,005	1,703
1985	2	45	1,678	1,725

Sources : Foreign and joint venture fisheries 1980-84: Berger et al. (1986). Foreign and joint venture fisheries 1985: personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE, BIN C15700, Building 4, Seattle, WA 98115. Domestic catches: Alaska Department of Fish and Game (some differ at this time from those reported in Table A, which appears in the front of this report).

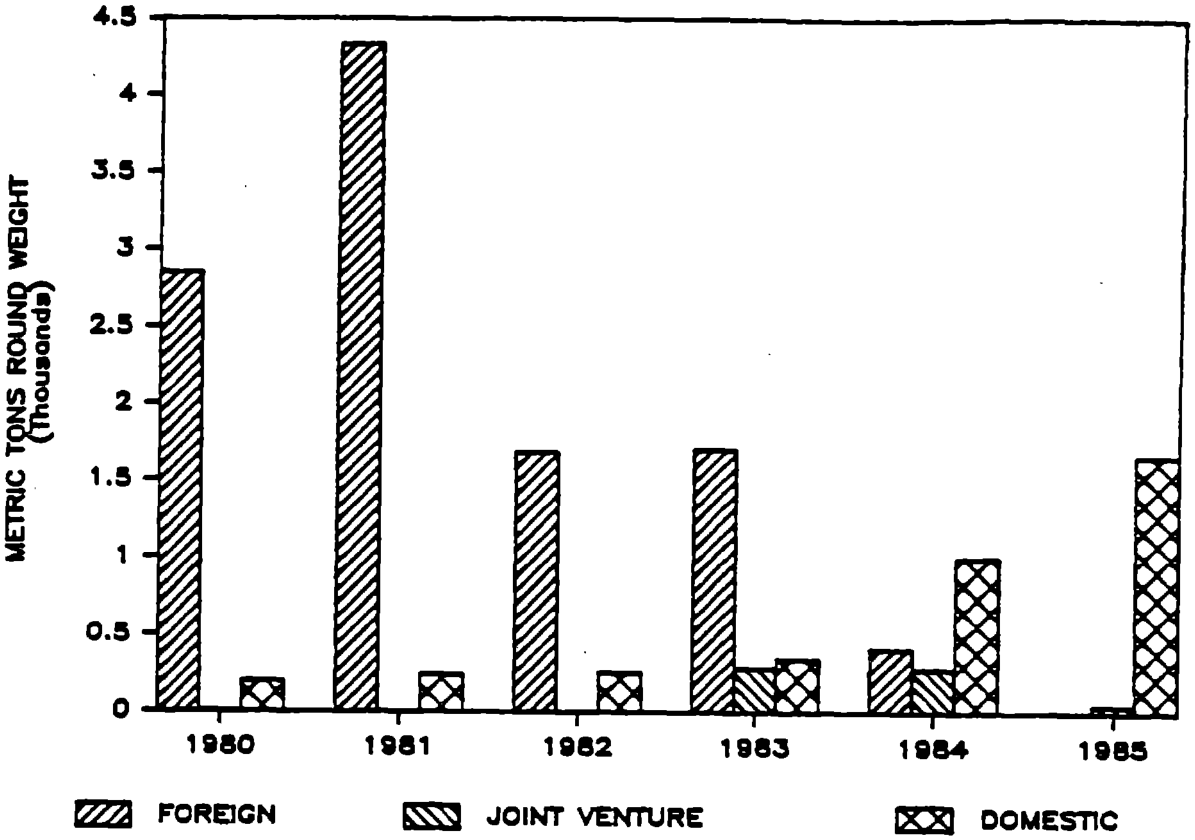

Figure 1 .--Estimated catch of other rockfish in the foreign, joint venture, and domestic fisheries in the Gulf of Alaska, 1980-85 (data from Table 2).

to some extent. There is some overlap between assemblages at some life history stages, but the assemblage groupings appear to offer adequate separation for management of the adult fish in the three groups.

Stock Assessment

Survey Results

The 1984 National Marine Fisheries Service (NMFS) triennial survey provided abundance estimates for other rockfish in offshore waters of the Gulf of Alaska. The triennial survey was made up of two parts--the U.S.-Japan cooperative trawl survey in the central and western gulf, and a complementary NMFS survey in the eastern gulf.

The U.S.-Japan survey took significant numbers of only one species of other rockfish in the areas surveyed. Biomass of dusky rockfish, a shelf pelagic species, was estimated at 25,589 t in the central and western gulf, with the bulk of the catch in the nearshore areas inside of where most foreign rockfish fisheries have operated (Brown 1986 (updated January 12, 1987)). Only traces of other species were found, with densities of less than 1 kilogram per hectare (kg/ha). Dusky rockfish were also taken in the eastern gulf survey in the INPFC Yakutat Statistical Area at densities of approximately 3 kg/ha. That survey also captured silvergrey rockfish and redstripe rockfish at rates of approximately 1 kg/ha. There have been no surveys for the shelf assemblages in the eastern gulf and no rockfish surveys have been conducted anywhere within the gulf since 1984.

Assessment of Shelf-Dwelling Species

Traditional methods of stock assessment are difficult to apply to the shelf rockfish assemblages, particularly the shelf demersal group. Maximum sustainable yield (MSY) is difficult to obtain because of the multi-species nature of the assemblage, the lack of biological data on the component species, and the lack of a time series of catch and effort data.

In many management schemes, catch per unit effort (CPUE) is used as an indicator of stock condition and abundance. The Alaska Department of Fish and Game (ADF&G) has been monitoring shore-based landings of other rockfish in the INPFC Southeastern Area since 1982. Most of the monitoring effort has been in the ports of Sitka and Ketchikan (Fig. 2). The CPUE values depicted for the Sitka area for 1986 are through June. The 1986 Ketchikan-area values are based on a very small sample and, for that reason, cannot be directly compared to the 1984 and 1985 CPUE values for that area. The CPUE data collected from the rockfish setline fishery is considered to have limited usefulness for assessing stock condition because of the high mobility of the rockfish fleet, changes in market demand, and advances in gear technology over time (Bracken and O'Connell 1986). A description of the fishery, detailed discussion of monitoring methods, and results of domestic rockfish sampling are also reported in Bracken and O'Connell (1986).

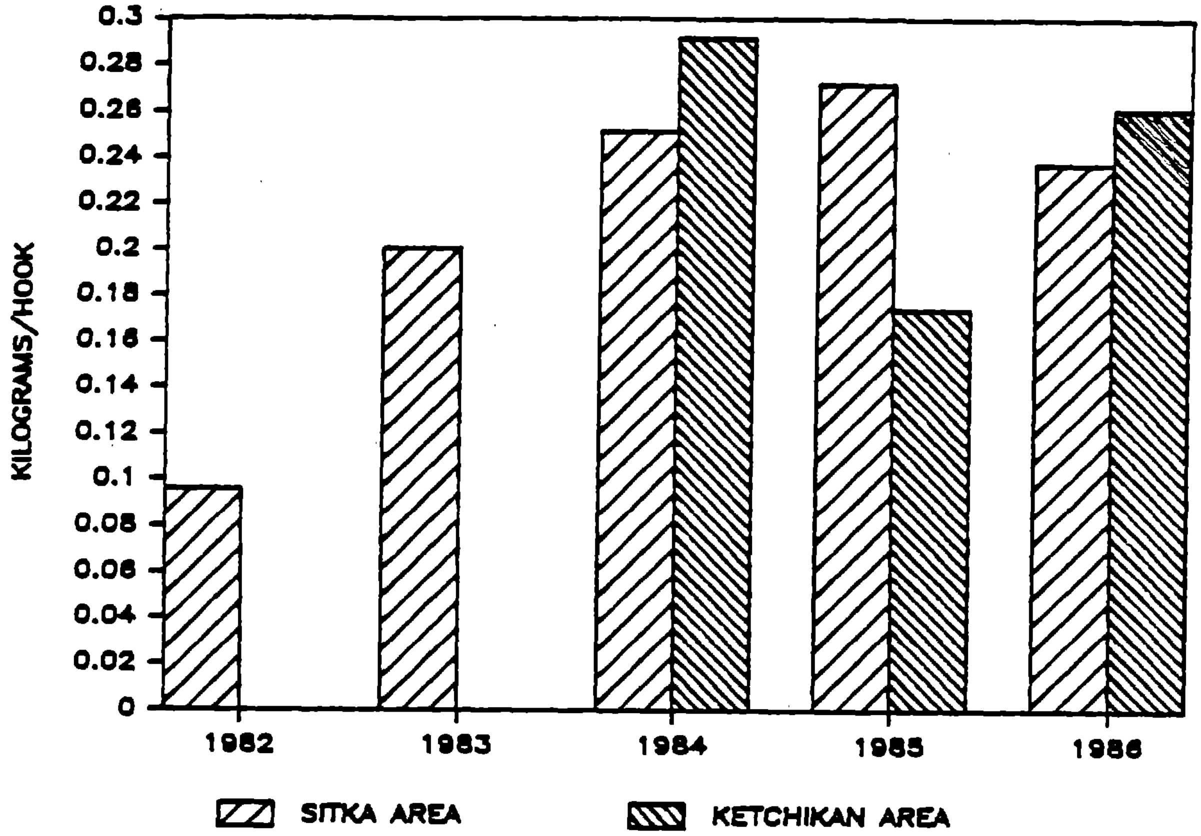

Figure 2.--Catch per unit effort (kilograms per hook) of shelf demersal rockfish landed in the Sitka and Ketchikan area, southeastern Alaska, 1982-86.

POTENTIAL YIELD

The gulf-wide optimum yield (OY) for other rockfish was set at 7,600 t when the Gulf of Alaska Groundfish Fisheries Management Plan was implemented in 1978. That level was based on the lower bound of the catch of rockfish other than S. alutus and the two species of Sebastolobus in the foreign fisheries from 1973 through 1975. Since the 7,600 t OY was established, there have been two important changes: 1) the four predominant species of Sebastes (excluding S. alutus) were removed from the other rockfish category and included with 2. alutus in the five-species POP complex (in 1979), and 2) a separate OY was established for the two species of Sebastolobus (in 1980). There was no corresponding reduction in the other rockfish OY to compensate for the removal of those species. In 1985, however, the gulf-wide OY for other rockfish was reduced to 5,000 t, of which 600 t were to be shelf demersal species in a portion of the INPFC Southeastern Area.

Slope Assemblage

Average harvest of the slope species in the trawl fisheries has averaged only 2,133 t since 1980 (Table,3), with the catch declining substantially in recent years (Fig. 3). It is unclear whether the decline is the result of stock reductions or of changes in fisheries regulations, or a combination of the two factors. However, with the reduction in landings and the poor showing of other rockfish in the triennial surveys, there is no evidence that the acceptable biological catch (ABC) for the other rockfish component of the slope assemblage exceeds the recent year average of 2,133 t, and it may be even lower. Because landings of these species occur predominantly with landings of the POP complex, and because they appear to be in such low abundance, consideration should be given, for management purposes, to combining the slope assemblage with the POP complex.

Shelf Assemblages

Determining ABC levels for the shelf assemblages is even more difficult. There is virtually no data on shelf pelagic species other than the biomass estimates of dusky rockfish in the INPFC Yakutat Area and in the central and western gulf from the 1984 triennial survey. Other species in that group also appear in the shore-based landing in the INPFC Southeastern Area, but in insignificant amounts (less than 4% of the landings by weight).

Harvest of shelf demersal species in the Sitka Area declined from 1984 to 1985 and again the first 6 months of 1986 (relative to the first 6 months of 1985). It is unclear from the available, data whether the decline is the result of market conditions, a reduction in fishing effort, or a decline in rockfish abundance. The CPUE for that area increased slightly from 1984 to 1985 and then declined during the first 6 months of 1986 (Fig. 2).

In the Ketchikan area, the harvest increased from 1984 to 1985, but declined during the first half of 1986. The CPUE declined substantially in the Ketchikan area between 1984 and 1985, but the 1986 sample size is too limited to determine if the decline continued.

Table 3.--Estimated landings (t) of other rockfish in the slope assemblage in the Gulf of Alaska by gear, 1980-85.

Year		Longline	Trawl	Total
1980		203	2,857	3,060
1981		244	4,341	4,585
1982		259	1,692	1,951
1983		349	2,001	2,350
1984		753	950	1,703
1985		771	954	1,725
	Total	2,579	12,795	15,374
	Average	430	2,133	2,562

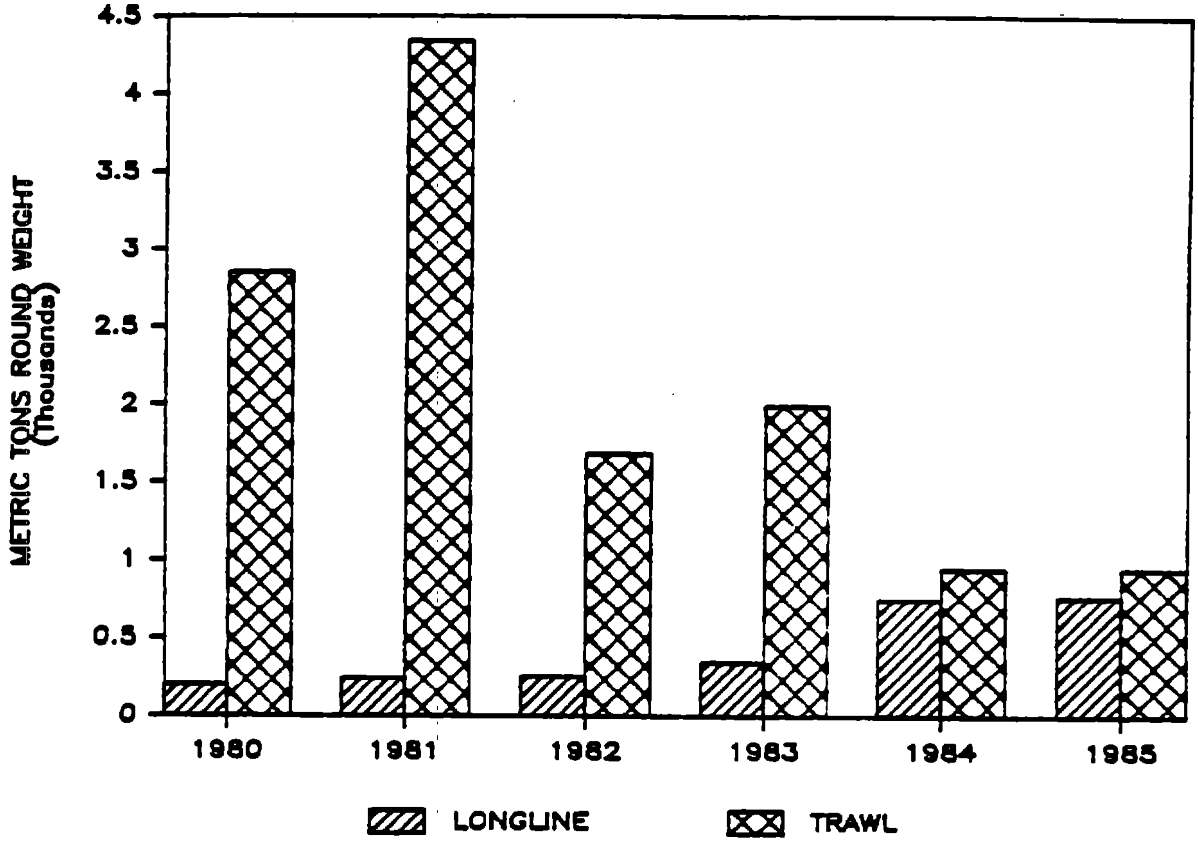

Figure 3 .--Estimated catch of other rockfish by gear type in the Gulf of Alaska, 1980-85.

There is no conclusive evidence that the harvest level in the ADF&G's Central Southeast Management District should be changed from the current level of 600 t. The substantial decline in CPUE in the Ketchikan area from 1984 to 1985 suggests that the current harvest level in that area may not be sustainable. However, because data are inadequate, ABC cannot be determined for any of the nearshore species at this time. It is reasonable to assume that because of the complex multispecies nature of the shelf assemblages, the extreme longevity of many species, and the apparent sensitivity to exploitation; sustainable yield levels are very low.

A comparison of suitable rockfish habitat in the shelf area from 20 to 100 fathoms using large scale marine charts shows that the ADF&G Central Southeast Management District contains the highest percentage of suitable habitat of the three southeast outside management districts. Expanding the current 600 t central district quota to the remainder of the southeast area using estimated suitable habitat as the primary criteria indicates that a sustainable demersal shelf rockfish harvest for the entire southeast area would be approximately 1,250 t (Bracken 1986). Of course, since this estimate is based on the current 600 t quota in the central district, it would have to be adjusted if the 600 t quota is found to be inappropriate.

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FLATFISH

by

Craig S. Rose

INTRODUCTION

This report deals with all flatfishes inhabiting the Gulf of Alaska, except Pacific halibut (*Hippoglossus stenolepis*). The major species, which made up 98% of the 1985 flatfish catch and account for 98% of the current biomass, are arrowtooth flounder (*Atheresthes stomias*) flathead sole (*Hippoglossoides elassodon*), rock sole (*Lepidopsetta bilineata*), rex sole (*Glyptocephalus zachirus*), Dover sole (*Microstomus pacificus*), yellowfin sole (*Limanda aspera*), and starry flounder (*Platichthys stellatus*). As a matter of practical convenience, the nonhalibut flatfish inhabiting the Gulf of Alaska have been managed as a single stock.

This report describes the catches taken in 1985 (noting the continued shift to U.S. harvesters and the decline in catch) and presents information from resource assessment surveys that is relevant to flatfish management in the gulf--including new estimates of potential yield. Catch data are discussed in terms of International North Pacific Fisheries Commission (INPFC) statistical areas; data pertaining to potential yields are presented by North Pacific Fishery Management Council (NPFMC) regulatory area. Figure 1 clarifies the relationship of the two sets of areas.

FISHERY STATISTICS

Between 1981 and 1985, the fishery for flatfish in the Gulf of Alaska went from one dominated by foreign (mostly Japanese) fleets, which took 97% of the catch in 1981, to one where 94% of the catch was harvested by U.S. trawlers (participating in the domestic or joint venture fisheries) in 1985 (Table 1). During the same period, the catch declined 79%--from 14,866 to 3,078 metric tons (t). The decline is not attributable to a diminishing resource, which is being harvested well below its potential yield, but is primarily due to restrictions on the fisheries, particularly on the 'foreign fleets.

In contrast to the large catches of flatfish by foreign fleets in 1978-84 (which were mostly incidental to fisheries targeting on other species), 59% of the 1985 catch was in the INPFC Kodiak Statistical Area, where flatfishes were a major component of the total all-species catch. Most of these fish were delivered to floating joint venture processors, although some were processed by domestic shore plants.

The 1985 joint venture catch was 2,447 t--down 1,001 t from 1984. With the rapid decrease in the foreign flatfish catch (from 14,444 t in 1981 to 170 t in 1985), the joint venture catch has become the dominant harvester of flatfish in the gulf.

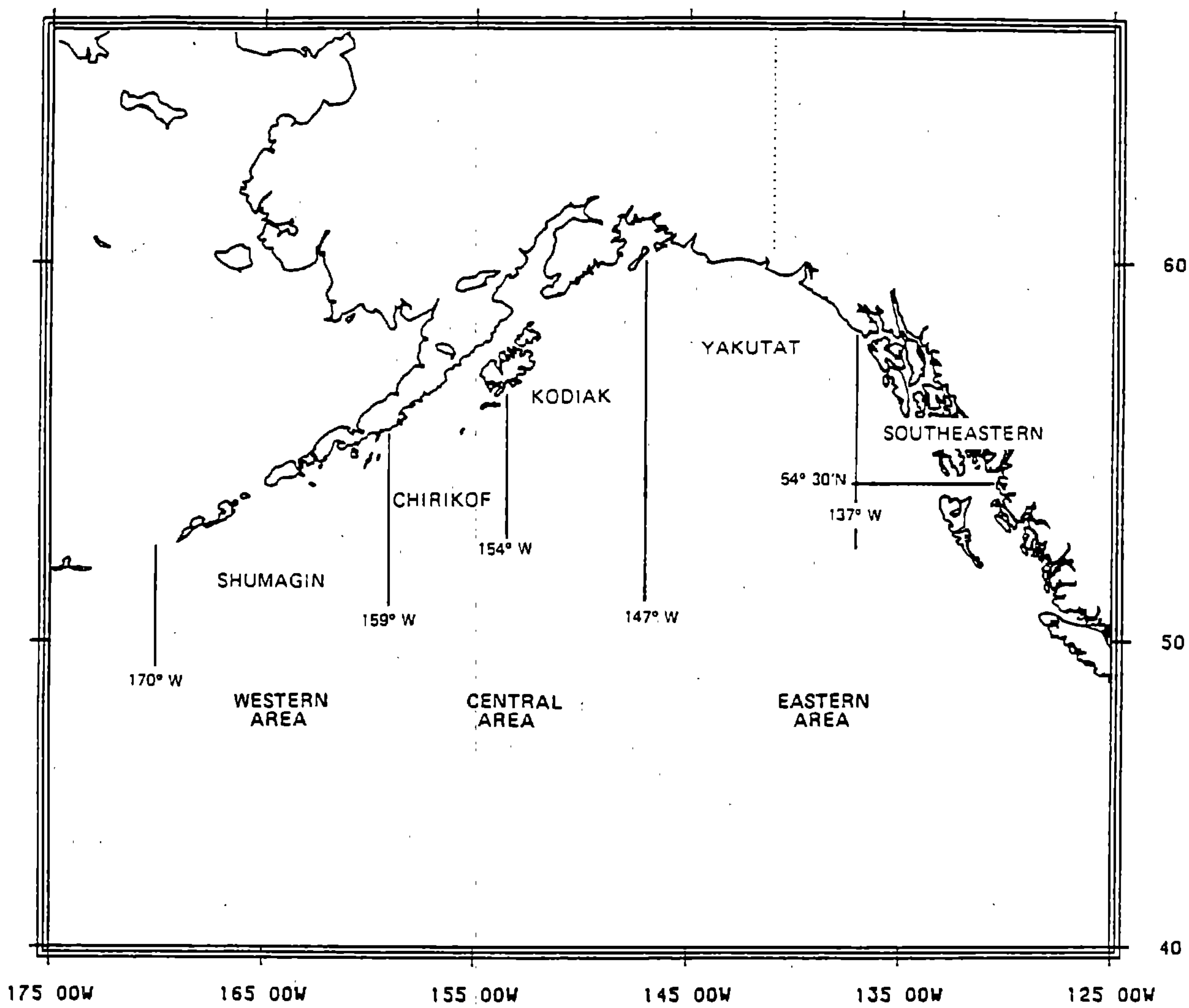

Figure 1.--Gulf of Alaska: International North Pacific Fisheries Commission statistical areas (Shumagin, Chirikof, Kodiak, Yakutat, and Southeastern) and North Pacific Fishery Management Council regulatory areas (Western, Central, and Eastern).

Table 1.--Catch (t) of flatfish in the Gulf of Alaska, by International North Pacific- Fisheries Commission statistical area and fishery category, 1978-85.

Fishery category	Shumagin	Chirikof	Kodiak	Yakutat	Southeastern	Total
Foreign						
1978	2,538	2,482	3,830	2,955	2,536	14,341
1979	2,817	618	4,408	3,290	2,341	13,474
1980	3,022	976	5,909	4,095	1,495	15,497
1981	3,224	3,653	2,106	3,308	2,153	14,444
1982	1,412	2,898	4,618	58	0	8,986
1983	2,020	4,235	3,224	51	0	9,530
1984	603	1,349	1,081	0	0	3,033
1985	115	54	1	0	0	170
Joint venture						
1978	5	0	0	0	0	5
1979	7	0	62	1	0	70
1980	11	106	92	0	0	209
1981	0	18	0	0	0	18
1982	6	12	0	0	0	18
1983	171	62	2,459	0	0	2,692
1984	566	224	2,658	0	0	3,448
1985	234	570	1,553	0	0	2,447
Domestic						
1978	6	4	82	0	760	852
1979	0	1	54	7	322	384
1980	0	0	46	0	94	140
1981	0	0	77	0	327	404
1982	0	0	71	0	203	274
1983	0	0	87	0	351	438
1984	5	10	230	0	152	397
1985	10	0	254	12	185	461
Total						
1978	2,549	2,459	3,912	2,955	3,296	15,171
1979	2,824	619	4,524	3,298	2,664	13,929
1980	3,033	1,082	6,047	4,095	1,589	15,846
1981	3,224	3,671	2,183	3,308	2,480	14,866
1982	1,418	2,910	4,689	58	203	9,278
1983	2,191	4,297	5,770	51	351	12,660
1984	1,174	1,583	3,969	0	152	6,878
1985	449	624	1,808	12	185	3,078

Sources: Foreign and joint venture catches: personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE., BIN C15700, Seattle, WA 98115; U.S. catches (1978-80): Rigby (1984); U.S. catches (1981-85): Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Bldg., 1400 SW. Fifth Ave., Portland, OR 97201.

As in past years, a large part of the 1985 flatfish catch was arrowtooth flounder (Table 21, which made up more than three-quarters of both the foreign and joint venture catches. Flathead sole and rock sole were the other major species in these fisheries, followed by rex sole and Dover sole. Of the two species groups described by Rose (1986), the deep-water group made up approximately 90% of both the foreign and joint venture catches, while the shallow-water group made up 83% of the domestic catch.

The most consistent component of the domestic fisheries has been the trawl fishery for starry flounder in the inside waters of southeastern Alaska. That catch has remained between 100 and 300 t annually since 1978. The domestic flatfish fishery in the Kodiak area has continued the expansion begun in 1984 and reached 254 t in 1985--162 t (63%) of which was rock sole. Rose (1986) indicated, however, that significant numbers of small flathead sole and arrowtooth flounder, which would have been discarded at sea, were probably captured with the rock sole as well.

STOCK CONDITION

When the flatfish stocks of the gulf were evaluated last year (Rose 1986), their potential yield was estimated from biomass estimates generated by 1) a 1984 survey of the western and central gulf and 2) rough estimates of mortality and growth rates. The eastern gulf was not included in the update because the survey of that area included little sampling shallower than 200 m, the principal habitat for most, flatfishes in the gulf.

This year, the availability of age data from the 1984 surveys in the western and central gulf makes possible better estimates of mortality and growth parameters as well as age composition of four major species. Therefore, a new yield analysis has been carried out. Also, biomass estimates from the 1984 surveys of the eastern gulf have been included this year. It was decided in retrospect that despite the sampling limitations of the 1984 survey in that area (and the corresponding low precision of the biomass estimates) the estimates would nonetheless be more useful than the previous estimates, which were based on surveys done more than 10 years ago.

Biomass Estimates

Estimates of flatfish biomass from the eastern gulf were calculated and added to those from the western and central gulf (Table 3). The 1984 survey of the eastern gulf followed the methods for the slope portion of the survey in the central and western gulf (described by Brown 1986). Catch rates for the 18 successful stations in the 101-200 m depth range were used to estimate the biomass of the entire shelf area in those depths. Some bias may result because of the proximity of all those stations to the edge of the shelf. As no sampling occurred in the 0-100 m depth stratum, the biomass of each species in that stratum was estimated by assuming that the proportion in shallow water in the eastern gulf was the same as that found in the western and central gulf. This method does not provide estimates for species which occur exclusively in waters shallower than 100 m, and this may account for the

Table 2.--Composition of the 1985 Gulf of Alaska flatfish catch (t), by fishery category and species (percentages of the grand total are in parentheses).

	Foreign		Joint venture		Domestic		Total	
	catch	(%)	catch	(%)	catch[a]	(%)	catch	(%)
Deep-water species								
Arrowtooth flounder	134	(79)	1,855	(76)	3	(1)	1,992	(65)
Flathead sole	9	(5)	257	(10)	0[b]		266	(9)
Rex sole	7	(4)	98	(4)	49	(11)	154	(5)
Dover sole	1	(1)	41	(2)	28	(6)	70	(2)
Other	0	(0)	4	(<1)	0[b]		4	(<1)
All deep-water	151	(89)	2,255	(92)	80	(17)	2,486	(81)
Shallow-water species								
Rock sole	16	(10)	150	(6)	170	(37)	336	(11)
Yellowfin sole	1	(<1)	7	(<1)	0[b]		8	(<1)
Butter sole	1	(<1)	8	(<1)	0[b]		9	(<1)
Starry flounder	0	(0)	7	(<1)	184	(40)	191	(6)
Other	1	(<1)	20	(1)	27	(6)	48	(2)
All shallow-water	19	(11)	192	(8)	381	(83)	592	(19)
All flatfish	170	(100)	2,447	(100)	461	(100)	3,078	(100)

[a]Landed catches only, discards at sea not included.

[b]All unidentified flatfish included in the "shallow-water, other" category.

Table 3.--Biomass estimates (t) for Gulf of Alaska flatfish, based on 1984 bottom trawl surveys, by North Pacific Fishery Management Council regulatory area and species (percentages of the grand total are in parentheses).

	Area				
	Western	Central	Eastern*	Total	(%)
Deep-water species					
Arrowtooth flounder	99,422	927,316	318,267	1,345,005	(65)
Flathead sole	60,789	208,203	50,265	319,257	(16)
Rex sole	10,476	49,555	14,857	74,888	(4)
Dover sole	4,704	54,678	10,834	70,216	(3)
Other	113	250	362	725	(<1)
All deep-water	175,504	1,240,002	394,585	1,810,091	(88)
Shallow-water species					
Rock sole	56,152	71,392	561	128,105	(6)
Yellowfin sole	53,321	22,773	88	76,182	(4)
Butter sole	1,222	16,976	151	18,349	(1)
Starry flounder	1,085	9,182	428	10,695	(<1)
Other	484	3,907	8,995	13,386	(1)
All shallow-water	112,264	124,230	10,223	246,717	(12)
All flatfish	287,768	1,364,232	404,808	2,056,808	(100)

*Biomasses in shallow areas of the eastern area were indirectly estimated due to lack of survey coverage (see text).

relatively low biomass of the shallow-water group in that area. The resulting total flatfish biomass estimate for the eastern gulf (404,808 t) is considerably higher than the previous estimate of 190,000 t and represents 17% of the total gulf biomass for the nonhalibut flatfish group.

Biological Information

Age determinations were made for samples of arrowtooth flounder, flathead sole, rock sole, and yellowfin sole. These species make up 91% of the current flatfish biomass and constituted 85% of the 1985 catch. The data were used to estimate their age compositions and growth characteristics (Figs. 2 and 3). In addition, a catch curve analysis (Ricker 1975), using the age composition as a synthetic cohort, was used to estimate mortality rates, average recruitment, and age selectivity of the survey effort (Table 4). While this method is effective if recruitment and mortality are not too variable, it may result in biased estimates if either variable has an increasing or decreasing trend. A comparison of catches and biomass estimates indicates that the rate of fishing mortality has been less than 0.01 since at least 1977. Therefore, mortalities from the catch curve analysis are considered to estimate the rate of natural mortality and the 1984 biomass approximates that of a virgin stock. While these are the best estimates available, the mortality estimates and the yield estimates which follow from them (see below) should be used with caution, since they were derived from a synthetic cohort of one year's data.

YIELD

The growth, mortality, and age composition estimates described above were used in two analyses to estimate potential yields of the key gulf flatfish stocks. The analysis used last year, from Gulland (1971), was repeated using the new mortality estimates (Table 5). This analysis used growth, mortality, and size-at-capture parameters to estimate the ratio of virgin biomass to maximum sustainable yield. All mortality estimates were significantly higher than their predecessors, resulting in higher production estimates. This was especially true for flathead sole, whose potential yield estimate exceeded that of the more abundant arrowtooth flounder because of a much higher mortality rate (0.8 vs. 0.3).

The data were also used in a modified version of the analysis of Thompson and Bell (1934) to examine the effect of different levels of fishing mortality (F) on yield. This analysis projected the yield of a cohort through its lifetime at each value of F, using the estimates of average recruitment, weight-at-age, and natural mortality. The principal modification was to use the survey selectivities rather than a fixed age at entry to model recruitment. A comparison of survey and fishery size compositions indicated that this was a reasonable first approximation, although the survey did catch a slightly higher proportion of smaller individuals.

None of the four species examined (arrowtooth flounder, flathead sole, rock sole, and yellowfin sole) had reached a maximum yield even when F = 16.0,

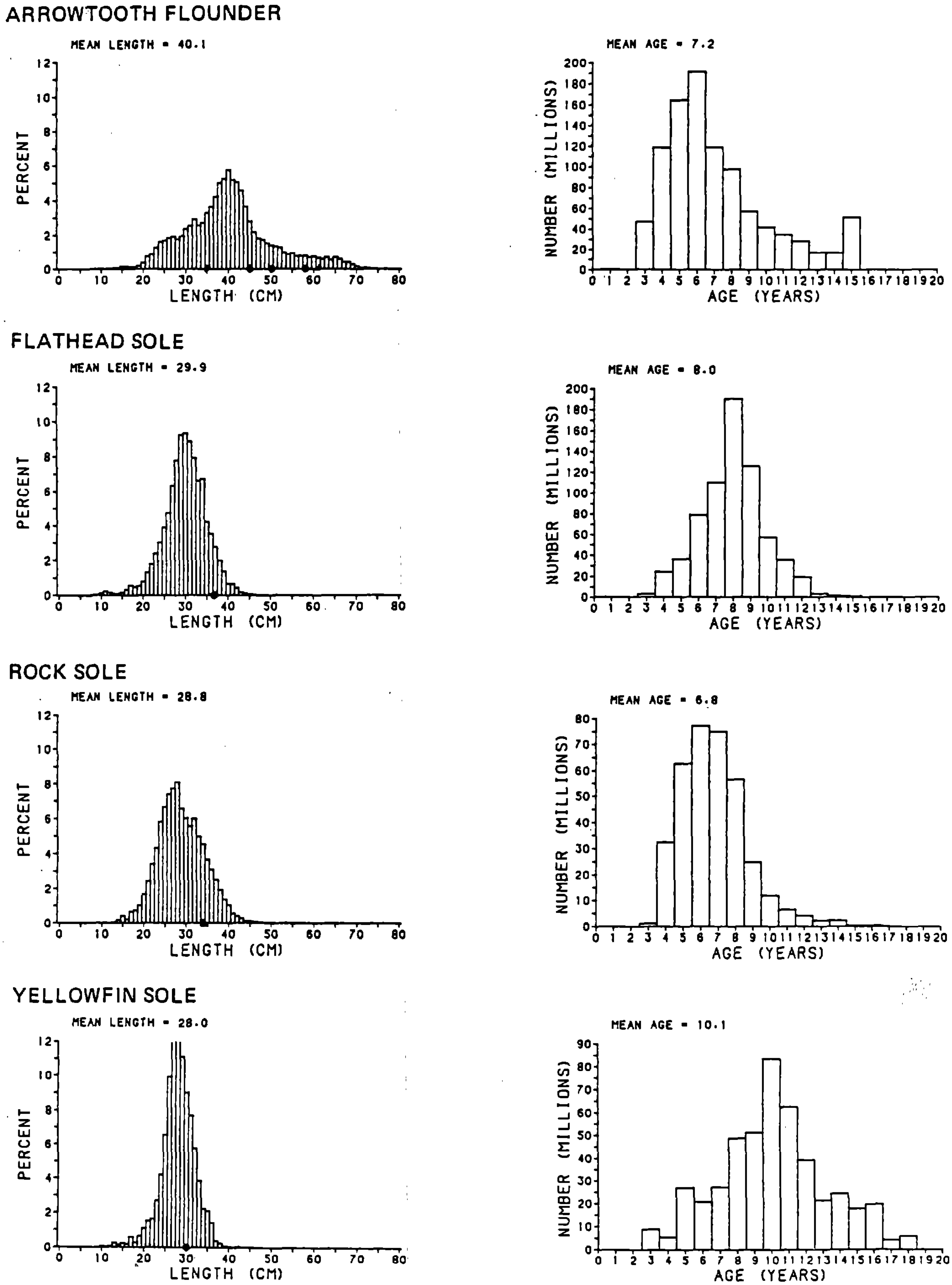

Figure 2.--Length and age composition of four flatfish species from the 1984 U.S.-Japan cooperative bottom trawl survey of the central and western Gulf of Alaska.

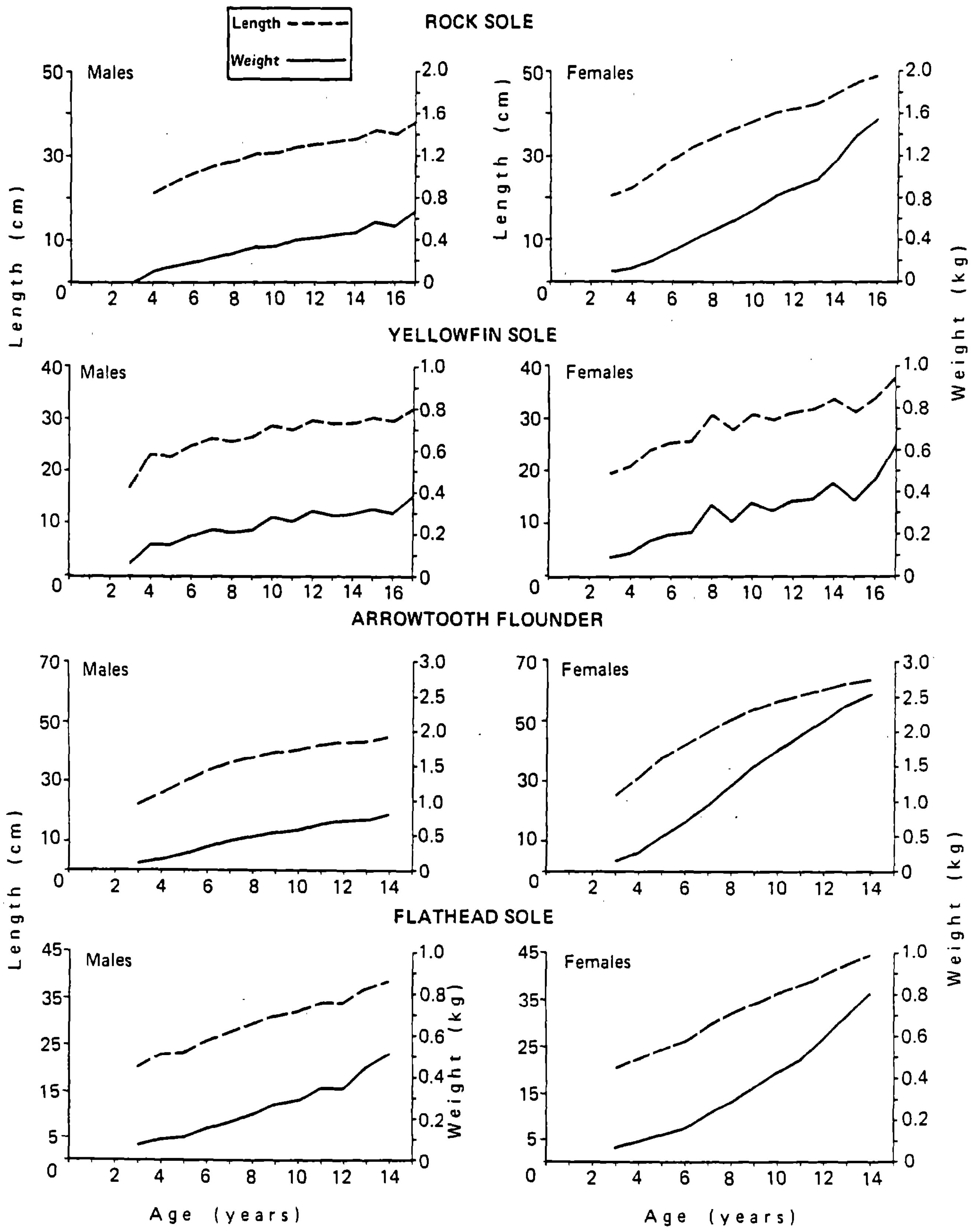

Figure 3.--Growth by length (cm) and weight (kg) of four flatfish species from the 1984 U.S.-Japan cooperative bottom trawl survey of the central and western Gulf of Alaska.

Table I.--Estimates of natural mortality, average recruitment, and significant ages of selected flatfishes of the Gulf of Alaska.

	Arrowtooth flounder		Flathead sole		Rock sole		Yellowfin sole	
	Male	Female	Male	Female	Male	Female	Male	Female
Natural mortality	0.304	0.361	0.817	0.862	0.529	0.638	0.314	0.343
Avg. recruitment at T_O (millions)	216	300	5,553	17,925	98	679	210	240
Age at first recruitment (T_O)	3	3	3	3	4	3	3	3
Age at 50% recruitment	6	5	8	8	5	6	8	9
Age at 100% recruitment	8	6	8	9	8	6	10	10
Age at 50% maturity	6	5	3	7	5	6	--	--

Table 5.--Maximum sustainable yield estimates (t) for selected Gulf of Alaska flatfish, based on 1984 bottom trawl surveys, by North Pacific Fishery Management Council regulatory area (percentages of the grand total are in parentheses).

	Area			
	Western	Central	Eastern	Total (%)
Deep-water species				
Arrowtooth flounder	9,934	92,125	24,403	126,462 (26)
Flathead sole	40,507	138,192	26,413	205,112 (43)
Other	2,873	22,052	4,749	29,674 (6)
All deep-water	53,314	252,369	55,565	361,248 (75)
Shallow-water species				
Rock sole	17,240	81,318	180	98,738 (21)
Yellowfin sole	6,647	2,839	11	9,497 (2)
Other	810	6,220	1,340	8,370 (2)
All shallow-water	24,697	90,377	1,531	116,605 (25)
All flatfish	78,011	342,746	57,096	477,853 (100)

indicating that their cohorts reach maximum biomass before they enter the fishery. Thus, the strategy yielding the greatest catch weight would be to take all of the fish as soon as they are available to the fishery. This strategy is clearly unrealistic, however, because it would result in a very small average size and a very low catch per unit effort (CPUE). The fact that these species begin reproduction after first entry into the fishery makes such high exploitation dangerous from the perspective of recruitment. While no spawner-recruit information is available to fully evaluate this danger, it is clear that if spawners are reduced to a low enough level, recruitment will suffer.

One alternative is the F (0.1) approach described by Gulland and Boerema (1973). This rule of thumb determines the fishing mortality where the marginal yield is one-tenth of the original CPUE in a very lightly exploited stock. This represents a compromise between a fishery which would maximize yield and an efficient fishery which would maintain a better spawning stock and mean size. Estimates of F (0.1) were 0.37 for arrowtooth flounder, 1.70 for flathead sole, 0.81 for rock sole, and 0.72 for yellowfin sole. These values and the natural mortality estimates can be used to estimate the proportion of a stock which would be harvested annually under this strategy from the formula:

$$\frac{Y}{B} = \frac{F}{F + M}\left(1 - e^{-(F + M)}\right)$$

where Y = yield, B = biomass, and F and M are fishing mortality and natural mortality, respectively. The resulting values are 0.15 for arrowtooth flounder, 0.50 for flathead sole, 0.40 for rock sole, and 0.47 for yellowfin sole. Because these values are strongly influenced by the natural mortality rates from the catch curve analysis, they also should be used with caution.

These biomass-yield ratios were multiplied by the 1984 biomass estimates to calculate current potential yield (Table 6). In addition, the mortality, recruitment, and selectivity estimates were used to estimate the biomass of these stocks at equilibrium with an F(O.l) fishery. The second half of Table 6 shows yield estimates at these stock levels. Since most of the other flatfish are small-mouthed flounders, their yields were estimated using the average biomass-yield ratios for rock sole and yellowfin sole. Although arrowtooth flounder has the highest current biomass and current potential yield, flathead sole yield at equilibrium is higher due to its higher productivity.

Due to the overlapping distributions of these species, it is not at all certain that they could all be fished at an optimum level simultaneously. Also, the fishery is likely to be limited by the potential for high by-catches of Pacific halibut.

Table 6.--Estimated potential yield (t) of selected flatfish in the Gulf of Alaska, based on data from 1984 trawl surveys with stocks A) at current levels and B) at equilibrium under conditions of an F(0.1) fishery, by North Pacific Fishery Management Council regulatory area (percentages of the grand totals are in parentheses).

	Area				
	Western	Central	Eastern	Total	(%)
A: CURRENT STOCK					
Deep-water species					
Arrowtooth flounder	15,336	142,221	49,091	206,648	(38)
Flathead sole	30,615	104,447	25,315	160,377	(30)
Other	6,542	46,524	11,145	64,211	(12)
All deep-water	52,493	293,192	85,551	431,236	(80)
Shallow-water species					
Rock sole	22,576	28,703	226	51,505	(10)
Yellowfin sole	25,117	10,728	42	35,887	(7)
Other	1,194	12,862	4,096	18,152	(3)
All shallow-water	48,887	52,293	4,364	105,544	(20)
All flatfish	101,380	345,485	89,915	536,780	(100)
B: AT EQUILIBRIUM					
Deep-water species					
Arrowtooth flounder	6,291	58,345	20,140	84,776	(34)
Flathead sole	17,274	58,935	13,885	90,094	(36)
Other	2,959	21,042	5,041	29,042	(11)
All deep-water	26,524	138,322	39,066	203,912	(81)
Shallow-water species					
Rock sole	10,923	13,885	109	24,917	(10)
Yellowfin sole	10,226	4,367	16	14,609	(6)
Other	540	5,819	1,852	8,209	(3)
All shallow-water	21,689	24,069	1,977	47,735	(19)
All flatfish	48,213	162,391	41,043	251,647	(100)

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OTHER SPECIES

by

Richard L. Major

INTRODUCTION

The fishes or groups of fishes in the "other species" category are currently of little economic value to the fisheries of the Gulf of Alaska. Although the groups making up the other species category: sculpins (family Cottidae), skates and sharks (class Chondrichthys), smelts (family Osmeridae), and octopuses (order Octopoda) are not the target objects of the present fisheries, they are regularly taken as by-catch. Nonetheless, with an eye to the ecological importance and potential economic importance of fishes in the other species category, it is instructive to examine the available information pertaining to their condition.

CATCH

Because of the relative unimportance of the other species category, there have been no special studies directed at assessing their condition. Commercial catch data provide virtually the only opportunity, therefore, to appraise the current status of the stocks. The catch data themselves, however, are not straightforward. Japan, for example, included Atka mackerel (Pleurogrammus monopterygius), in the 1977 data, and the 1979 catches included shortspine thornyhead (Sebastolobus alascanus). Similarly, rattails and grenadiers (family Macrouridae) have been in and out of the other species category. It was not until 1981 that the makeup of the other species category stabilized in its present form. Using 1981 as a starting point, therefore, catches are as follows (in metric tons (t)):

	Fishery category		
	Foreign	J. venture	Total
1981	7,112	33	7,145
1982	2,049	301	2,350
1983	2,255	391	2,646
1984	576	1,268	1,844
1985	97	2,246	2,343

It is clear that the total catch of other species remains at a low level. Because the magnitude of the catches and their distribution among the component foreign and joint venture fisheries are largely shaped by regulatory decree, the catches offer little real insight as to the condition of the other species group. Because the catches have been relatively small over the years, however, it is intuitively unappealing to project the stocks as being less than stable.

SPECIES COMPOSITION

It is worthwhile to note the similarity in species composition between the 1984 commercial catch and the samples taken by the 1984 U.S.-Japan cooperative bottom trawl survey of the central and western Gulf of Alaska (which, together with a complementary survey in the eastern gulf, is also referred to as the triennial survey). Expressed in terms of the major groups making up the other species category, composition was as follows (commercial catch first, then survey catches in parentheses): sculpins 50% (41%), skates 20% (32%), smelts 16% (9%), sharks 11% (16%), and octopuses 4% (2%). Excluded from the computations is a disproportionately large catch of eulachon (smelts; *Thaleichthys pacificus*), taken by the U.S.-Japan joint venture for walleye pollock (*Theragra chalcogramma*) in Shelikof Strait. This gives rise to the precaution that trawls are generally a poor tool with which to sample smelts--mainly because the species of this family primarily inhabit pelagic waters. It must be assumed, therefore, that the abundance of this family is substantially underestimated.

PARTIAL BIOMASSES OF SELECTED SPECIES

The 1984 U.S.-Japan cooperative bottom trawl survey in the central and western Gulf of Alaska provided data with which to generate biomass estimates for a few bottom-dwelling species or groups of species that were taken in fair number[1/]. Estimates are as follows:

Species	Biomass (t)
Skates	
Unidentified	74,174
Sharks	
Spiny dogfish (*Squalus acanthias*)	3,524
Salmon shark (*Lamna ditropis*)	6,391
Pacific sleeper shark (*Somniosus pacificus*)	166
Sculpins	
Myoxocephalus spp.	10,680
Yellow Irish Lord (*Hemilepidotus jordani*)	10,079
Bigmouth sculpin (*Hemitripterus bolini*)	5,073
Blackfin sculpin (*Malacocottus kincaidi*)	836
Spinyhead sculpin (*Dasycottus setiger*)	498
Total	111,421

1/ Personal communication with Eric Brown, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE., Seattle, WA 98115. (Data updated January 12, 1987.)

It is important to emphasize, for reasons of later discussion, that the so-called "total" biomass estimate is for the International North Pacific Fisheries Commission Shumagin, Chirikof, and Kodiak Statistical Areas only. Excluded, because data for the species of primary interest were scanty, are the Yakutat and Southeastern Statistical Areas. Also, smelts (which could make up a large element in the other species category), octopuses, and many sculpins are not included.

MAXIMUM SUSTAINABLE YIELD, EQUILIBRIUM YIELD, ACCEPTABLE BIOLOGICAL CATCH, AND OPTIMUM YIELD

The maximum sustainable yield, equilibrium yield, and acceptable biological catch have not been estimated for the other species category because of the dearth of information. Rather, the North Pacific Fishery Management Council, per terms of the Fishery Management Plan (FMP) for the Gulf of Alaska Groundfish Fishery, sets optimum yield (OY) at 5% of the sum of the OYs for the nine other species categories. Using this procedure, the 1986 OY was 12,186 t. Considering that 12,186 t is only 11% of the bare minimum current biomass estimated above (and probably a much lower percentage of the real biomass), the procedure called for in the FMP does not jeopardize the well-being of the other species category. The population, in fact, could probably sustain a higher harvest rate, providing that the weaker elements in the multispecies complex were not thereby imperiled.

SQUID

by

Thomas Wilderbuer

The abundance and potential yield of squid in the Gulf of Alaska have not been evaluated through research findings. However, catches of *Berryteuthis magister, Berryteuthis anonychus*, and *Gonatus* spp. by commercial fishing vessels and research vessels, and their occurrence in the stomachs of fish and marine mammals, indicate a large standing stock. Maximum sustainable yield is intuitively believed to be greater than 5,000 metric tons (t). Accordingly, optimum yield (OY) has been set at 5,000 t (North Pacific Fishery Management Council 1986).

Catches, however, have averaged just 428 t--most of which has been taken by foreign fleets fishing in the central and western gulf. Catches by joint venture fisheries are insignificant, with the squid being taken (as with the foreign fisheries) in the pursuit of other species. There have been no reported catches of squid by the U.S. domestic fishery.

The total catch of squid in the Gulf of Alaska has decreased sharply since 1981 as fishing by. foreign nations has decreased.

Table 1 .--Catch (t) of squid in the Gulf of Alaska, by fishery category, 1978-85.

Year	Japan	Rep. of Korea	Poland	U.S.S.R.	Mexico	Foreign total	Joint venture	Total catch	OY
1978	86	133	1	2	--	322	--	322	2,000
1979	259	143	9	1	13	425	--	425	5,000
1980	697	107	T	37	--	841	T	841	5,000
1981	554	562	19	--	--	1,135	T	1,135	5,000
1982	202	76	--	--	--	278	16	294	5,000
1983	252	15	--	--	--	267	4	271	5,000
1984	100	17	3	--	--	120	5	125	5,000
1985	4	2	--	--	--	6	7	13	5,000

T: Trace

Sources: 1978-84: Berger et al. (1986); 1985: personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE., Bin C15700, Building 4, Seattle, WA 98115.

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1986 U.S. RESEARCH SURVEYS AND RESEARCH PLANS FOR 1987 IN THE NORTHEASTERN PACIFIC OCEAN

by

Lael L. Ronholt

FIELD RESEARCH CONDUCTED IN 1986

Gulf of Alaska

U.S. Research

Walleye pollock: hydroacoustic stock assessment--A hydroacoustic survey to assess the magnitude of the walleye pollock spawning concentration in Shelikof Strait was completed during March-April aboard the NOAA ship *Miller Freeman*.

Walleye pollock: juveniles--During September-October a survey of juvenile (young-of-the-year) walleye pollock was conducted in the Kodiak Island-Aleutian Peninsula areas of the Gulf of Alaska. Echo sounding, midwater trawling, and on-bottom trawling were employed aboard the NOAA vessel *John N. Cobb* to study distribution and abundance.

Walleye pollock: egg and larvae study--During April-May, ichthyoplankton surveys focusing on the early life history of walleye pollock were conducted aboard the NOAA vessel *Miller Freeman*. Specific objectives were to 1) estimate the magnitude of the spawning stock in Shelikof Strait from egg surveys, 2) relate the distribution of eggs and larvae to oceanographic conditions, and 3) trace the drift and assess the feeding condition of larvae. This research was part of the Fisheries-Oceanographic Experiment (FOX) (see below).

FOX--This multi-discipline, multi-agency research was undertaken in Shelikof Strait to examine the environment in which walleye pollock spawn and the young develop. The NOAA ship *Miller Freeman* provided the research platform for scientists from NOAA's Pacific Marine Environmental Laboratory and the Northwest and Alaska Fisheries Center. This research was supported under the new NOAA initiative, FOCI (Fisheries-Oceanography Coordinated Investigations).

Sablefish: longline experiment--A longline gear experiment to study the effects of hook spacing and soaking time on catch rates was conducted off southeastern Alaska during June aboard the NOAA ship *John N. Cobb*.

Sablefish: trap survey--The annual trap index survey off southeastern Alaska was conducted during July aboard the NOAA ship *John N. Cobb*.

Sablefish: juvenile tagging--Juvenile sablefish were captured and tagged during July-August aboard the NOAA ship *John N. Cobb*.

Sablefish: flesh quality--During January-February, sampling was conducted aboard the NOAA ship John N. Cobb to study the flesh quality of sablefish and its relationship to water depth.

Sablefish: early life history-- During January-February, a survey to locate spawning locations and to determine the timing of spawning of sablefish was conducted aboard the NOAA ship Miller Freeman.

Pacific ocean perch: age composition--A trawl survey was conducted during January-February aboard the NOAA ship Miller Freeman to provide data on the age composition of the Pacific ocean perch stock off southeastern Alaska.

Cooperative Research

Sablefish: longline survey--The annual Japan-U.S. cooperative longline survey of the Gulf of Alaska was conducted during July-September aboard the Fukuyoshi Maru No. 8. This survey provides data on the distribution and abundance of Pacific cod, sablefish, and other deep-water species.

Ichthyoplankton: eggs and larvae--During March-April, the U.S. and the U.S.S.R. conducted a cooperative ichthyoplankton survey in the central Gulf of Alaska aboard the Soviet research vessel Gissar. The survey was included in the previously described FOX experiment.

walleye pollock: hydroacoustic-- A hydroacoustic survey to locate spawning concentrations of walleye pollock was conducted in the eastern and central portions of the Gulf of Alaska. Cooperative U.S.-U.S.S.R. survey operations were conducted aboard the Soviet research vessel, Gissar during March.

U.S. West Coast Research

Groundfish: resource assessment--The fourth triennial trawl/hydroacoustic survey of the groundfish resources on the west coast of the United States was conducted during July-October using the charter vessels Pat San Marie and Alaska. Principal species of interest for the 1986 survey were Pacific whiting, yellowtail rockfish, and canary rockfish.

Sablefish: trap index study--The annual trap index study to measure changes in the abundance of sablefish along the west coast was conducted aboard the charter vessel American Viking during September-October. Also, sablefish were tagged as part of the continuing program to study their movements. Transition from rectangular to conical traps was completed during 1986.

FIELD RESEARCH PLANS FOR 1987

Gulf of Alaska

U.S. Research

Walleye pollock: juveniles--A survey to study the distribution and relative abundance of young-of-the-year walleye pollock is planned for the western Gulf of Alaska.

FOCI--Field research will continue and expand the studies on walleye pollock and larvae in Shelikof Strait--studies initially started as the FOX program. A survey is planned during April-July aboard the NOAA ship Miller Freeman to trace the development, distribution, drift, and feeding condition of young-of-the-year walleye pollock through the early juvenile stages.

Sablefish: longline survey--The first U.S. longline survey of the sablefish, Pacific cod, and other deep-water resources is scheduled for the Gulf of Alaska during the summer of 1987.

Sablefish: longline experiments--Gear experiments to study the effect of hook spacing on the catch rates will continue in 1987 aboard the NOAA ship John N. Cobb.

Sablefish: habitat--A study designed to relate the distribution of sablefish to habitat types is scheduled to begin in 1987.

Sablefish: feeding study--Also scheduled to begin in 1987 is a study to obtain data on the feeding habits of sablefish.

Sablefish: trap surveys--The annual trap index off southeastern Alaska is expected to continue in 1987.

Pacific ocean perch: hydroacoustics--A program to begin assessing the Pacific ocean perch stock off southeastern Alaska using hydroacoustic techniques is planned for 1987.

Walleye pollock: hydroacoustic resource assessment--A hydroacoustic survey to assess the condition of the walleye pollock spawning concentration in Shelikof Strait is planned for March of 1987, using the NOAA ship Miller Freeman.

Cooperative Research

Groundfish: resource assessment--A second cooperative U.S.-Japan groundfish resource assessment survey of the Gulf of Alaska is anticipated during the summer of 1987.

Sablefish: longline survey--The annual cooperative Japan-U.S. longline survey for sablefish, Pacific cod, and other deepwater species is anticipated for the summer of 1987.

West Coast

Sablefish: abundance index--A survey is scheduled for August-September off the Washington and Oregon coast to obtain standardized catch per unit effort and biological data for monitoring population changes of sablefish. Tagging will also be continued to study the movement of juveniles (particularly into Canadian fisheries) and tag loss.