NOAA Technical Memorandum NMFS F/NWC-80

Condition of Groundfish Resources of the Gulf of Alaska Region As Assessed in 1984

Edited by
Richard L. Major

May 1985

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

This TM series is used for documentation and timely communication of preliminary results, interim reports, or special purpose information, and has not received complete formal review, editorial control, or detailed editing.

CONDITION OF GROUNDFISH

RESOURCES OF THE GULF OF ALASKA REGION

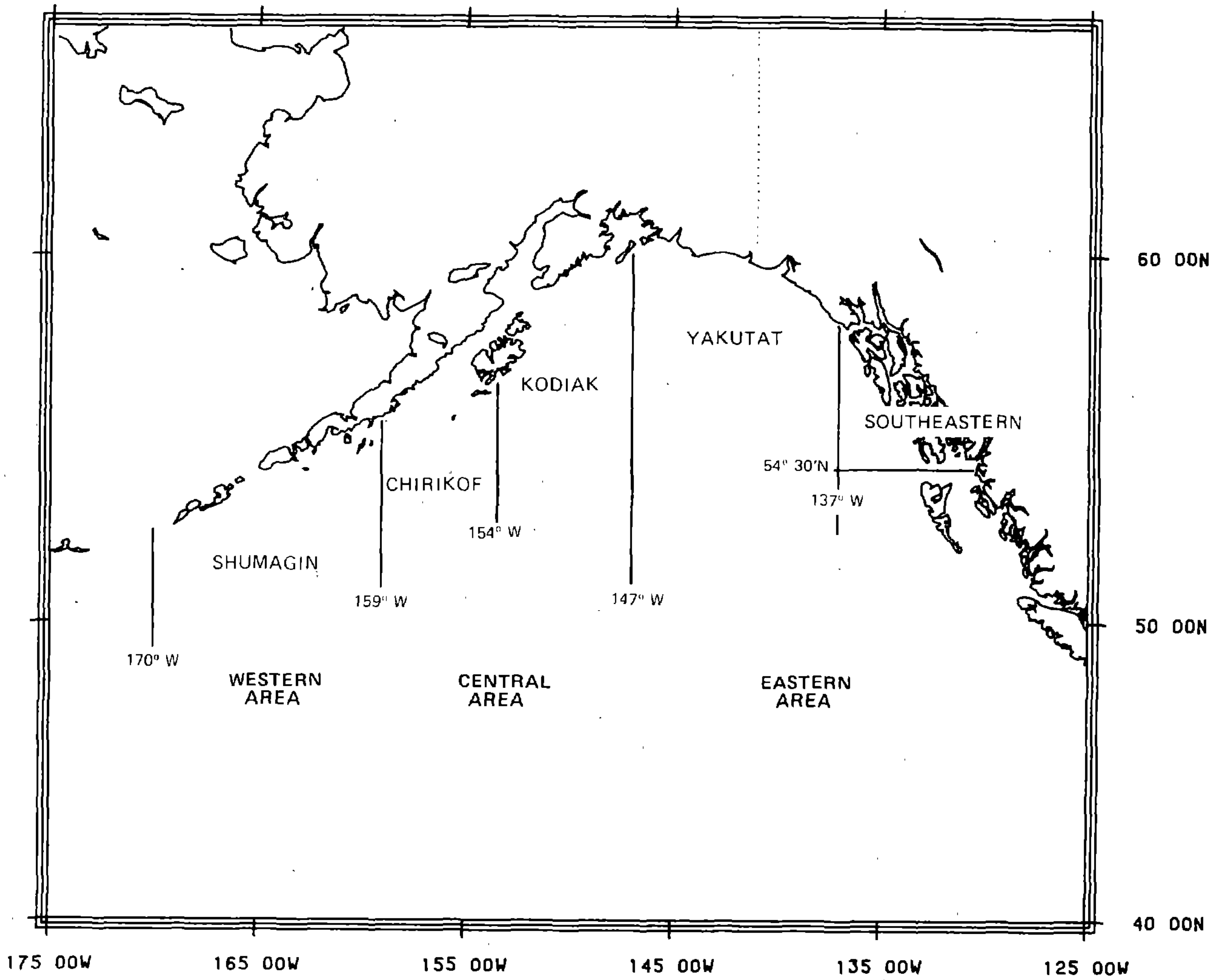
AS ASSESSED IN 1984

Edited by

Richard L. Major

Northwest and Alaska Fisheries Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
7600 Sand Point Way NE
Bin C15700, Bldg 4
Seattle, Washington 98115

May 1985



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

Presented here are 10 contributions by U.S. scientists dealing with Gulf of Alaska groundfish resources. The papers were originally submitted as an annual report to the International North Pacific Fisheries Commission in October 1984 by the U.S. National Section. Eight of the 10 contributions summarize information on the condition of commercially important species--walleye pollock, sablefish, Pacific cod, Atka mackerel, Pacific ocean perch, thornyhead rockfish, flatfish, and squid. There are also descriptions of the commercial fisheries for walleye pollock in 1983 and 1984, and of acoustic-midwater trawl surveys on the spawning populations of walleye pollock on the Shelikof Strait region in 1980, 1981, 1983, and 1984. Finally, the 1984 U.S. research surveys are reviewed and plans for 1985 are outlined.

Table A.--Gulf of Alaska groundfish: optimum yield (OY) and catch (t) 1977-84, current status of stocks, and abundance trends.

Species and Year	OY	Catch: Foreign	J. Venture	Domestic	Total	Status of Stocks	Abundance trend
Walleye pollock							
1977	150,000	117,835	0	228	118,063		
1978	168,800	96,328	34	1,044	97,406		
1979	168,800	103,807	566	2,031	106,404		
1980	168,800	112,997	1,136	904	115,037		
1981	168,800	130,324	16,826	563	147,713		Exploitable
1982	168,800	92,612	73,918	2,217	168,747		biomass
1983	256,600	81,318	134,131	120	215,609		declining
1984	416,600	99,212	207,115	329	306,656	Good	in 1985
Sablefish							
1977	22,000	15,959	0	1,179	17,138		
1978	15,000	7,127	0	1,738	8,865		
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	9,480	4,965	275	3,761	9,001		
1984	9,480	1,110	533	8,454	10,097	Fair	
Pacific cod							
1977	6,300	1,988	0	270	2,258		
1978	40,600	11,369	7	785	12,161		
1979	34,800	13,174	712	985	14,871		
1980	60,000	34,245	466	611	35,322		
1981	60,000	34,969	58	1,060	36,087		
1982	60,000	26,936	193	2,250	29,379		
1983	60,000	29,777	2,426	4,198	36,401		
1984	60,000	15,976	4,657	2,206	22,839	Good	Stable
Atka mackerel							
1977	20,000	19,455	0	0	19,455		
1978	24,800	19,586	0	0	19,586		
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		Stock
1982	28,700	6,760	0	0	6,760		disappearing
1983	28,700	11,470	790	0	12,260		in Central
1984	28,700	536	585	31	1,152	Depressed	Gulf
Pacific ocean perch							
1977	30,000	23,581	0	12	23,593		
1978	25,000	8,171	0	5	8,176		
1979	25,000	9,750	67	105	9,922		
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	2,580	1,734	119	4,433	Depressed	

Table A.--Continued.

Species and Year	OY	Catch: Foreign	J. Venture	Domestic	Total	Status of Stocks	Abundance trend
Thornyhead rockfish							
1977	--	0[a]	0	0	0		
1978	--	0[a]	0	0	0		
1979	--	0[a]	0	0	0		
1980	3,750	1,351	0	0	1,351		
1981	3,750	1,340	0	0	1,340		
1982	3,750	788	0	0	788		
1983	3,750	718	12	0	730		
1984	3,750	164	19	24	207	Unknown	
Flatfish							
1977	23,500	16,038	0	684	16,723		
1978	33,500	14,314	5	852	15,171		
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	3,040	3,466	641	7,147	Good	
Squid							
1977	--	0[a]	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		Assumed to
1984	5,000	120	5	0	125	Unknown	be stable

[a]There probably were small catches of thornyhead rockfish in 1977-80 and squid in 1977 but the source used here (Berger et al. 1985) does not list them inasmuch as OY had not yet been established.

Definition of Pacific ocean perch: foreign and joint venture catches 1977: all species of rockfish; 1978: only Pacific ocean perch; 1979-84: Pacific ocean perch and 4 similar species. Domestic catches: only Pacific ocean perch.

Sources: foreign and joint venture catches: Berger et al. 1985; domestic catches 1977-80: Rigby 1984; domestic catches 1981-84: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 S.W. Fifth Avenue, Portland, OR 97201. (Full references for Berger et al. 1985 and Rigby 1984 are given on page 34 of the text.)

CONTENTS

CONDITION OF THE WALLEYE POLLOCK RESOURCE OF THE GULF OF ALASKA AS ESTIMATED IN 1984

by

Miles S. Alton and Craig S. Rose

The Gulf of Alaska walleye pollock, *Theragra chalcogramma*, is considered a separate stock from those of the Bering Sea and Aleutian Islands. The Shelikof region near Kodiak Island is a major spawning site where it is assumed that fish from various parts of the western and central Gulf mix from January through April for reproduction; The existence of other, but relatively minor, spawning sites in the western and central Gulf has been inferred from the occurrences of eggs and larvae during ichthyoplankton surveys. A minor spawning aggregation was also found in Prince William Sound during an April 1984 hydroacoustic survey [Nelson and Nunnallee 1985 (in this report)].

Most of the Gulf of Alaska pollock resource lies within the central and western regulatory areas where the fisheries are concentrated (Alton et al. 1977). Currently, there are two distinct types of fisheries that harvest Gulf of Alaska pollock: joint venture fisheries that take most of their catch during the pollock's reproductive period in the Shelikof Strait region, and trawl fisheries by foreign nationals that operate outside of the Shelikof region during May-December in the western and central Gulf [Alton 1985 (in this report)]. The pollock catch by conventional domestic fisheries (domestic fisheries other than joint venture fisheries) remains negligible.

The annual pollock catch by all nations and fisheries in the Gulf of Alaska continued to increase in 1983, reaching 215,600 metric tons (t). Joint venture operations accounted for 62% of the catch, with most of the remainder being shared by Japanese and Korean trawl fisheries. The 1984 joint venture fisheries caught an estimated 207,100 t from the Shelikof region, the highest so far from that region;

Optimum yield (OY) of pollock for the western and central regulatory areas was set at 240,000 t in 1983; an increase of 54% over that of 1982. For 1984 it was raised again to 400,000 t. The OY for the eastern regulatory area remained 16,600 t.

Catch-at-age analysis by Alton and Deriso (1983a, 1983b) indicated that Gulf of Alaska pollock increased substantially between 1976 and 1982 (from 0.6 to 2.6 million t of exploitable biomass) because of a succession of five strong year classes (1975-79). Biomass estimates from hydroacoustic surveys on the pollock spawning stock in 1983 fairly well matched the estimates obtained from the catch-at-age analysis for that year.

There was no acoustic survey in 1982, but the 1981 and 1983 survey biomass estimates indicate that stock size declined between these two, years. Catch per unit effort (CPUE) information provided by Japanese scientists showed a trend toward increasing stock size from 1977 to 1982 (Alton and Deriso 1983b). The 1983 CPUE value was not available for this report.

Here we emphasize the results of the hydroacoustic surveys of 1981, 1983, and 1984 in evaluating the current stock condition of Gulf of Alaska pollock. We have not updated the catch-at-age analysis to include more recent data because of problems with fitting the catch-at-age model to the updated catch statistics (Alton and Deriso 1983b). We are continuing our analysis of the fisheries data, but consider the results of the hydroacoustic surveys the best data with which to interpret the changes occurring in pollock abundance and recruitment.

EVALUATION OF STOCK CONDITION

The poor showing of 3-year-old fish in the 1983 joint venture fisheries and the hydroacoustic research survey sampling in the Shelikof region was the first indication that the 1980 year class was potentially weak, thereby interrupting a series of strong year classes (1975-79). Confirmation that the 1980 year class was weak came in early 1984 when these fish, now 4-year-olds, were relatively scarce in the fisheries and in the hydroacoustic survey. Normally age-4 fish are an important contributor to the joint venture fisheries [Alton 1985 (in this report)].

The weakness of the 1980 year class has contributed to the continued decline of the stock--as evidenced from the hydroacoustic trawl survey biomass estimates [Nelson and Nunnallee 1985 (in this report)] obtained in the Shelikof region since 1981:

	Year of Survey			
	1981	1982	1983	1984
Biomass (million t)	3.8	no survey	2.4	1.8

Based on the 1984 acoustic survey results, the abundance of age-3 fish appears to be low for a second consecutive year. The estimated numbers of 3-year-old fish (10^6) are 1,490.7, 325.7, and 258.9 for the 1981, 1983, and 1984 surveys, respectively. These are fish from the 1978, 1980 and 1981 year classes. Although age-3 fish are not fully recruited to survey sampling gear, the 3-year time series appears to be providing a relative measure of abundance of recruiting year classes.

The 1981 estimate of 3-year-olds was high; these fish represented a strong year class (1978) which ultimately dominated the commerical catch in 1982, 1983, and early 1984. The 1983 survey estimate of the 1980 year class at age 3 was low; this year class definitely appears to be weak judging from samples obtained from the commercial catch in 1984. Since the estimate of the 1981 year class as three-year-olds is also low, that year class may also be weak.

To assess the impact of two successive poor year classes on the stock biomass in the near future, projections of exploitable biomass were made using various recruitment conditions and various catch levels. These projections were generated with a program written by Bernard Megrey[1/], which forecasts biomass and exploitable biomass from an initial population given parameter values for natural mortality, growth, and age selectivity of the fisheries and a schedule of catches and recruitment. The initial population size used in making the forecasts was derived from the 1984 hydroacoustic survey of Shelikof Strait. Other parameters were estimated from previous catch-at-age analyses. This age-specific simulation model accounts for the partitioning of the annual catch between the foreign and joint venture fisheries.

For these projections, six scenarios of recruitment were considered. Recruitment was defined in a general sense as the population of age-3 fish early in the year. Three recruitment levels were used: below average (500 million fish), average (1,500 million fish), and above average (2,500 million fish). These levels were based on estimates of age-3 fish from catch-at-age analyses (Alton and Deriso 1983a). The scenarios were as follows:

Scenario	1984	1985	1986	1987
A	below	below	below	below
B	average	below	below	below

[1/]Center for Quantitative Sciences, University of Washington, Seattle, WA 98105.

Scenario	1984	1985	1986	1987
C	below	average	average	average
D	average	average	average	average
E	below	above	above	above
F	average	above	above	above

Recruitment in early 1984 was considered below average (at best, average). For all scenarios the 1984 catch was kept at 300,000 t, which appears to be a realistic figure; for subsequent years (1985 and 1986) six catch levels were used (0 t, 150,000 t, 200,000 t, 250,000 t, 300,000 t, and 400,000 t). Projections are terminated at the beginning of 1987. Instantaneous natural mortality was fixed at 0.4 for all ages and years. Projections were in terms of exploitable biomass (EB) since this represents the portion of the stock that is available to the fisheries and is involved in most of the reproduction.

The changes in EB for each scenario are given in Figure 1. The initial EB for early 1984 has two values because of the two different beginning recruitment levels: 1.69 million t when recruitment is below average and 1.74 million t when recruitment is average. The EB for early 1985 is constant for each scenario because the 1984 catch was fixed at 300,000 t. The analysis suggests the following population changes:

1. EB will continue to decline in 1985 regardless of the recruitment level set for 1984 and 1985. Under two of the worst possibilities (scenarios A and C): below average recruitment for both 1984 and 1985 or below average recruitment in 1984 and average recruitment in 1985), EB will drop to 1.2 and 1.27 million t respectively by early 1985, a decrease of some 400,000 to 500,000 t.

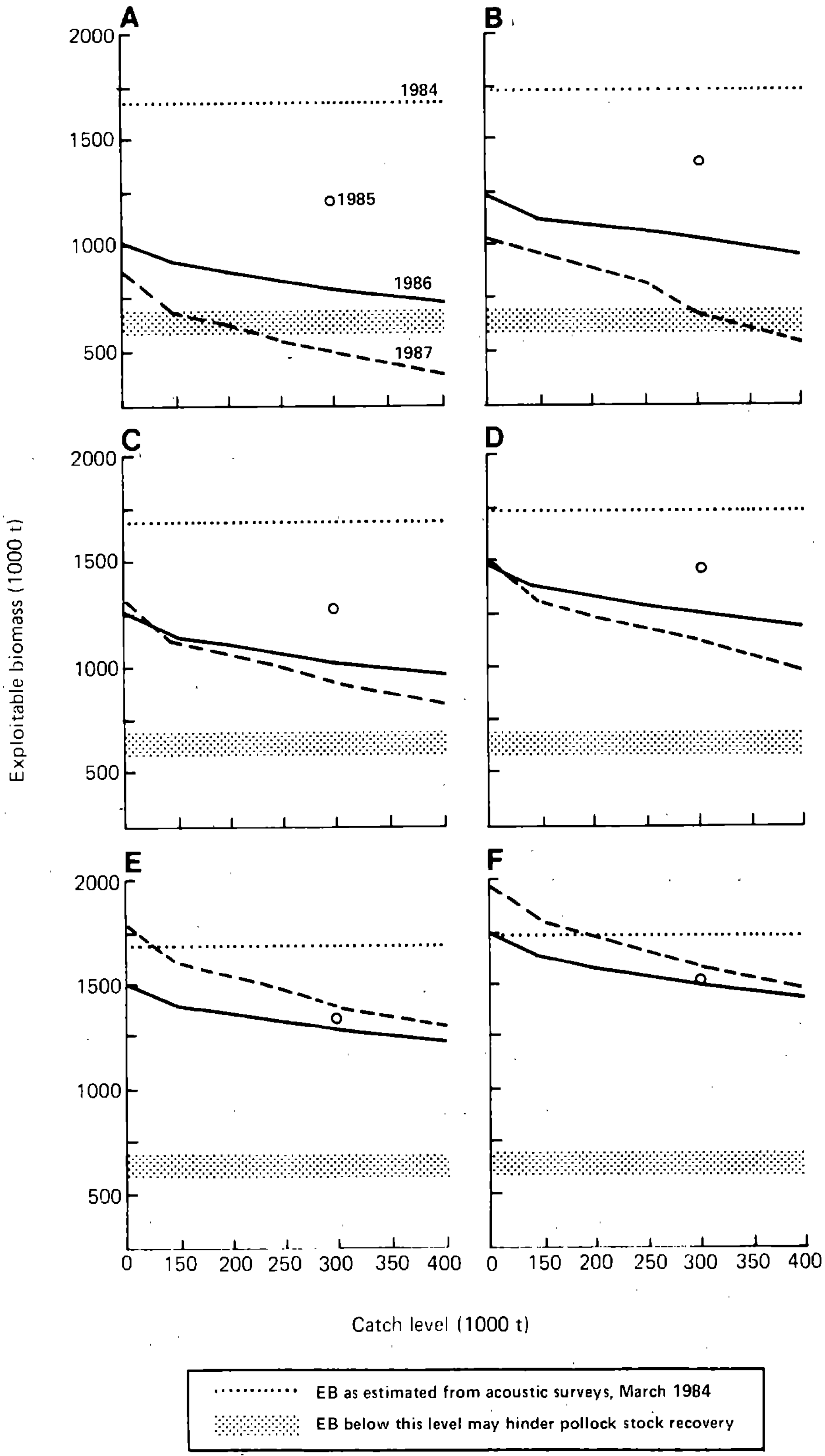


Figure 1. --Changes in exploitable biomass of pollock for various catch and recruitment levels: A. below average recruitment in 1984-87; B. average recruitment in 1984 and below average recruitment in 1985-87; C. below average recruitment in 1984 and average recruitment in 1985-87; D. average recruitment in 1984-87; E. below average recruitment in 1984 and above average recruitment in 1985-87; F. average recruitment in 1984 and above average recruitment in 1985-87. (Recruitment refers to the population of 3-year old fish.)

2. Under the poorest recruitment, schedule--below average for all years (scenario A)--the 1984 expected catch level of 250,000 to 300,000 t, if continued in 1985 and 1986, would reduce the EB to some 500,000-600,000 t by the beginning of 1987. If there were no catch in 1985 and 1986, EB would drop to 850,000 t.
3. Average recruitment for all years (scenario D) would lower EB to 1.2 to 1.3 million t by 1987, given an annual catch of, 250,000-300,000 t.
4. The most favorable conditions would come about with above average recruitment for 1985-87 (scenarios E and F). This would result in an EB above or approximately to the expected 1985 EB level (1.32-1.5 million t), given annual removals by the fisheries of 250,000-300,000 t.
5. An annual catch of 400,000 t in 1985 and 1986 could lower EB to 500,000 t or less if recruitment is below average in 1985-87 (scenarios A and B).

These projections demonstrate how sensitive pollock abundance is to recruitment. This sensitivity is attributed to the large differences that are possible in year-class strength. Alton and Deriso (1983b) have estimated that the most abundant year class at age 3 and the least abundant at that age during the years, 1976-82, differed in number by a factor of six. Within that brief period, EB went from approximately 600,000 t to 2.6 million t (Alton and Deriso 1983b). The low EB in 1976 and 1977 was the result of two consecutive weak year classes (1973 and 1974) that followed a strong year class.

There are now indications of another pair of weak year classes following a period of high biomass. Optimum yield currently set at 400,000 t which, if taken in 1985 and 1986, would decrease EB to below 1 million t by early 1987, given below average or average recruitment for 1984-87 (Figure 1).

Since EB is declining, consideration should be given to establishing some minimum level of EB (below which harvest would be seriously restricted) in order to allow the stock to rebuild and avoid serious impacts on fisheries and on populations of other fish that feed on pollock. This could mean reducing the pollock catch in the near future. However, catch reduction, might have no effect on a declining pollock population, since other factors such as predation may be the primary cause of the decline. The introduction of an increasing amount of biomass into the ecosystem of the central and western Gulf of Alaska during 1977-82 could have caused a positive, but lagged, response in the abundance of pollock predators, so that by the early 1980's predator populations may have reached high levels. Important predators of pollock are Pacific halibut, *Hippoglossus stenolepis*, and Pacific cod, *Gadus macrocephalus*. Other predators are birds which feed on very young pollock, and marine mammals which consume subadults and adults.

Assuming that a decline in pollock abundance could be arrested by control of the fisheries, it is not clear what the level of EB should be to allow rebuilding and at the same time minimize the impact on the fisheries and predator populations. Our limited knowledge shows that the 1976 and 1977 populations produced exceptional year classes, yet the EB in those years (600,000-700,000 t) was the lowest for the period for which we have information on the stock (1976-84). This level of EB then, could be considered the minimum that could be tolerated if the stock were to rebuild without having drastic effects on the fisheries and other populations. Of course, we know very little about the interactions between pollock and its predators and are assuming that the minimum EB level suggested would not seriously reduce predator populations.

If results from the early 1985 assessment survey indicate that the worst possible recruitment situation has become reality (below average recruitment for 1984 and 1985), then a catch level of 250,000-300,000 t in 1985 would, according to our projections (Figure 1), reduce EB to about 800,000-900,000 t in 1986. This approaches the suggested minimum allowable level. There would be a lag effect, however, in that EB would continue to drop and, if a strong year class was produced in 1986, it would not begin contributing significantly to EB until 1989 or 1990. There remains, of course, the possibility that recruitment could improve in 1985, and that recruitment in 1984 may not have been as low as the survey results suggest.

RESEARCH AND ANALYSIS: ONGOING AND SCHEDULED

1. The annual acoustic trawl survey will be continued in early 1985 to obtain estimates of pollock biomass and its composition in the Shelikof region.
2. Analysis of fisheries data will continue in 1985 to better understand the changes that have taken place in the stock due to the fisheries and natural causes.
3. Biochemical genetic studies and analysis of growth data will continue in an effort to understand the stock structure of the Gulf of Alaska pollock.

REFERENCES

Alton, M. S. 1985. Walleye pollock fisheries of the Gulf of Alaska, 1983-84. In R. L. Major (editor), Condition of groundfish resources of the Gulf of Alaska region as assessed in 1984., p. 11 U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-80.

Alton, M. S., and R. B. Deriso. 1983a. Pollock. In D. Ito and J. Balsiger (editors), Condition of groundfish resources of the Gulf of Alaska in 1982, p. 1-62. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-52.

Alton, M. S. and R. B. Deriso. 1983b. Condition of Gulf of Alaska pollock resource. In G. Stauffer (editor), Condition of groundfish resources of the Gulf of Alaska region as assessed in 1983, p. l-l to 1-19. NWAFC Processed Rep. 84-2. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112. (Document submitted to the International North Pacific Fisheries Commission in October 1983.)

Alton, M., S. Hughes, and G. Hirschhorn. 1977. Gulf of Alaska pollock--its fisheries and resource potential. Unpubl. rep., 25 p. Northwest and Alaska Fish. Cent. Natl. Mar. Fish. Serv. NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Nelson, M. O., and E. A. Nunnallee. 1985. Acoustic-midwater trawl surveys of spawning walleye pollock in the Shelikof Strait region, 1986-81. In R. L. Major (editor), Condition of groundfish resources of the Gulf of Alaska region as assessed in 1984. p. 179 U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-80.

WALLEYE POLLOCK FISHERIES OF THE GULF OF ALASKA 1983-84

by

Miles S. Alton

This report updates information for walleye pollock, _Theragra chalcogramma,_ fisheries of the Gulf of Alaska as given by Alton (1983) by including data for all fisheries in 1983 (foreign, joint venture, and domestic) and for joint venture fisheries in the Shelikof Strait region, January-April 1984.

DATA SOURCES AND COMPILATION PROCEDURES

Catch

Each foreign nation reports its annual catch by statistical blocks of 1° longitude and 1/2° latitude, by month, and by vessel class. This information is used here to describe the time-space distribution of the catch of pollock by the foreign nation's fisheries and to indicate the proportion of the catch taken by the various vessel classes. For estimates of the pollock catch by foreign nation fisheries as well as by joint venture fisheries a "best blend" is used. This "best blend" is obtained from U.S. observer sampling as described by Wall et al. (1981). Domestic catch was obtained 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 1983 was 51% and 38%, respectively. For the 1984 joint venture fisheries in the Shelikof Strait region (January-April), observer coverage was 88%.

Length and Age Composition

Estimates of the length and age composition of both the foreign and joint venture catch come from 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 is given by Nelson et al. (1981). The procedures for determining the age of pollock from otoliths is described by LaLanne (1979), and the procedure for estimating the age composition of the pollock catch is given by Alton and Deriso (1983).

ALL FISHERIES

1. The annual pollock catch in the Gulf of Alaska reached its highest level, 215,600 metric tons (t), in 1983 (Table 1), but that total seems certain to be exceeded in 1984.
2. Catch by foreign fisheries continued to decline in 1983 while that of joint venture fisheries continued to increase. Domestic catches continued to be at a very low level in 1983 (Table 2).
3. Eighty-one percent of the annual catch in 1983 was taken in the North Pacific Fishery Management Council (NPFMC) central regulatory area followed by 18% in the western area and less than 1% in the eastern regulatory area (Table 2).

FOREIGN FISHERIES

1. Only Japanese and Republic of Korea (ROK) vessels were involved in foreign directed fisheries in 1983. Pollock catch by Japanese fisheries was greater than that by ROK fisheries (Table 2).
2. In the 1983 Japanese trawl fisheries, surimi factory trawlers continued to take most of the catch (Table 3). Catch by this vessel type increased markedly in the last quarter of 1983 (Fig. 1). The availability of pollock, as indicated by the catch per unit effort (CPUE) of surimi factory trawlers, also increased markedly in the last quarter (Fig. 2).

Table 1.--Catch (1,000 t) of pollock in the Gulf of Alaska, by fishery category, 1977-84.

Year	Fishery category			
	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	N.A.	207.1	N.A.	N.A.

T: Trace.

N.A: Not available.

Sources: Foreign and joint venture catches: Berger et al. 1985. Domestic catches 1978-80: Rigby 1984. Domestic catches 1981-83: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 S.W. Fifth Avenue, Portland, OR 97201.

Table 2.--Catch (t) of pollock in the, Gulf of Alaska in 1983 by fishery category and North Pacific Fishery, Management Council regulatory area.

Nation or fisheries category	Area			
	Western	Central	Eastern	All areas
Japan	17,492	30,192	41	47,725
Republic of Korea	21,827	11,806	0	33,633
Joint venture	497	133,634	0	134,131
Domestic	1	118	0	119
Total	39,817	175,750	41	215,608

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 N.E., Seattle, WA 98115. Domestic catch: Pacific Fishery Information Network (PacFin), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 S.W. Fifth Avenue, Portland, OR 97201.

Table 3.--Japanese catch (1,000 t) of pollock in the Gulf of Alaska by trawler class, 1976-83.[a,b]

	Trawler class			
Year	Surimi factory trawler (1,500-4,505 gt)	Small freezer trawler (<1,500 gt)	Large freezer trawler (1,500-4,504 gt)	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

[a]Foreign reported catch for 1976 and 1977; best blend estimate for 1978-83.

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

Source: Personal communication with Jerald Berger, U.S. Foreign Fisheries Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin Cl5700, Building 4, 7600 Sand Point Way N.E., Seattle, WA 98115.

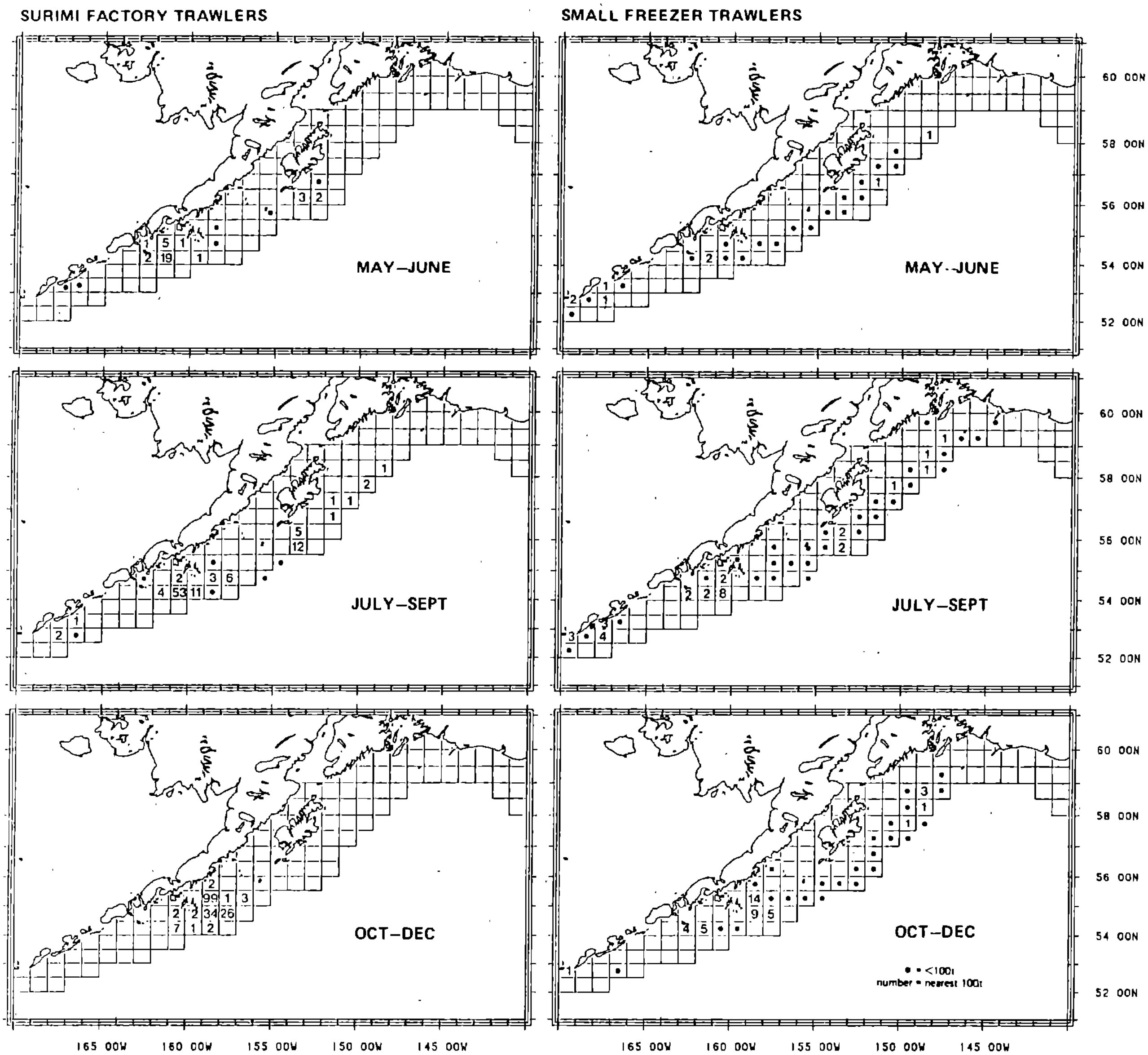


Figure 1.--Distribution of pollock catch by Japanese trawlers (surimi factory trawlers and small freezer trawlers) in the Gulf of Alaska in 1983.

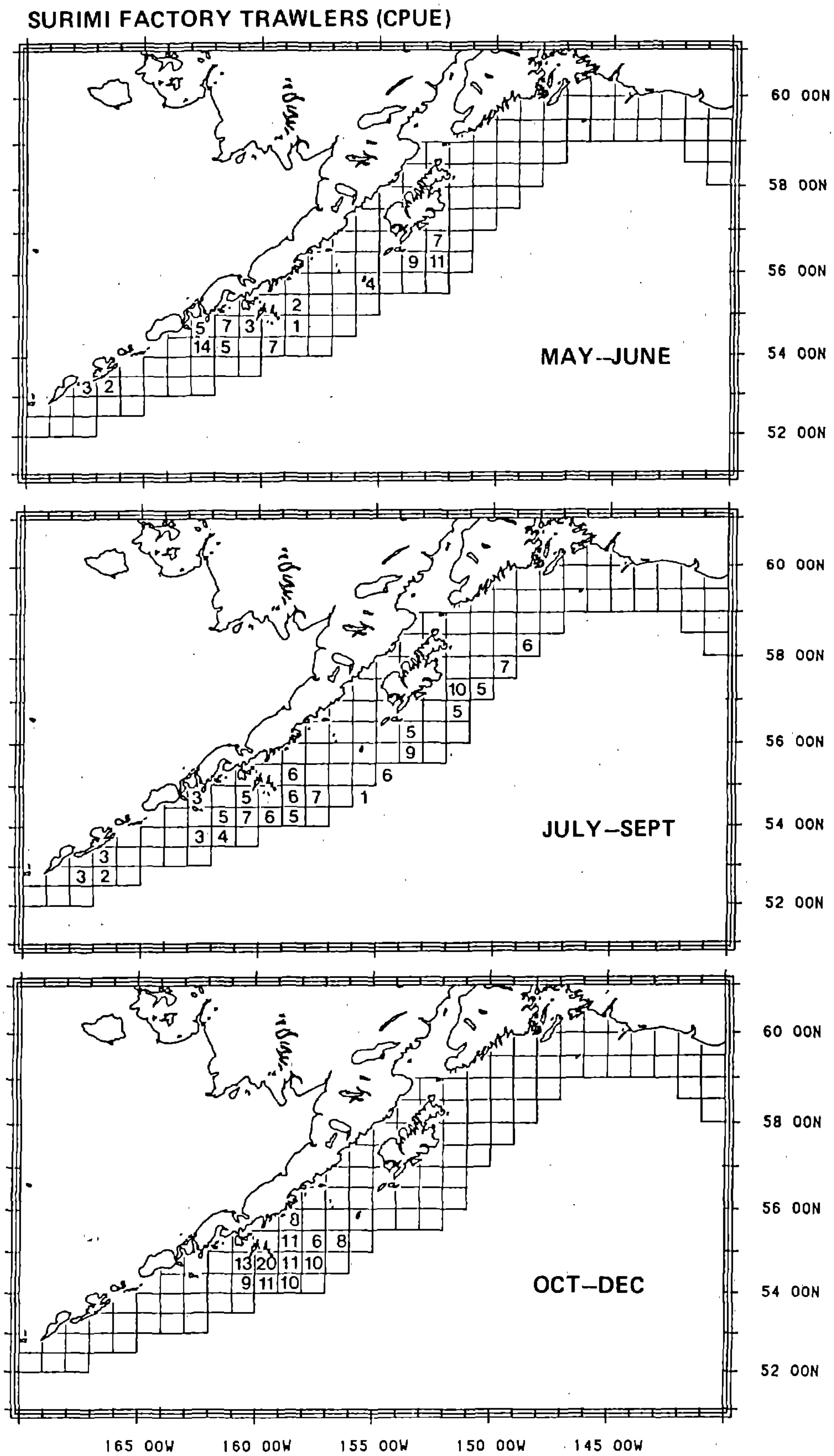


Figure 2.--Catch rates of pollock (t/hr) by Japanese surimi factory trawlers in the Gulf of Alaska in 1983.

3. The ROK fisheries caught most of their pollock in the last quarter of the year (Fig. 3). Of the two classes of trawlers in the ROK fisheries, small and large foreign trawlers, the latter took the bulk (88%) of the 1983 pollock catch.

4. The region between 156° and 162°W. long. continued to be productive for the foreign trawl fisheries in 1983 (Fig. 4). The proportion of the total foreign fisheries pollock catch in 1983 by region is as follows:

Kodiak - Chirikof	(140° to 156°W. long.)--9%
Chirikof - Shumagin	(156° to 162°W. long.)--73%
Shumagin	(162° to 170°W. long.)--18%

5. The length and age of pollock taken by the foreign trawl fisheries showed the foliowing features:

   a) There was a greater spread of sizes and ages in the pollock taken between 146° and 164°W. long. than in the most westward region, 166°-170°W. long. (Figs. 5-7). This difference was most pronounced during May and June (Fig. 5).

   b) For all periods the pollock in the westward region (166°-170°W. long.) showed sharp modes in the age composition (age-5 fish) (Figs. 8-10) and length composition (frequently at 44 and 45 Cm) (Figs. 5-7).

   c) In the Kodiak area (146°-156°W. long.), where the catch of pollock was relatively minor, age-3 pollock, representing the 1980 year class, were most prominent in the catches during the spring (May-June) and summer (July-September).

   d) In the region (156°- 164°W. long.) where most of the foreign pollock catch was taken, age-2 fish, representing the 1981 year

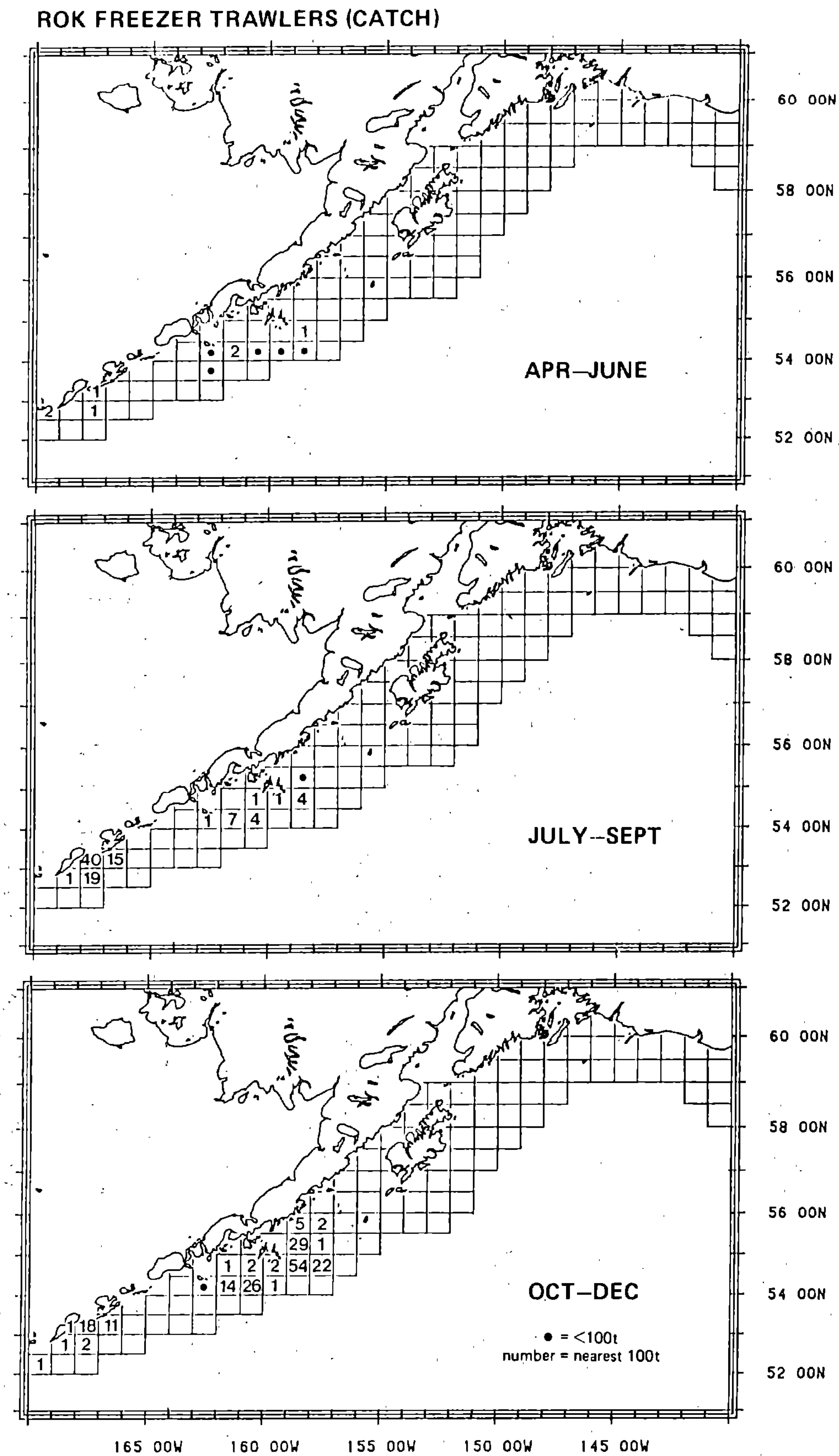


Figure 3 .--Distribution of pollock catch by Republic of Korea (ROK) freezer trawlers in the Gulf of Alaska in 1983.

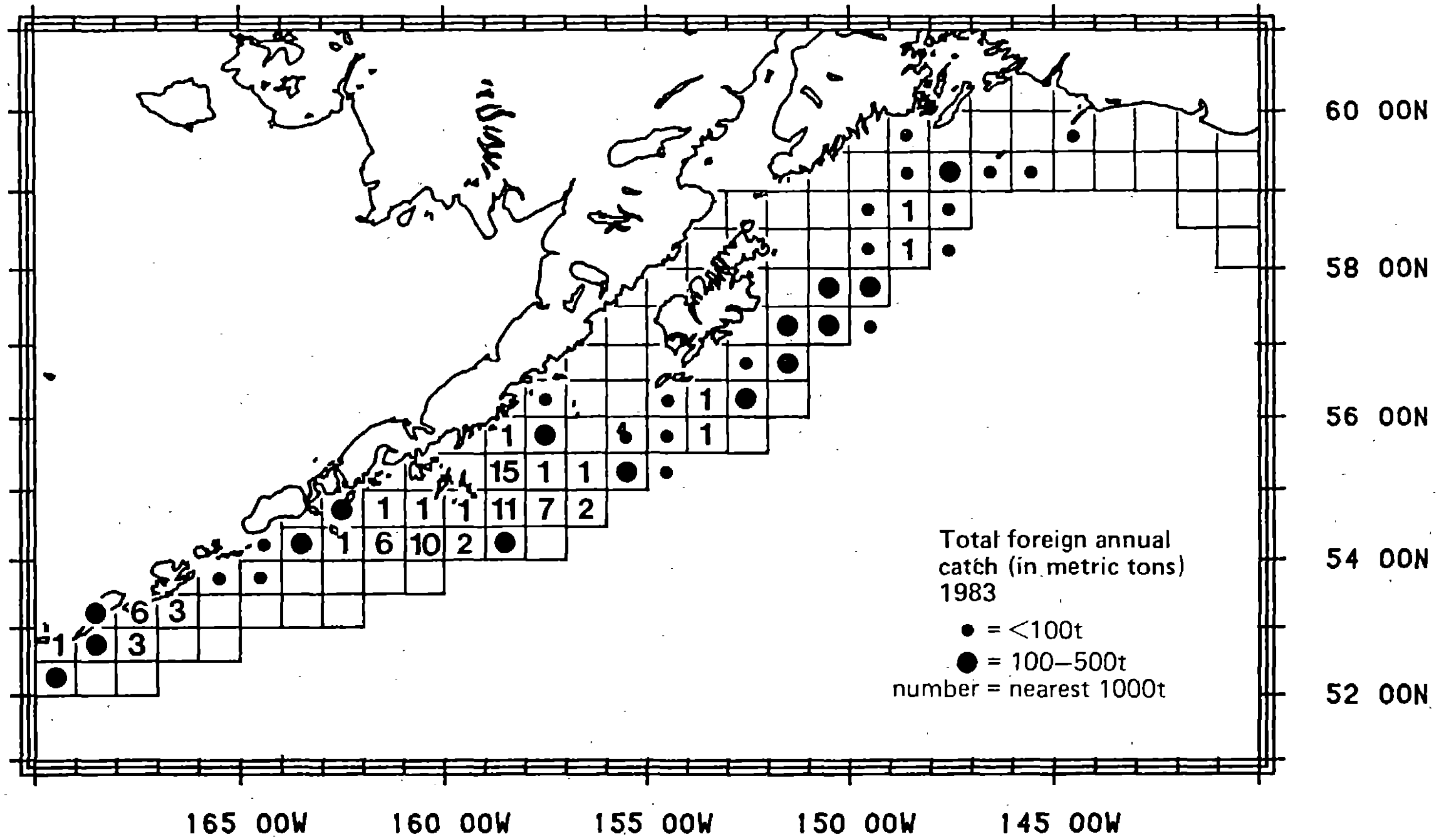


Figure 4.--Distribution of pollock catch by all foreign nations in the Gulf of Alaska in 1983.

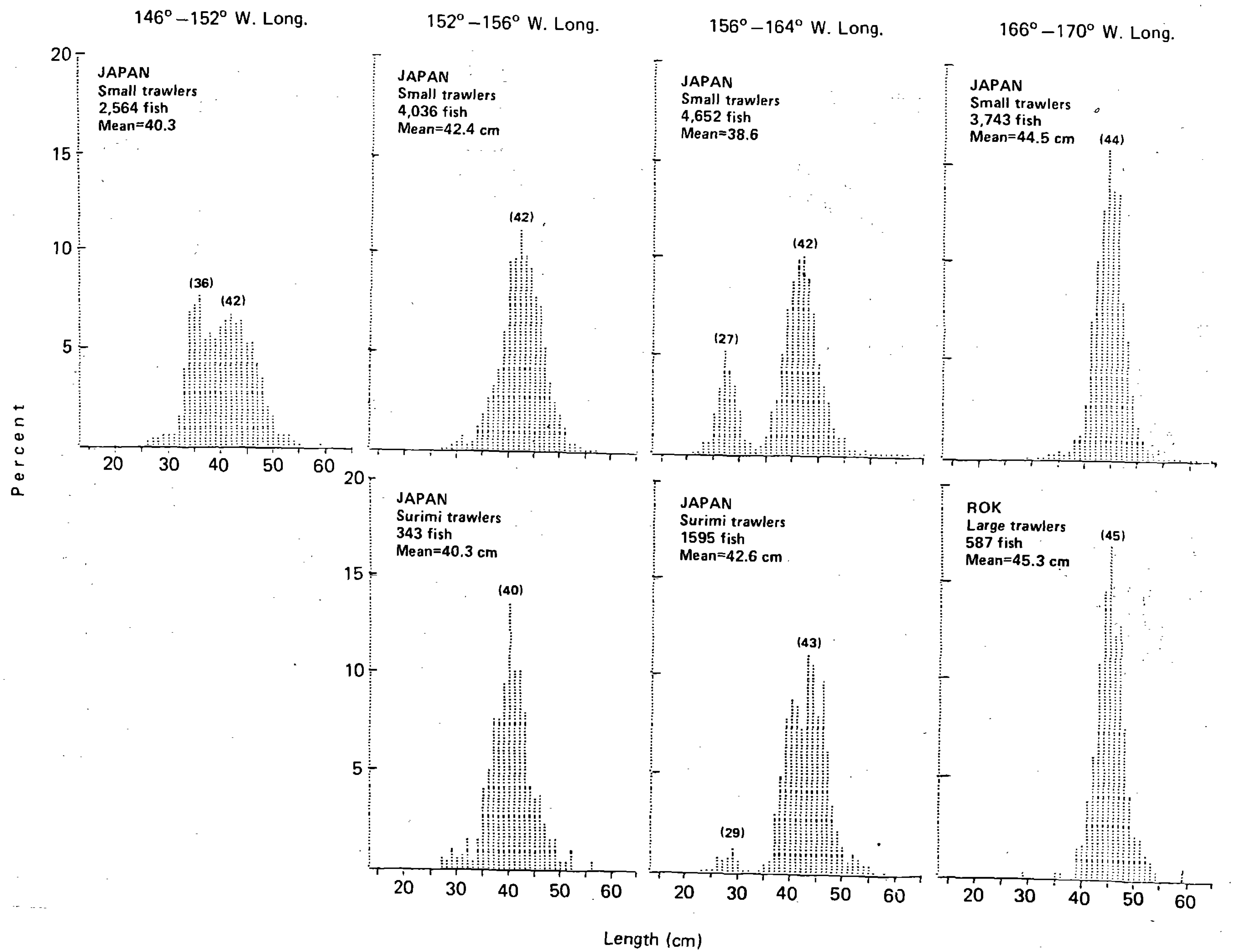


Figure 5.--Length composition (%) of pollock taken in the foreign trawl fisheries of the Gulf of Alaska by region, May-June 1983.

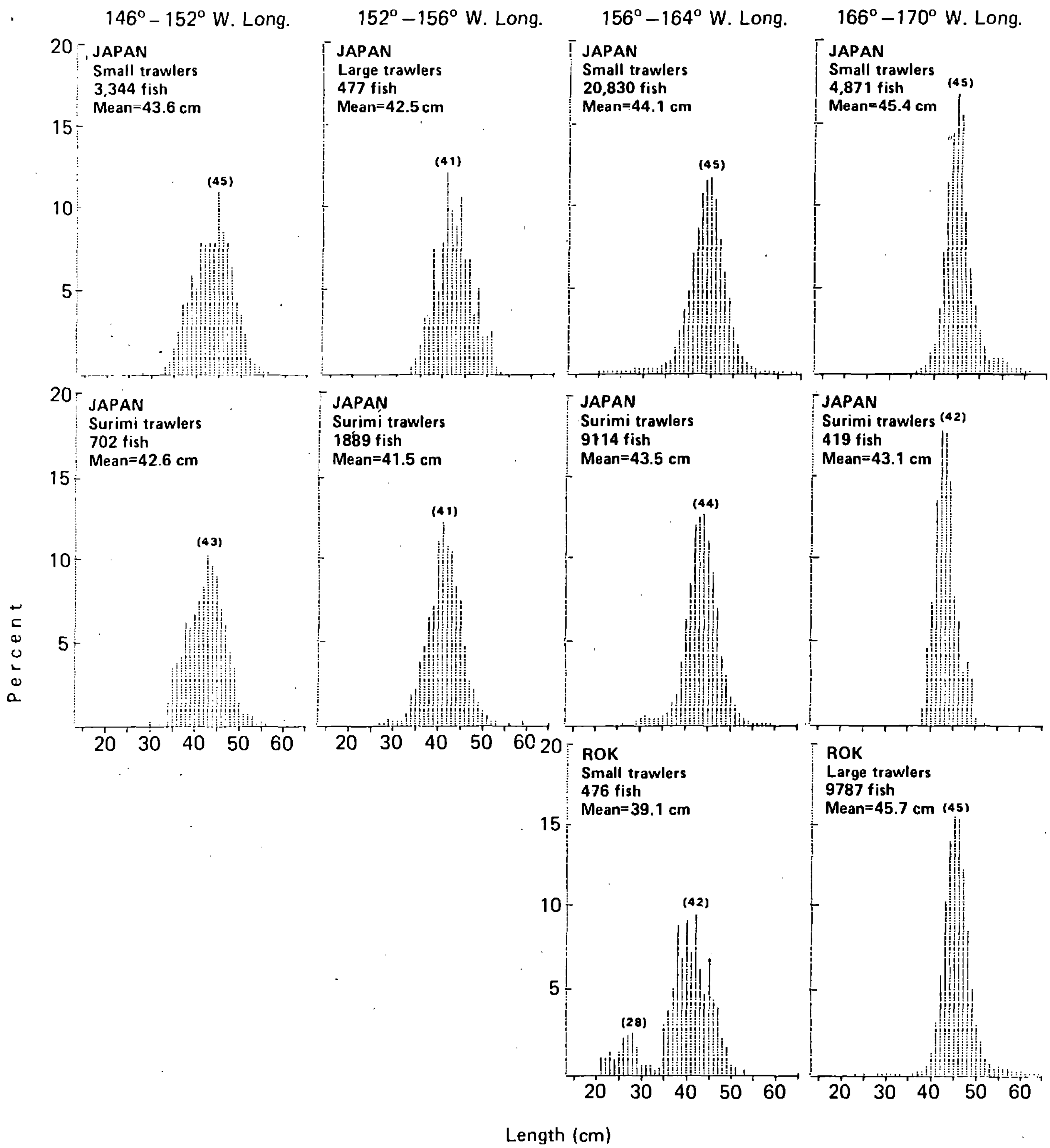


Figure 6.--Length composition (%) of pollock taken in the foreign trawl fisheries of the Gulf of Alaska by region, July-September 1983.

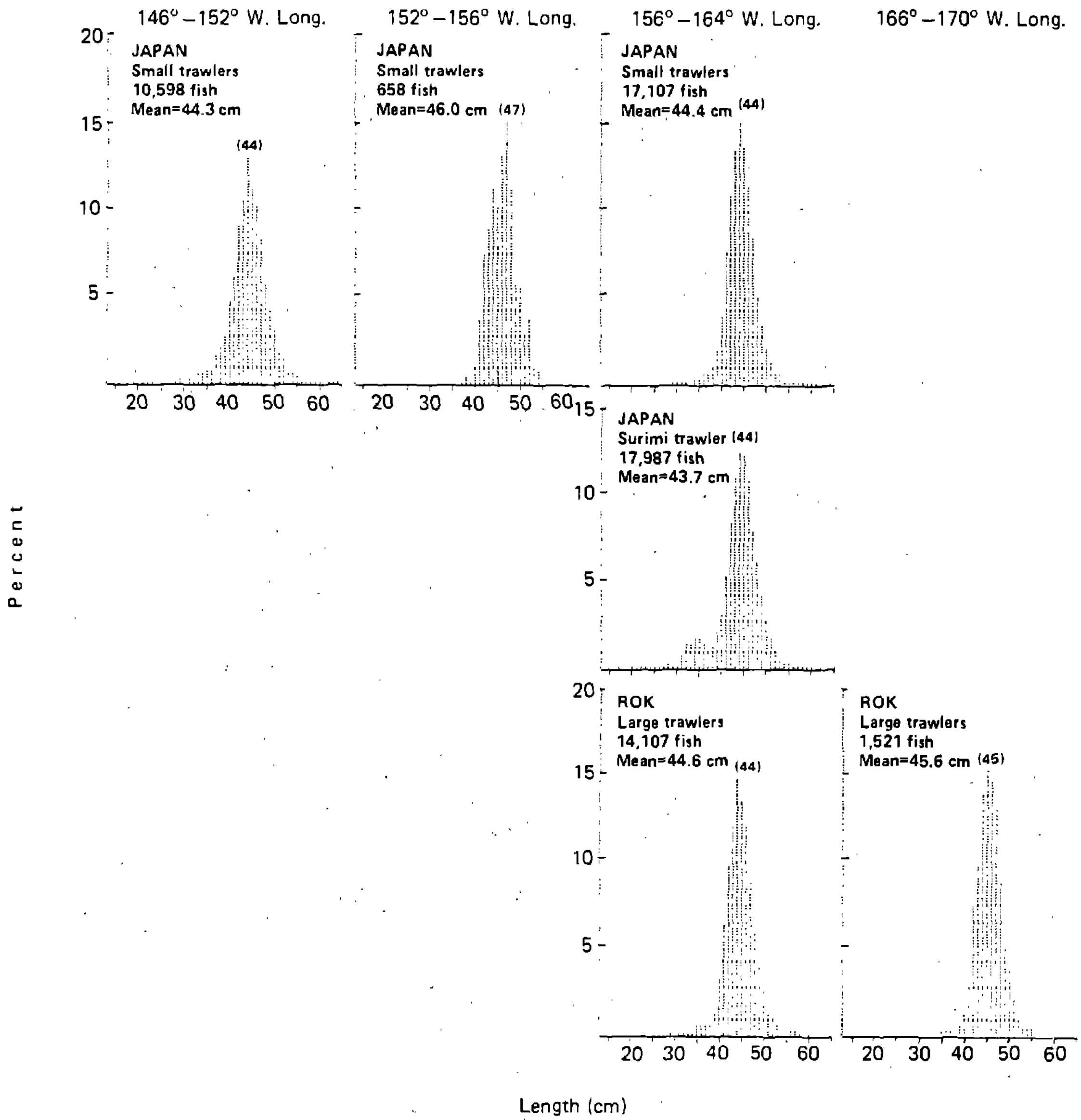


Figure 7.--Length composition (%) of pollock taken in the foreign trawl fisheries of the Gulf of Alaska by region, October-December 1983.

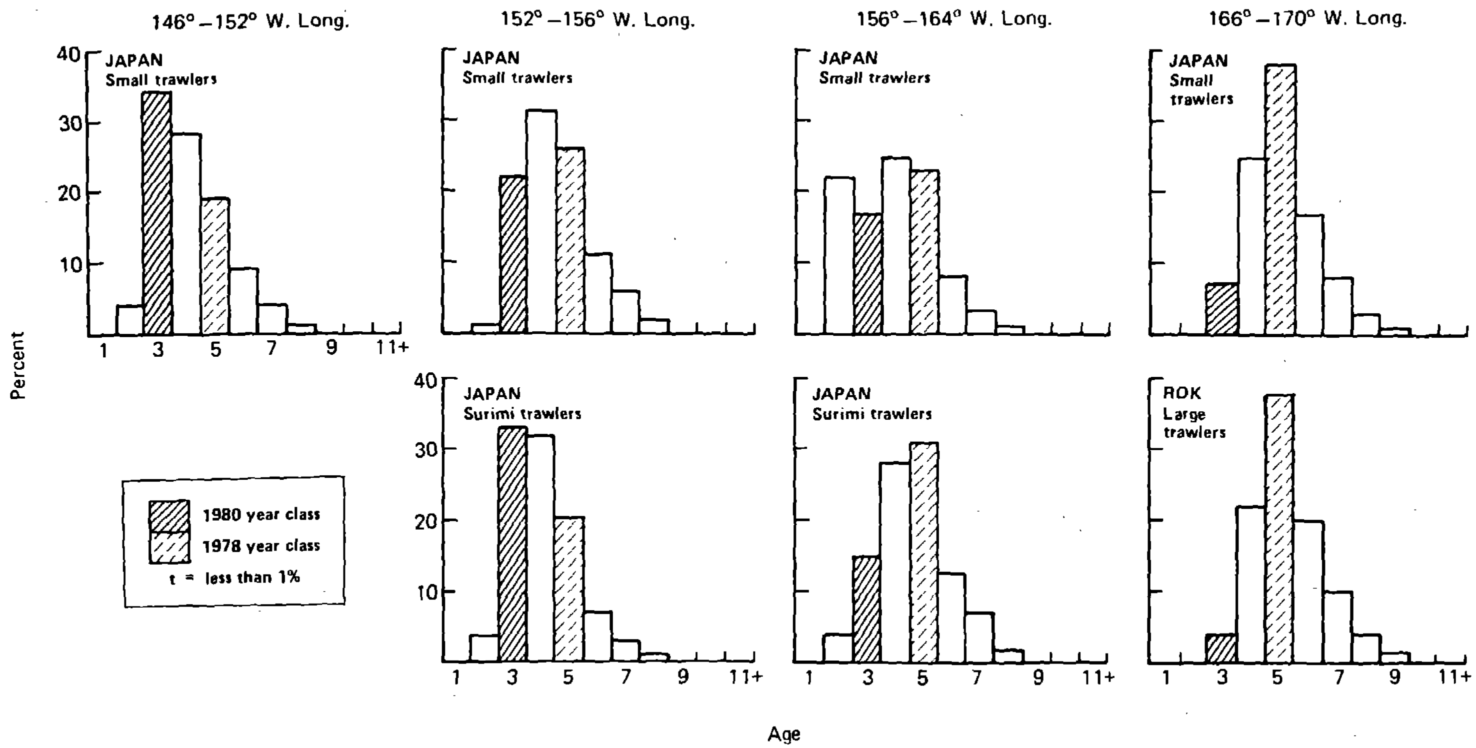


Figure 8.--Age composition (%) of pollock taken in the foreign trawl fisheries of the Gulf of Alaska by region, May-June 1983.

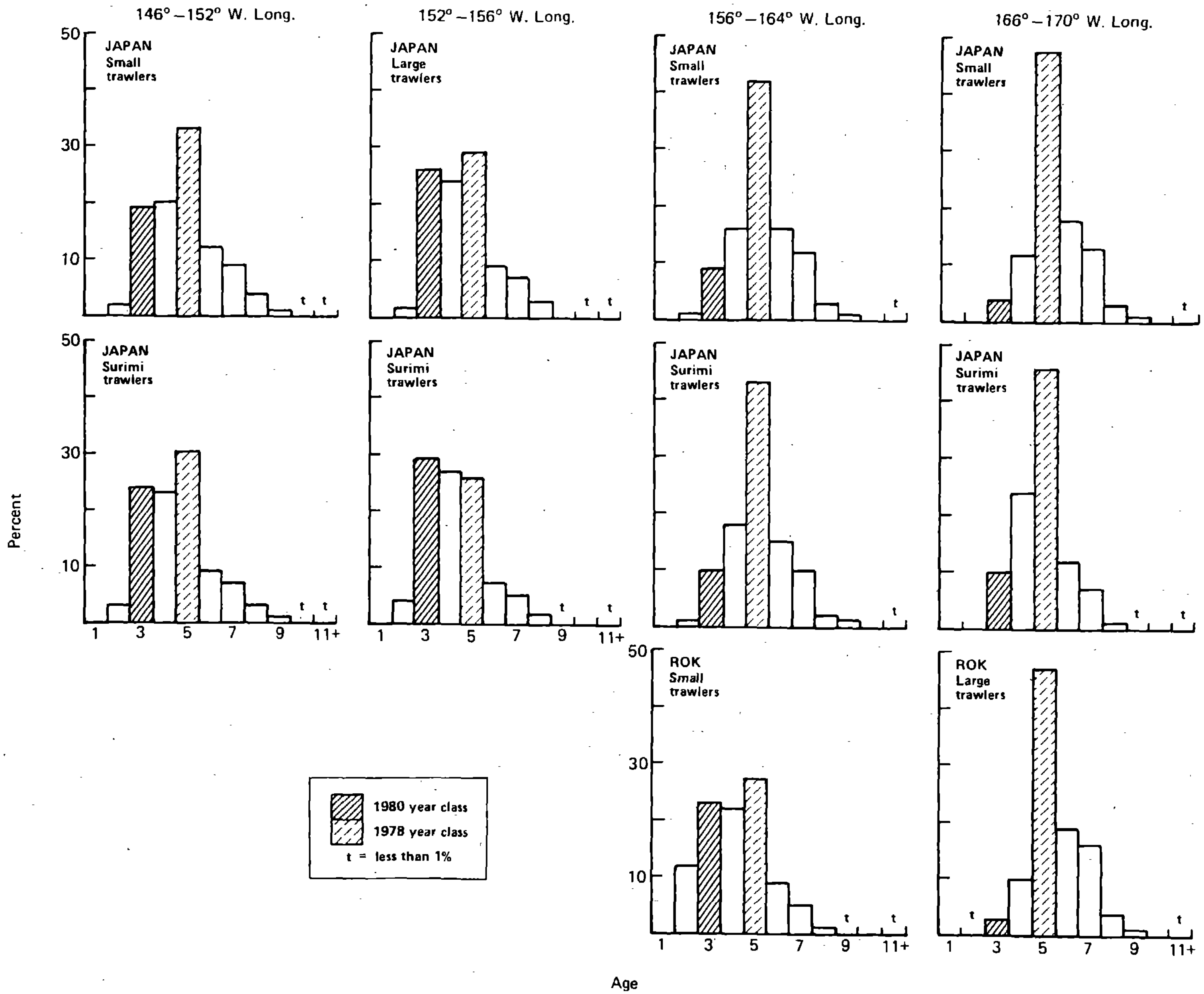


Figure 9.--Age composition (%) of pollock taken in the foreign trawl fisheries of the Gulf of Alaska by region, July-September 1983.

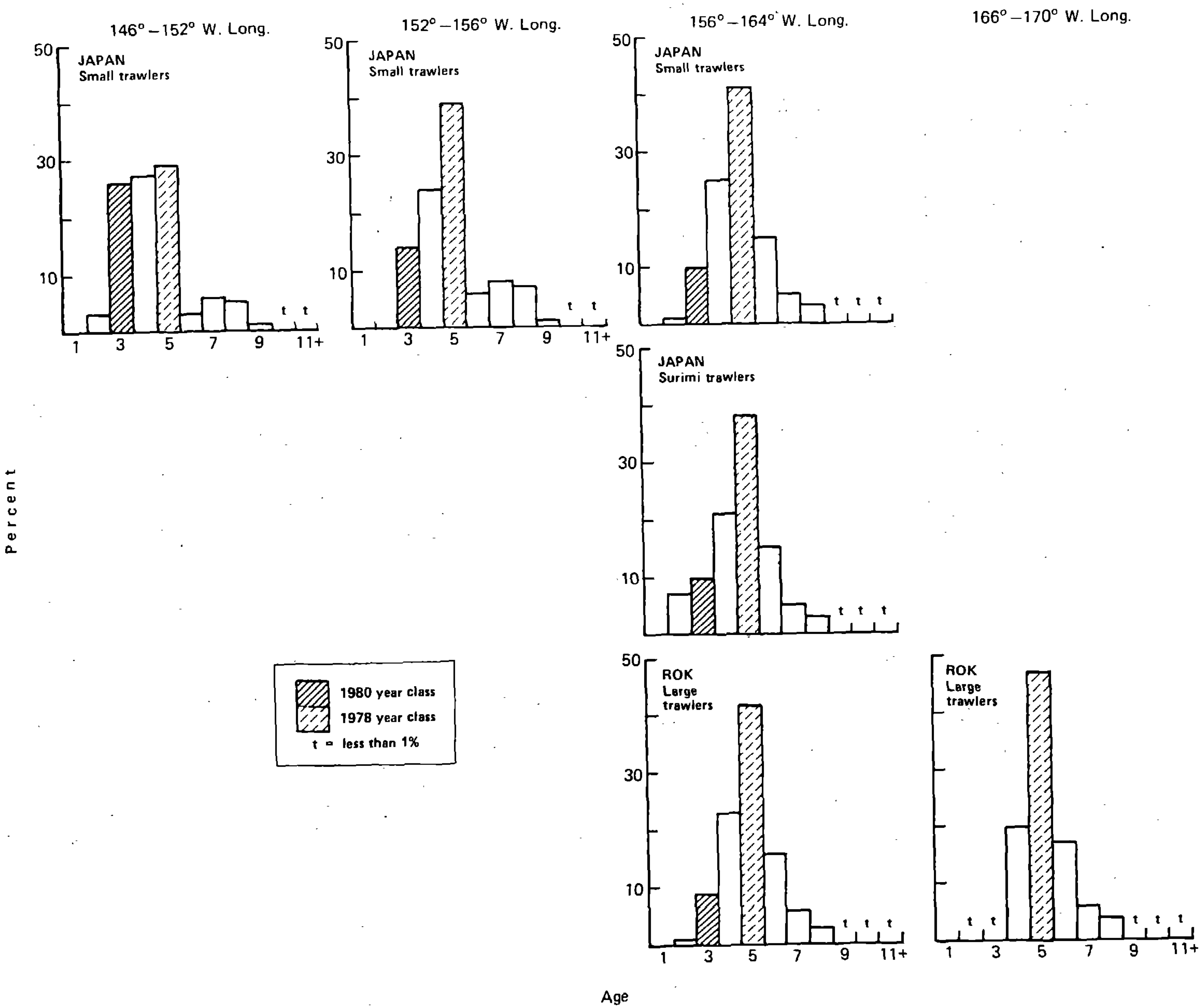


Figure 10.--Age composition (%) of pollock taken in the foreign trawl fisheries of the Gulf of Alaska by region, October-December 1983.

class, were most prominent. These fish accounted for the sharp mode (27 cm) in the length composition of fish taken by Japanese small freezer trawlers in May and June (Fig. 5).

e) The length composition of pollock taken in the foreign trawl fisheries for all regions and nations in 1983 showed a sharp unimodal distribution somewhat comparable to those of the two previous years, 1981 and 1982 (Fig. 11).

f) Age-5 fish, representing the strong 1978 year class were the dominant component of the annual catch in 1983 (Fig. 12).

JOINT VENTURE FISHERIES

1. Most of the catch of pollock by joint venture fisheries in the Gulf of Alaska in 1983 was taken in the Shelikof Strait region (Table 2).
2. Most of the pollock in the 1984 Shelikof Strait fisheries was taken during February and March:

Month	Percent of Total Catch
January	3
February	47
March	50
April	less than 1

3. During January and February the length composition of pollock taken in the 1984 fisheries was bimodal (at 32 cm and 41-43 cm) (Fig. l3). The smaller mode is estimated to represent mainly age-3 fish of the 1981 year class. In March the length composition was essentially unimodal at 44 cm.
4. The length composition of pollock taken in the 1984 fishery for January-April shows 3 modes: a small one at about 25 cm, another at 32 cm, and the

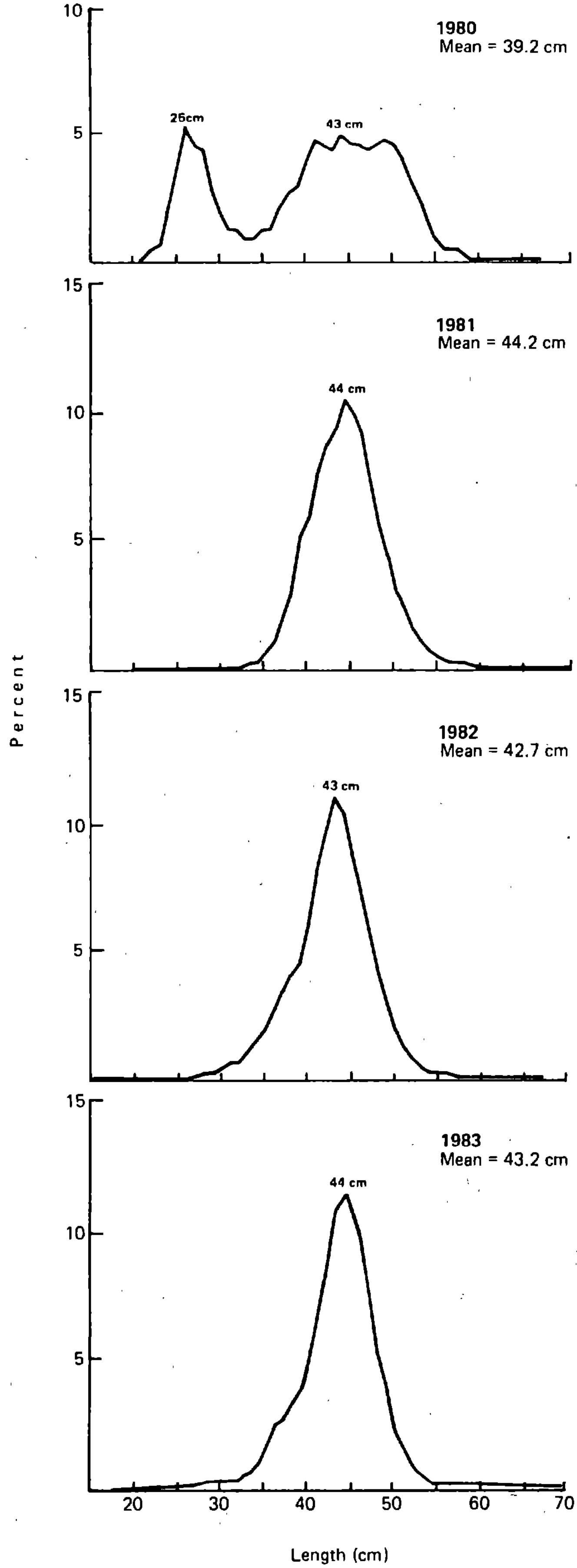


Figure 11 .--Length composition of pollock taken in the foreign trawl fisheries of the Gulf of Alaska. 1980-83.

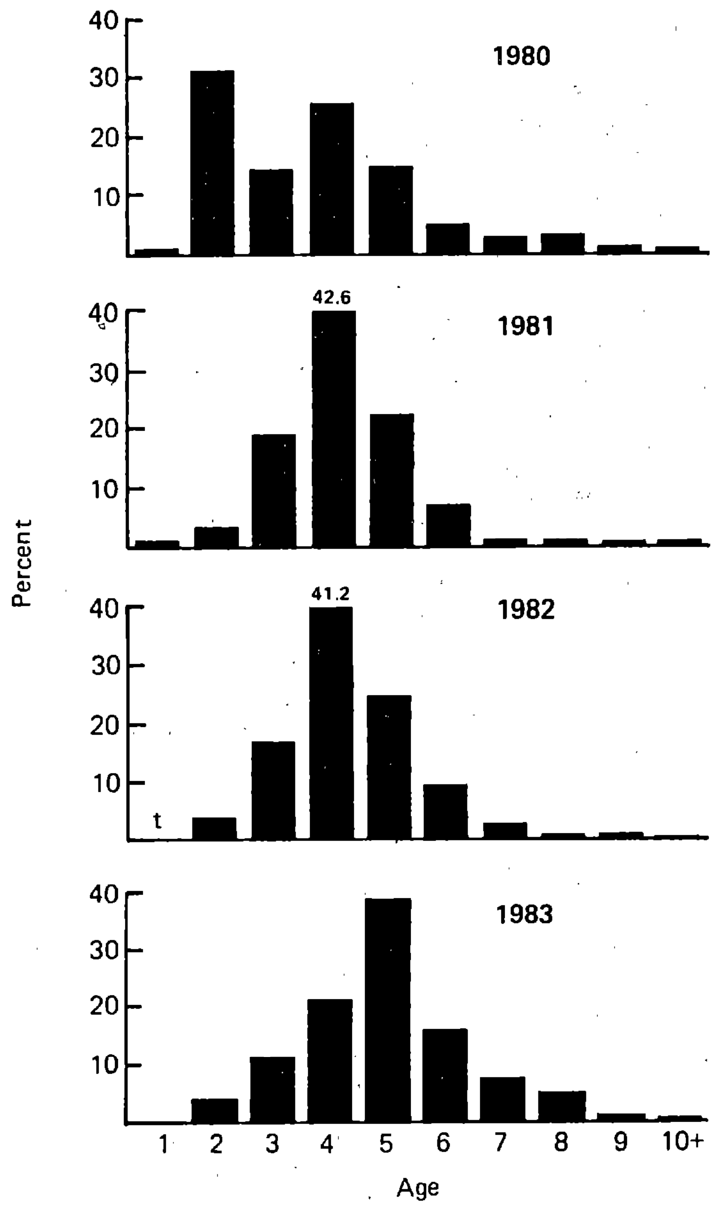


Figure 12.--Age composition of pollock taken in the foreign trawl fisheries of the Gulf of Alaska, 1980-83.

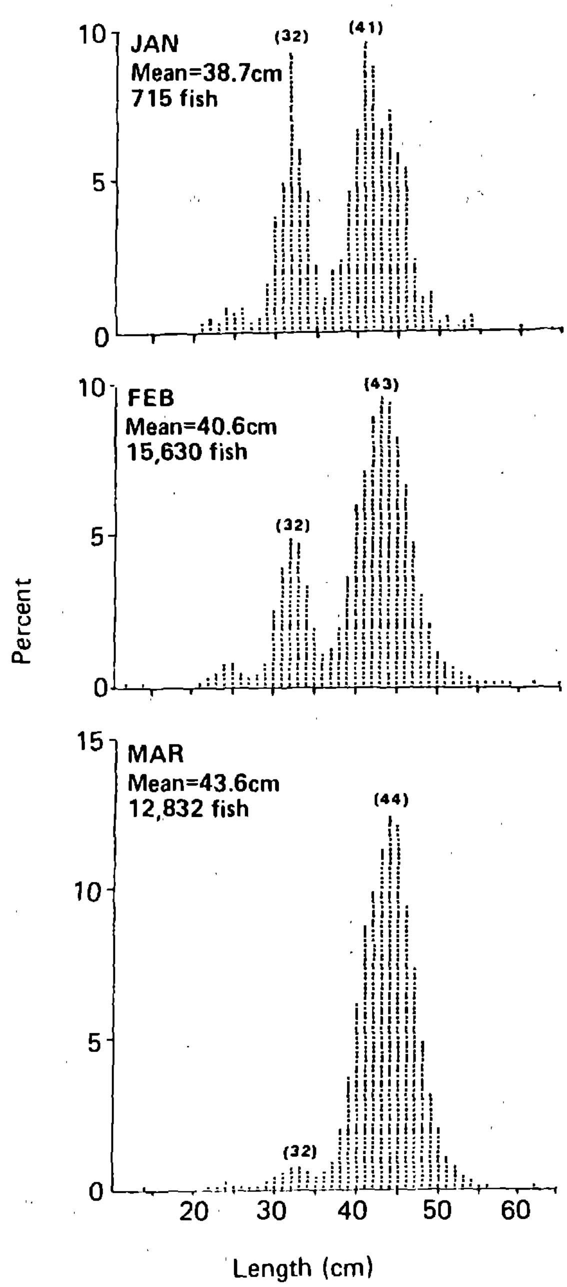


Figure 13.--Length composition (%) of pollock taken in joint venture fisheries in the Shelikof Strait region in 1984 by month.

most prominent one at 44 cm (Fig. 14). There was a major shift in the primary mode from 38 to 44 cm between 1983 and 1984 (Fig. 14). Preliminary information shows that fish of age groups 5 and 6 (1979 and 1978 year classes, respectively) were important in the catch. The strength of the 1980 year class (age-4 fish) apparently is weak, since age-4 fish have in the past been an important part of the joint venture catch (Fig. 15).

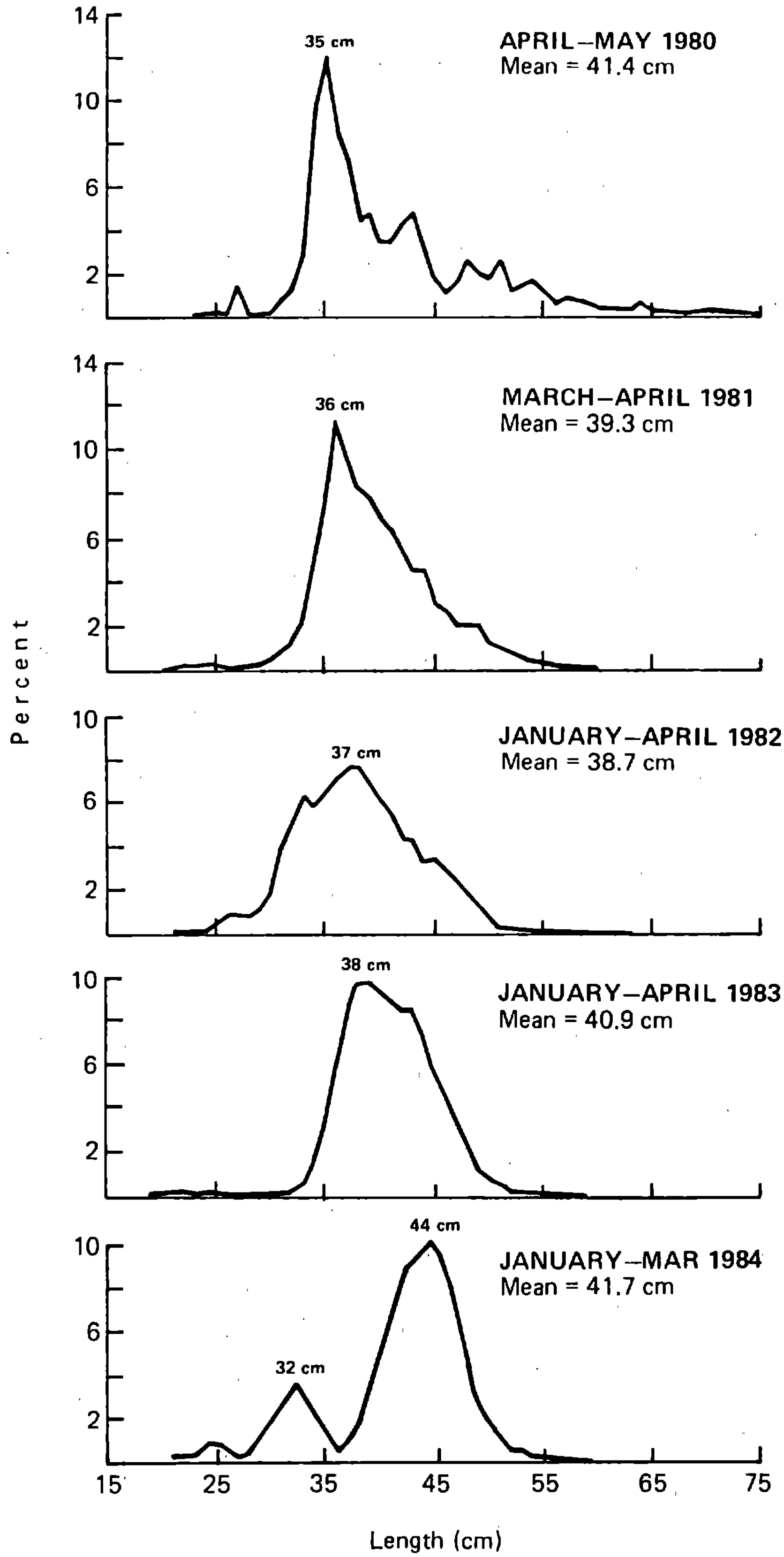


Figure 14.--Length composition (%) of pollock taken in joint venture fisheries in the Shelikof region, 1980-83.

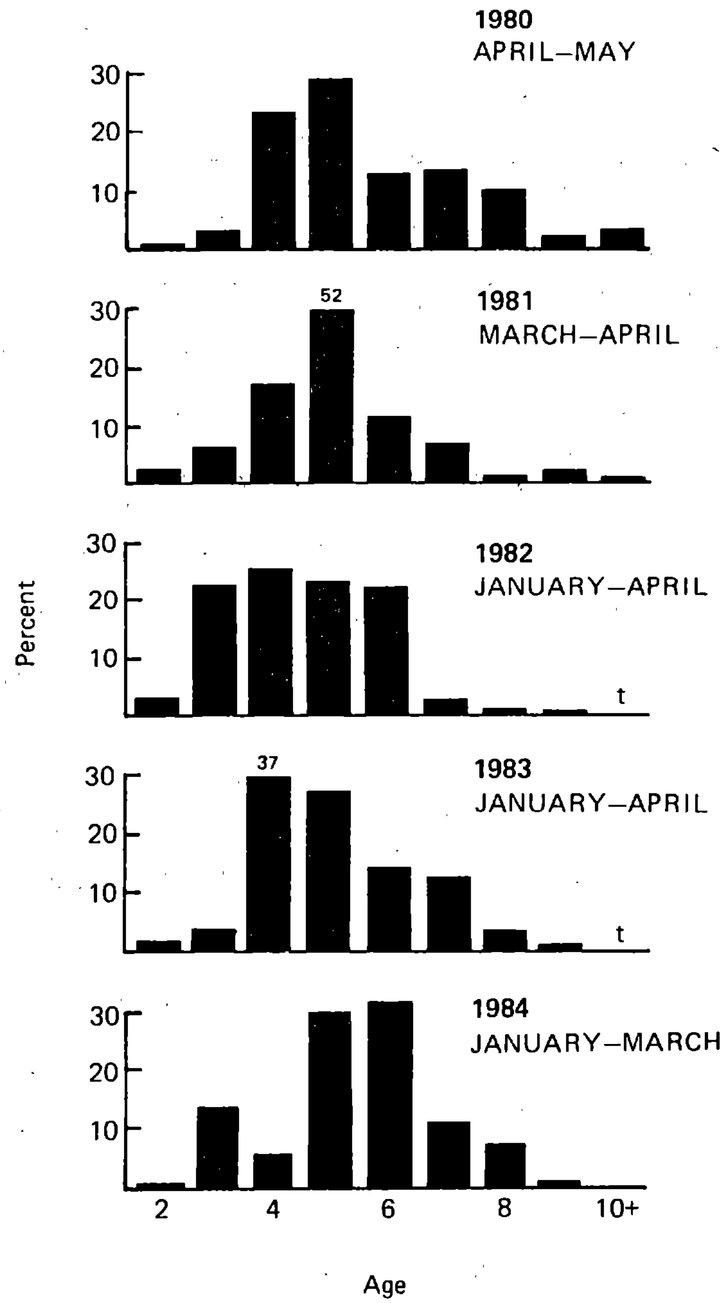


Figure 15.--Age composition of pollock taken in joint venture fisheries in the Shelikof Strait region, 1980-84.

REFERENCES

Alton, M. 1983. Gulf of Alaska pollock fisheries. In G. Stauffer (editor), Condition of groundfish resources of the Gulf of Alaska region as assessed in 1983, p. 1-1 to 1-19. NWAFC Processed Rep. 84-02. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112. (Document submitted to the International North Pacific Fisheries Commission in October 1983.)

Alton, M., and R. Deriso. 1983. Pollock. In D. Ito and J. Balsiger (editors), Condition of groundfish resources of the Gulf of Alaska in 1982, p. 1-62. U.S. Dep. Commer., NOAA Tech. Memo., NMFS F/NWC-52.

Berger, J. D., J. E. Smoker, and K. A. King. 1985. Foreign and joint venture catches and allocations in the Pacific Northwest and Alaskan fishing areas under MFCMA, 1977-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS/NWAFC. (In press).

LaLanne, J. J. 1979. The validity and consistency of age determinations from otoliths of Pacific pollock (Theraga chalcogramma). Int. North Pac. Fish. Comm., Annu. Rep. 1977:99-107.

Nelson, R., Jr., R. French, and J. Wall. 1981. Sampling by U.S. observers on foreign fishing vessels in the eastern Bering Sea and Aleutian Island region, 1977-78. U.S. Natl. Mar. Fish. Serv., Mar. Fish. Rev. 43(5):1-19.

Rigby, P. W. 1984. Alaskan domestic groundfish fishery for the years 1970 through 1980 with a review of two historic fisheries--Pacific cod (Gadus macrocephalus) and Sablefish (anoplopoma fimbria). Alaska Dept. Fish Game, Tech. Data Rep. 108. 446p.

Wall, J., R. French, and R. Nelson, Jr. 1981. Foreign fisheries in the Gulf of Alaska, 1977-78. Mar. Fish. Rev. 43(5):20-35.

SABLEFISH

by

Gary D. Stauffer

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. The resource has been harvested by U.S. and Canadian fishermen since early in this century, but catches were relatively small and generally limited to areas near fishing ports in the stretch from California to southeastern Alaska. Catches in the Gulf of Alaska averaged about 1,500 metric tons (t) from 1930 to 1950 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). In 1963 the Japanese longline fleet expanded to the Aleutian Island region and the Gulf of Alaska. Catches rapidly escalated until the record, all-nation catch from the northeastern Pacific reached 67,000 t in 1972. Following that, the total northeastern Pacific catch averaged about 50,000 t from 1973 to 1976.

Evidence of declining stock abundance has led to significant fisheries 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.

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. The catch peaked in 1972 at 37,503 t and averaged 27,715 t in 1973-76. Following the passage of the Magnuson Fishery Conservation and Management Act in 1976 (MFCMA), catch quotas were implemented. The foreign harvest of sablefish has since declined from 15,961 t in 1977 to 4,966 t in 1983. U.S. domestic harvests from 1976 to 1982 averaged about 2,107 t and increased to 4,036 t in 1983--including 275 t taken by joint venture fisheries. In 1984 the domestic sablefish fishery completely replaced the directed foreign fishery in the North Pacific Fishery Management Council (NPFMC) central and eastern regulatory areas.

The directed foreign sablefish fishery in the Gulf of Alaska is regulated to the use of longline gear. An allowance is made, however, for incidental catches taken in trawl fisheries and from 1979 to 1983 the foreign trawl incidental catch of sablefish was 686 t, 1,422 t, 919 t, 540 t and 514 t, respectively; an annual average of 816 t. Domestic sablefish gear in the Gulf of Alaska has consisted almost exclusively of longline gear although 105 t was landed with pot gear and bottom gill nets in 1984.

Table 1.--Catch (t) of sablefish in the Gulf of Alaska, by nation, 1958-83.

Year	U.S.	Canada	Japan	U.S.S.R.	ROK	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	16	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[a]
1976	1,151	23	21,924	41	3,551	27,738[b]
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[c]
1980	2,384	0	4,831	416	891	8,542[d]
1981	1,941	0	6,910	0	1,062	9,917[e]
1982	2,910	0	4,921	0	724	8,556[f]
1983	3,761	0	4,334	0	632	9,002[g]

[a]Includes 250 t by Taiwan.
[b]Includes 1,048 t by Taiwan.
[c]Includes 55 t by Mexico and 18 t by joint venture fisheries.
[d]Includes 20 t by. joint venture fisheries.
[e]Includes 4 t by Poland.
[f]Includes 1 t by joint venture fisheries.
[g]Includes 275 t by joint venture fisheries.

Sources: U.S. 1958-69: Funk and Bracken 1984; 1970-80: modified from Rigby 1984; and 1981-83: Pacific Fishery Information Network (PacFIN) Pacific Marine Fisheries Commission, 305 State Office Building, 1400 S.W. Fifth Avenue, Portland; OR 97201.

Canada 1958-71: Department of Fisheries and Oceans (Canada) 1959-72; 1972-78: Department of Fisheries and Oceans (Canada) 1973-79.

Japan 1963-70: Forrester et al. 1978; 1971-76: Forrester et al. 1983.

U.S.S.R. 1972: Parks 1973; 1975 and 1976: untitled data presented by the U.S.S.R. at the U.S.-U.S.S.R. Bilateral Fisheries Meetings in the late 1970's. (On file at the Northwest and Alaska Fisheries Center.)

ROK 1972: Anon 1973; 1975: Fisheries Research and Development Agency (Republic of Korea) 1976; 1976: Fisheries Research and Development Agency (Republic of Korea) 1977.

U.S.S.R. and ROK 1973: Parks 1975; 1974: Parks 1976.

Taiwan: National Marine Fisheries Service 1980.

All foreign nations except Canada and joint ventures 1977-83: Berger et al. 1985.

In 1977 the Gulf-wide optimum yield (OY) was set at 22,000 t (Table 2). The OY was reduced to 15,000 t in 1978, and to 13,000 t in 1979 with the implementation of the Fishery Management Plan for the Gulf of Alaska Groundfish Fishery (FMP). Also, the OY was prorated between the three new regulatory regions, 2,100 t to the western regulatory area [International North Pacific Fisheries Commission (INPFC) Shumagin statistical areal, 3,800 t to the central regulatory area (Chirikof and Kodiak INPFC areas), and 7,100 t to the eastern regulatory area (Yakutak and southeastern INPFC areas). The 1983 OY was reduced to 12,300 t (as a basis) but then temporarily increased 16.7% to allow for a allow for a 14-month season that resulted from adjusting the reporting year to coincide with the calendar year. In 1982 for the first time, the eastern region OY of 6,400 t was partitioned into separate parts for the Yakutat and southeastern statistical areas. Gulf-wide that year the OY was 12,300 t. In 1983, Amendment 11 to the FMP established OY at 8,230 to 9,460 t, 75% of equilibrium yield (EY). The 1984 OY was maintained at the 1983 level.

Annual landings averaged 70% of the OY for the 6 years following 1976. Domestic landings during this same period averaged 54% of the domestic annual harvest (DAH). Foreign landings exceeded the initial allocations of total allowable level of foreign fishing (TALFF), but have averaged 78% of the final allocations. The foreign landings in 1983 equaled 91% of the final allocation. The U.S. harvest, including the joint venture catch, exceeded the DAH in 1983 and is projected to exceed DAH again in 1984.

CONDITION OF THE STOCKS

Stock Structure

Experiments designed to identify sablefish stock units in the Gulf

Table 2.--Year-end sablefish optimum yield (OY), domestic annual harvest (DAH) and total allowable level of foreign fishing (TALFF) for the Gulf of Alaska regulatory areas 1977-84.

		Western	Central	Eastern		All regions
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[a]
	DAH	115	423	3,805		4,343
	TALFF	2,335	4,101	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.[c]	
1983	OY	1,670	3,060	1,680	1,320-2,570	7,730-8,980[b]
	DAH	270	300	266	1,320-2,570	2,656-3,906
	TALFF	1,400	2,660	1,414	0	5,474
Initial 1984						
	OY	1,670	3,060	1,680	1,320-2,570	7,730-8,980[b]
	DAH	300	1,650	1,344	1,320-2,570	5,114-6,364
	TALFF & Reserve	1,370	1,410	336	0	3,116

[a]The OY was reduced to 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.

[c]The OY in the area east of 140° W 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.

of Alaska continue. National Marine Fisheries Service (NMFS), Alaska Department of Fish and Game (ADF&G); Japanese, and Canadian scientists have released tagged sablefish over the past several years. The results of these experiments indicate that sablefish throughout the northeastern Pacific are of one genetic pool. There is less agreement as to the degree of interchange of fish between regions. Wespestad (1981) 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. The analysis showed that fish under 60 cm tended to move westward, while those 60 cm or greater tended to migrate eastward.

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 occurs 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 they reach maturity. A large portion of the mature fish then migrates back into the eastern Gulf to spawn. Bracken concluded by recommending management of sablefish as a single stock, Gulf-wide, with OY prorated over all management areas and suggested that lower harvest levels throughout the Gulf of Alaska would speed rebuilding of the depleted spawning population in the southeastern statistical 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, moves north to Gulf-of Alaska waters. On the other hand, most of the 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, they contended that adult sablefish in the Canadian zone should be managed separately and not as part of one large stock off the west coast of North America. In a review of U.S. tagging studies, Dark (1983) found what appeared to be a similar northward movement of small sablefish (40-65 cm) that had been released off Alaska and Washington, and less movement of fish larger than 65 cm. Gharrett et al. (1983) re-examined 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 Yakutat area, and in the vicinity of Cape Addington in the southeastern area.

Currently, management of sablefish in the Gulf of Alaska is by five management regions--the western, central, Yakutat, southeastern (inside), and southeastern (outside) regions. Clearly, the questions of migration and stock structure are basic to rational management of sablefish, but are yet unresolved.

Year-class Strength

The recruitment of the strong 1977 year class has been noted by Balsiger and Alton (1981), Sasaki (1981), McFarlane and Beamish (1983), and Funk and Bracken (1984). The significant decrease in the mean length of sablefish taken by the Japanese longline fishery from waters deeper than 500 m reflects the initial harvest of the 1977 year class. The mean sizes for 1982 and 1983 are greater than or equal to the 1981 means (Table 3). The greatest increase occurred in the Yakutat area, although the sample sizes there are the smallest. The length frequency data for 1982 and 1983 (Figs. 1 and 2, respectively) from the Japanese fishery show a high percentage of fish less than 55 cm compared to data for earlier years [summarized by Balsiger (19831). This indicates that fish less than 4 or 5 years of age occurred in significant numbers in 1983, implying that other year classes (since 1977) are recruiting to the fishery.

Catch per Unit Effort (CPUE) of the Japanese Longline Fishery

Until 1977, catch and effort statistics from the Japanese North Pacific longline fishery provided consistent information for assessing the condition of sablefish stocks in the Gulf of Alaska. The CPUE in terms of kilograms of sablefish per 10 hachi units of effort are shown in Table 4 for 1967-81.

Prior to 1974, CPUE was generally greater than 200 in all INPFC areas. In 1975, CPUE dropped to as low as 154 in the Shumagin area and was generally about 185 in the other areas. In 1976, CPUE increased in all areas of the Gulf of Alaska. From 1976 to 1977, CPUE dropped in all areas with the decline ranging from 13% to 34%, and averaging about 25%.

In 1978, fishing regulations were changed to permit Japanese longliners to fish for Pacific cod, Gadus macrocephalus, in depths shallower than 500 m in the Shumagin-Chirikof region. In 1979, the permission was extended to the rest of the Gulf. Also in 1978, catch limits for the Japanese longline fishery were imposed. This resulted in a shift of Japanese longline fishing

Table 3.--Average size (cm) of sablefish, taken at depths greater than 500 m by the Japanese longline fleet in the Gulf of Alaska, by International North Pacific Fisheries Commission statisticalarea, 1969-83.

Year	All areas	Shumagin	Chirikof	Kodiak	Yakutat	Southeastern
1969	67.2	--	65.2	--	68.7	--
1970	66.2	--	--	60.5	67.8	68.6
1971	65.4	61.4	60.6	63.6	66.3	66.0
1972	62.3	62.4	60.8	60.8	63.9	63.5
1973	62.8	63.2	61.2	63.7	63.7	64.4
1974	--	--	--	--	--	--
1975	67.1	66.4	--	--	--	67.9
1976	66.2	66.3	65.5	64.1	65.9	68.4
1977	64.7	--	60.9	--	64.6	65.0
1978	67.4	65.8	67.0	67.0	69.9	--
1979	--	66.3	64.7	63.5	63.5	--
1980	--	60.4	60.9	61.8	59.1	--
1981	--	58.9	56.1	59.7	55.8	--
1982	--	58.9	58.4	60.3	59.3	--
1983	--	60.8	58.9	60.4	59.2	--
Average (1969-78)	64.6	64.5	62.0	63.5	66.3	65.7

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

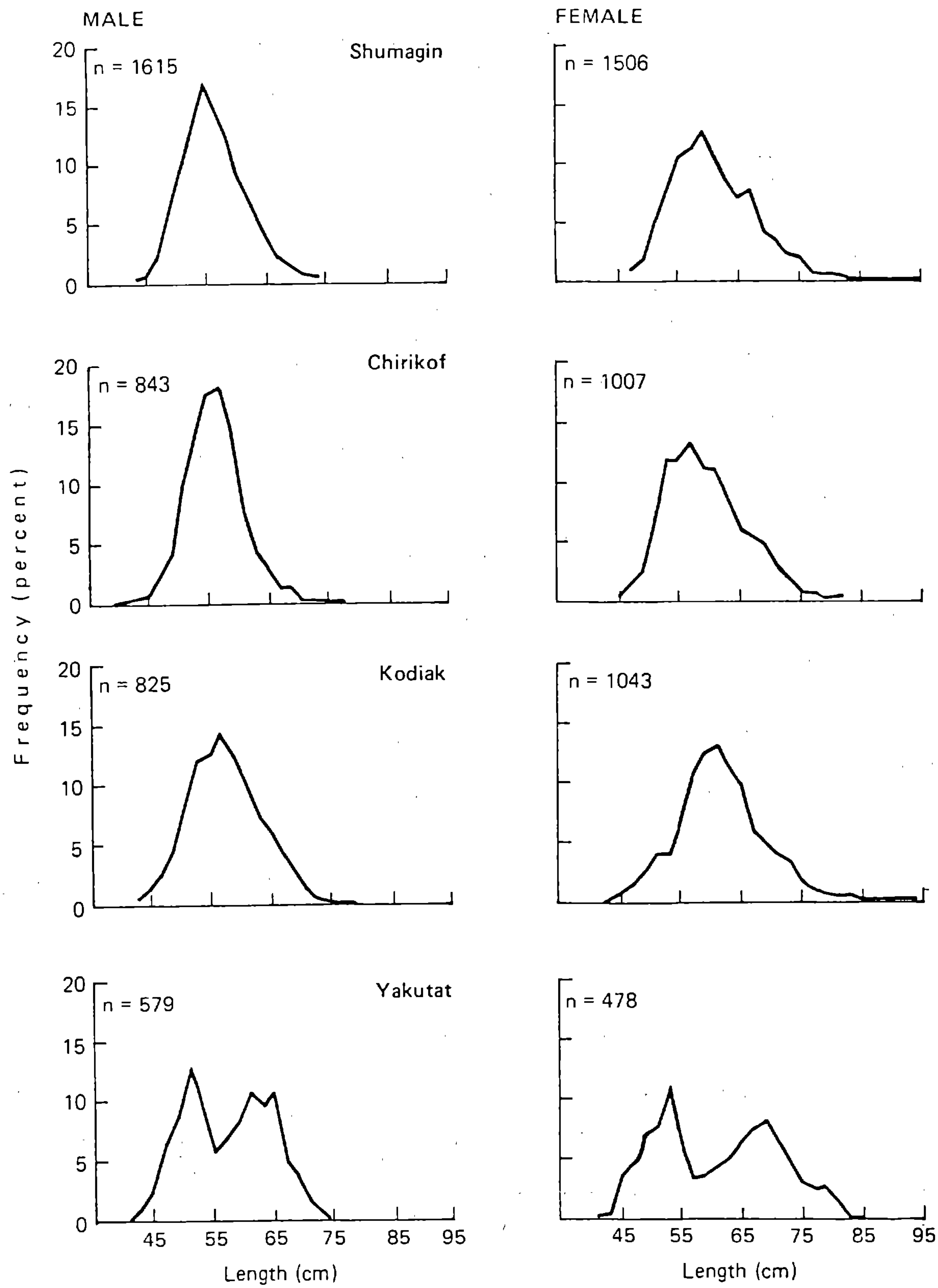


Figure 1 .--Length frequency of samples of sablefish collected by U.S. observers aboard Japanese longline vessels fishing deeper than 500 m in the Gulf of Alaska in 1982.

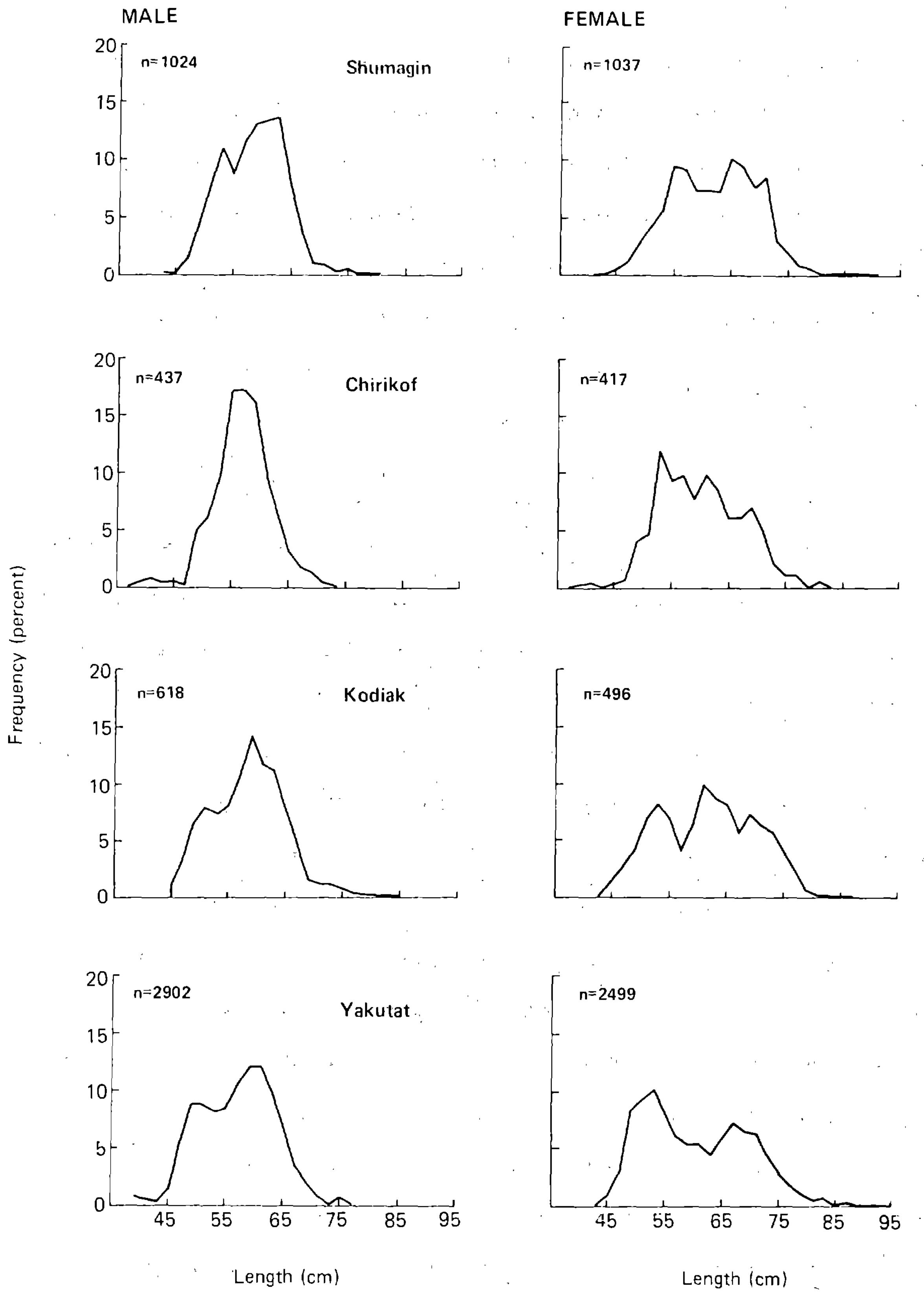


Figure 2.--Length frequency of samples of sablefish collected by U.S. observers aboard Japanese longline vessels fishing deeper than 500 m in the Gulf of Alaska in 1983.

effort toward Pacific cod in depths 100-300 m, whereas in the past all effort was directed at sablefish in depths generally greater than 500 m. Since target effort cannot be detected in the statistics reported by the Japanese, this source of information is available only through 1977. Okada et al. (1982) provided Gulf-wide CPUE's in an attempt to continue this data series (Table 4), but it is not clear how it was determined how much effort was specifically directed at sablefish. These latest data points show significant increases in 1980 and 1981.

U.S. Foreign Fishery Observer Data

From observer data on the depth of the fishing gear, Japanese longline effort in the Gulf can be categorized as effort which was directed at Pacific cod--depths shallower than 300 m, or effort which was directed at sablefish--depths deeper than 500 m (Balsiger and Alton 1981).

Japanese longline CPUE for trips directing effort only at sablefish is shown in Tables 5 and 6. Comparing the combined CPUE's for the Shumagin to Yakutat region, 1977-80, it appears that a 25% decline occurred from 1977-79, but that in 1980 the stocks recovered to about the 1977 level. In 1981, CPUE was up sharply in the Chirikof and Kodiak areas, but down significantly in the Yakutat area. It should be noted that observer coverage in the Yakutat area in 1981 was about 0.8%, which was considerably less than for any other area or year combination (Table 7). This raises some question as to the accuracy of this particular statistic since the Yakutat area provided a major part of the Japanese longline catch of sablefish in 1981 (Table 8).

The increasing trend in CPUE continued into 1982 in each INPFC area, with the greatest increase being in the Yakutat area--additional evidence

Table 4.--Indices of sablefish abundance in the Gulf of Alaska, 1967-79, catch per unit effort (kg/l0 hachi).

Year	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern	Shumagin-Southeastern
1967	184	234	175	175	301	212
1968	153	226	272	282	257	263
1969	239	246	239	238	229	235
1970	221	245	266	255	229	235
1971	177	206	207	223	204	207
1972	220	198	210	203	207	208
1973	214	216	213	206	203	209
1974	181	191	185	191	195	190
1975	154	188	181	186	184	177
1976	165	210	182	196	191	186
1977	144	133	133	142	139	139
1978	a	a	136	137	b	135
1979	a	a	60	74	b	109
1980	a	a	a	a	b	122
1981	a	a	a	a	b	151

[a]Prior to 1978, Japanese longliners were not permitted to fish in depths shallower than 500 m. Since 1978, some of these longliners have been permitted to fish in waters shallower than 500 m for Pacific cod. Therefore, the total longline fishing effort no longer reflects total effort on sablefish.

[b]No foreign longlining has been permitted east of 140°W. long. since 1978.

Source:: Okada et al. 1982.

Table 5.--Catch per unit effort (t/1000 hooks) for sablefish in Japanese longline fishery for observed hauls from > 500 m depth as determined by U.S. observers in the Gulf of Alaska, by International North Pacific Fisheries Commission statistical area, 1977-83. Numbers of observed hooks in thousands is shown in parentheses.

Year	Shumagin	Chirikof	Kodiak	Yakutat	Southeastern	Shumagin-Yakutat t/1000 h	Shumagin-Yakutat kg/10 hachi
1977	.237 (191)	---	.247 (510)	.361 (500)	.428 (773)	.293	132
1978	.236 (549)	.204 (494)	.241 (1,525)	.232 (1,155)	a	.232	104
1979	.140 (1,041)	.202 (931)	.228 (1,781)	.268 (1,359)	a	.216	97
1980	.286 (273)	.275 (211)	.350 (347)	.254 (209)	a	.298	134
1981	.238 (375)	.419 (220)	.491 (203)	.194 (104)	a	.334	150
1982	.480 (383)	.483 (253)	.641 (213)	.527 (121)	a	.522	235
1983	.397 (226)	.403 (105)	.439 (123)	.441 (723)	a	.429	193

[a]The area east of 140°W. in the Yakutat area was closed to foreign longlining beginning in 1978.

Table 6.--Catch per unit effort (t/1000 hooks) for large sablefish (67 cm and greater) in the Japanese longline fishery for hauls from >500 m depth as determined by U.S. observers in the Gulf of Alaska, by International North Pacific Fisheries Commission statistical area, 1977-83.

Year	Shumagin	Chirikof	Kodiak	Yakutat	Southeastern	Shumagin-Yakutat
1977	.123	---	.169	.211	.269	.179
1978	.140	.107	.141	.126	a	.132
1979	.085	.109	.117	.149	a	.117
1980	.133	.100	.174	.086	a	.131
1981	.112	.130	.167	.037	a	.122
1982	.106	.087	.176	.197	a	.132
1983	.125	.095	.146	.143	a	.136

[a]The area east of 140°W. in Yakutat was closed to foreign longlining beginning in 1978.

Table 7.--Percentage of Japanese longline catch taken with U.S. observers aboard, by International North Pacific Fisheries Commission statistical area for 1977-83.

Year	Shumagin	Chirikof	Kodiak	Yakutat	Southeastern
1977	2.0	0	5.6	4.2	8.3
1978	13.3	16.5	21.9	10.7	-
1979	34.9	21.9	23.8	19.3	-
1980	14.9	10.9	13.1	5.1	-
1981	16.0	14.3	9.6	0.8	-
1982	21.8	14.3	13.6	5.7	-
1983	44.3	40.5	15.1	32.4	-

Table 8.--Distribution of Japanese longline catch of sablefish (t) in the Gulf of Alaska, by International North Pacific Fisheries Commission statistical area, 1977-83.

Year	Shumagin	Chirikof	Kodiak	Yakutat
1977	2,316	963	2,252	4,258
1972	1,173	761	1,676	2,491
1979	775	1,059	1,723	1,890
1980	705	1,204	1,032	1,154
1981	1,225	1,345	1,167	2,507
1982	1,212	1,126	1,055	1,112
1983	1,062	1,098	847	990

that the low 1981 value was a poor estimator. The 1982 CPUE values, by area, are the highest in the 6-year series with the overall value being 56% greater than 1981, and approximately 75% greater than 1977 or 1980. The 1983 CPUE value, on the other hand, declined by 18% from that of 1982.

If these CPUE estimates (expressed in units of t/1,000 hooks) are converted to kg/l0 hachi by assuming 45 hooks/hachi, then the CPUE data from the observer program can be compared with the CPUE records for the Japanese longline fleet from 1967 to 1977 (Table 4). The two time series overlap for 1977 in which year the observer CPUE of 135 kg/l0 hachi is nearly equal to the 139 kg/l0 hachi from Japanese catch statistics. The 1982 estimate of, 235 kg/l0 hachi is the same as the 1969 and 1970 values. The southeastern INPFC area, however, has not been fished by the Japanese since 1977. Based on the mean fish lengths for 1969 and 1970, compared to 1982 (Table 3), the catches in earlier years consisted of larger fish or fewer small fish. It is also likely that more than 45 hooks were fished per hachi in these earlier years. If catchability of longline gear has remained constant over the years, these data suggest that the abundance of sablefish in 1982 was similar to that in 1969 and 1970 when the fishery first expanded, although the present structure of the population has a greater proportion of smaller and younger fish. Sasaki. (1983a) came to a similar conclusion for the Japanese longline survey data for which the 1982 abundance index was 19% greater than it was for a similar 1969 Japanese survey.

The comparison of the 1982 catch rates with the earlier years should: be used cautiously because CPUE has. probably not remained proportional to stock abundance over these 14 years. As discussed in the FMP, increasing experience and technological improvements in gear and vessels as a fishery develops tend to maintain high catch rates even as a stock declines. In addition, longline gear with its limited catch potential is easily saturated such that stock abundance must decrease for some time before CPUE is affected.

The CPUE rates for the Japanese longline fishery 1977-83 were partitioned into three fish-size categories--small (<57 cm), medium (57-66 cm), and large (>66 cm) as shown in Figure 3. The CPUE for small fish increased significantly for the four areas (Shumagin, Chirikof, Kodiak, and Yakutat) beginning in 1980. The 1982 values, which averaged 0.130 t/1,000 hooks and the 1983 values, which averaged 0.092 t/1,000 hooks (down 29% from 1982) are approximately 10 times greater than the 1977-79 values. The increasing trend in the medium-sized category first occurred in the Chirikof and Kodiak areas in 1979. Increases in the Shumagin and Yakutat areas did not follow until 1982. The 1982 values, which average 0.261 t/1,000 hooks, are approximately double the 1977-79 values. The 1983 average of 0.201 t/1,000 hooks is 23% lower than the 1982 average. The increases in CPUE are apparently the result of the recruitment of the strong 1977 year class to the Japanese longline fishery. The CPUE for the large fish, which was probably in a depressed condition prior to 1977, has remained relatively stable over the 7-year span, except for the major increase in the Yakutat area in 1982, which may be largely the result of the large, previously discussed, sampling error in 1981. In summary, these data suggest that the increase in the stock biomass from the recruitment of the 1977 year class has leveled off.

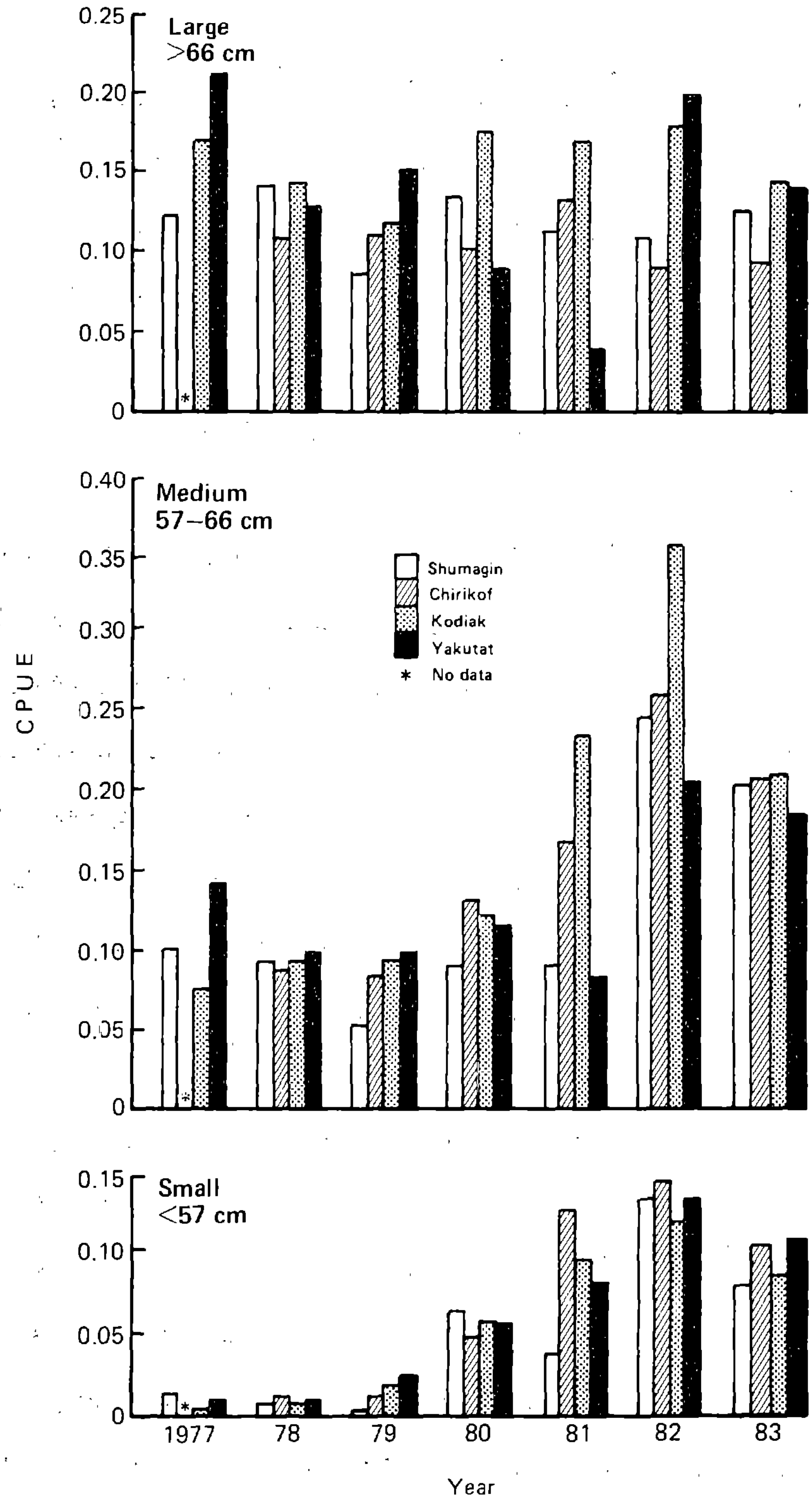


Figure 3.--Catch per unit effort (CPUE) (in t/1000 hooks) for small (<.57 cm), medium (57-66 cm), and large (>66 cm) sablefish taken by Japanese longline vessels at depths >500 m as determined by U.S. observers, 1977-83.

Japanese-U.S. Cooperative Longline Survey

Japan and the United States have cooperatively conducted an annual longline survey since 1978 in the Gulf of Alaska which, in recent years, has expanded to the Aleutian and Bering Sea areas. The objective of the survey is to study the stock condition of sablefish and other longline-caught species. The relative abundance and size structure of sablefish in the northeastern Pacific and Bering Sea based on the results of these surveys have been updated by Sasaki (1983a, b and 1984a, b) for years 1979-83, including a comparison with a 1969 Japanese survey in the Gulf of Alaska, The index of biomass referred to as relative population weight (RPW) 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 which lies in those depth categories. Index values have been summarized by INPFC area, bottom depth interval, and fish-size category for 1979-83 (Table 9). Results of the 1978 surveys were excluded because the fishing techniques were not standardized until 1979.

In general, RPW for the Gulf increased 70% between 1979 and 1980. Approximately 80% of the relative biomass occurs within the 101-400 m stratum, shallower than the target area for the directed longline fishery. From 1980 to 1982, the index for the interval 401-1,000 m increased more or less uniformly in all five INPFC statistical areas. For this depth stratum, the 1982 index was approximately 100% greater than that for 1980 in the Shumagin, Chirikof, Kodiak, and Yakutat areas, and 43% greater in the southeastern statistical areas. Overall, the 1983 RPW declined 5% although it did increase in the Shumagin and Kodiak areas. The RPW for fish longer than 58.1 cm increased 73% between 1979 and 1982, but decreased 8.3% in 1983. In the Shumagin area, relative biomass has increased annually, while in the Chirikof

Table 9.--Relative population weight (RPW) as an index of sablefish biomass for the Gulf of Alaska, by International North Pacific Fisheries Commission statistica. area, 1979-83.

Year	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern	Total
Total						
1979	11,580	61,237	55,413	35,148	25,324	188,702
1980	17,819	57,951	57,945	52,437	27,982	214,134
1981	27,851	52,437	51,640	66,712	51,123	249,763
1982	41,309	87,115	79,715	67,076	44,752	319,967
1983	52,409	73,761	83,812	51,175	39,329	297,486
101-400 m						
1979[a]	--	--	--	--	--	--
1980	12,739	51,319	48,955	44,994	18,658	176,665
1981	20,888	45,183	39,030	55,991	38,510	199,602
1982	31,353	72,125	60,026	51,872	31,453	246,829
1983	41,247	61,006	67,807	40,951	23,250	234,261
401-1000 m						
1979[a]	--	--	--	--	--	--
1980	5,080	6,632	8,990	7,443	9,324	37,469
1981	6,963	7,254	12,610	10,721	12,613	50,161
1982	9,956	14,990	19,689	15,204	13,299	73,138
1983	11,162	12,755	16,005	10,224	13,079	63,225
Fish >58.1 cm						
1979	7,493	37,284	40,053	25,224	19,891	129,945
1980	11,121	39,120	31,006	25,445	16,593	123,285
1981	16,431	35,662	32,868	46,292	40,207	171,460
1982	32,642	64,381	55,377	39,631	33,088	225,119
1983	39,663	52,638	53,238	32,697	28,032	206,268

[a]Data not available because of incomplete size composition by depth.

Sources: Sasaki 1983a and Sasaki 1984a.

and Kodiak areas it increased between 1981 and 1982. In the Yakutat and southeastern areas, the increases in these medium and large sablefish occurred between 1980 and 1981 and has since decreased each year. From 1979 to 1983 the overall increase for fish greater than 58.1 in the Shumagin, Chirikof, Kodiak, and Yakutat areas has been 62%. This increase is consistent with the 69% increase in CPUE from the U.S. Observer data for fish longer than 57 cm west of 140° W. long. taken in depth strata deeper than 500 m.

U.S. Pot Index Survey

The NMFS pot index survey conducted annually since 1978 has provided another assessment of the sablefish stocks in the southeastern area to replace the foreign longline fishery statistics. Based on the 1978-80 surveys, Zenger and Hughes (1981) estimated that acceptable biological catch (ABC) for June 1980-May 1981 should not exceed the previous season's harvest of 2,580 t. An unknown fraction of this harvest, however, actually occurred in the Cape Spencer area which, along with the Cape Cross index site, is technically in the Yakutat area (in INPFC terms). The population index for the 1981 pot survey (Zenger 1981) appeared to be down about 50% from the previous years (Fig. 4). Results from the 1982 survey were still slightly lowr. Unfortunately, this survey encountered problems with weather, and two stations--Cape Cross and Cape Ommaney--were fished with what was believed to have been inferior bait. A test comparison of baits, conducted in the spring of 1983, found no detectable differences in catch rates between the 1982 bait and fresh bait.[1/]

The 1983 survey showed a slight improvement in the catch rates of marketable-size sablefish (equal to or larger than 57 cm) at all four index

---

[1/] Personal communication with Jeff Fujioka, Northwest and Alaska Fisheries Center, Auke Bay Laboratory, P.O. Box 210155, Auke Bay, AK 99821.

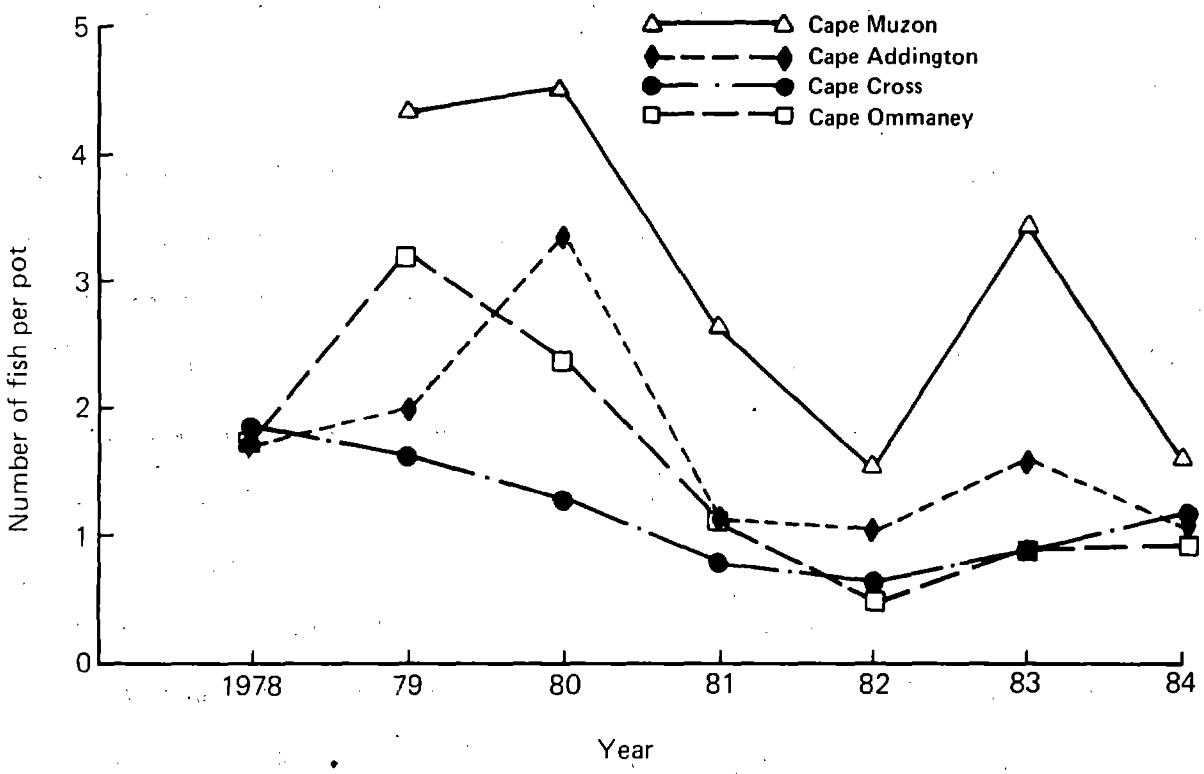


Figure 4.--Average number of fish > 57 cm per pot from the U.S. sablefish survey. in southeastern Alaska, 1978-83.

sites (Fig. 4). The greatest increase occurred at Cape Muzon and the smallest at Cape Cross--one of the major domestic fishing grounds. Preliminary results from the 1984 survey showed a slight decline in catch from 1983 (Fig. 4). The catch rates for the two northern sites, Cape Cross and Cape Ommaney, continued to increase, but the rates at the two southern sites, Cape Muzon and Cape Addington, decreased to the 1982 levels. The pattern of decreasing catch rates between 1980 and 1981 for the pot survey index runs counter to the increases of the RPW index for marketable sablefish for the same 2 years in the Yakutat and southeastern areas. Also, the increasing trend for the two northern sites is opposite of the trend in RPW values from the longline survey for Yakutat and southeastern Alaska. There is no indication in the pot survey data of a strong year class recruiting to the fishery,

Domestic Fishing Rates in Southeastern Alaska

The CPUE data for the domestic longline fleet operating on the offshore grounds of the southeastern INPFC area have been examined for each year 1980-84.[2/] Funk standardized fishing effort to the new circle hook gear, because almost all vessels had converted to this more efficient gear in 1984. The adjusted CPUE values show little change in sablefish catch rates between 1983 and 1984 (Fig. 5-A). In addition to the gear change, many new vessels entered the fishing in 1984. To examine the CPUE data of experienced fishermen, Funk selected a subset of vessels on which the same captain had fished in both years. For this subset, the standardized CPUE increased by 44% in the period 1983-84 (Fig. 5-B).

[2/] Personal communication with Fritz Funk, Alaska Department of Fish and Game, P.O. Box 3-2000, Juneau, AX 99802.

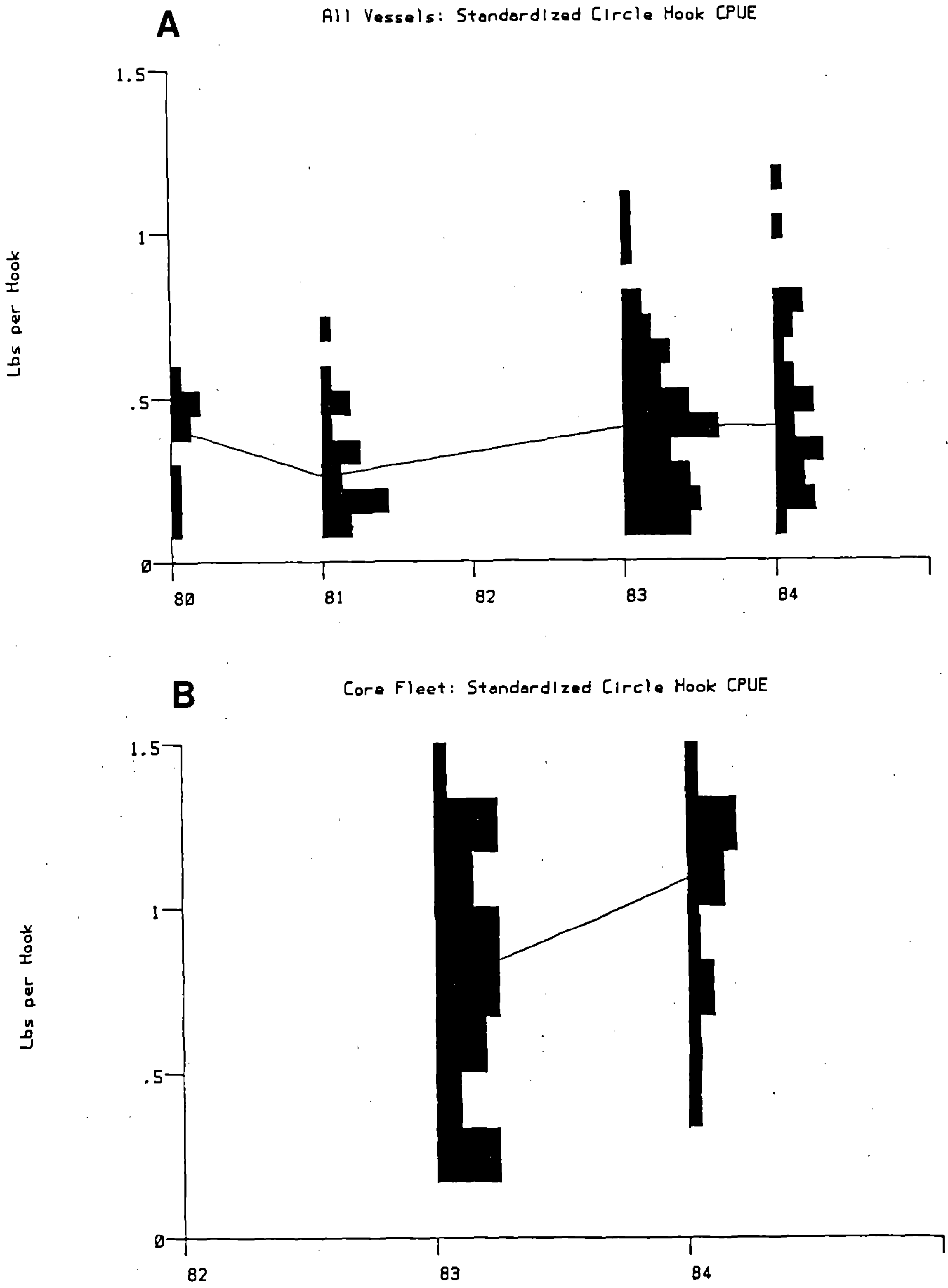


Figure 5.--Catch per unit effort (CPUE) for sablefish taken by U.S. longline vessels in the northern offshore grounds of the International North Pacific Fisheries Commission southeastern statistical area, standardized to circle hook gear: (A) all vessels, 1980-84; (B) selected core fleet, 1983-84 (Fritz Funk, Alaska Department of Fish and Game, P.O. Box 3-2000, Juneau, AK 99802. Pers. commun.).

The combination of these CPUE trends for the entire fleet 1980-83 and for the subset 1983-84 parallels the trend for the two northern pot index sites. Both indices apply to the same general fishing grounds in the northern portion of the INPFC southeastern area; Compared to the indices of abundance from the Japanese longline survey, this trend is similar to RPW values for the 401-1,000 m depth zone. The other RPW indices shown in Table 9 show a steady decline from the 1981 peak values.

POTENTIAL YIELD

Estimates of Maximum Sustainable Yield (MSY)

Although the sablefish resource is managed by regions, the long-term productivity in each region is assumed to be related to the overall condiiton of the resource. Japanese and U.S. scientists have estimated 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 among regions, Low and Wespestad (1979) estimated MSY for the California to Bering Sea resource at 50,300 t.

By region, historical catches were Bering Sea (25%), Aleutian region (4%), Gulf of Alaska (47%), and British Columbia-Washington region (25%). The apportioned MSY estimates were then compared to MSY estimates derived by applying general production models, 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 22,000-25,000 t used in the Fishery Management Plan. Production models are most appropriate for relatively short-lived stocks in which annual recruitment is relatively stable. It is questionable whether time-series of catch and effort data are appropriate for use in general production modeling of sablefish stocks, given that the lifespan of sablefish may be much longer than previously thought and that the fisheries are apparently supported by infrequent strong year classes (McFarlane and Beamish 1983).

Equilibrium Yield

The determination of equilibrium yield (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 estimates of MSY derived from surplus production models of the foreign longline fishery. For the areas east of 140° W. EY was based on annual landings prior to 1980. In 1982, EY in the eastern region was reduced by 50% because of the decline observed in the U.S. pot index between 1980 and 1981. The EY established in 1982 was not modified for 1983 even though the condition of the resource appeared to be improving.

Current EY for sablefish should be based on an assessment of the resource that incorporates information on the magnitude of the 1977 year class and updates estimates of growth and mortality parameters, Funk and Bracken (1984) utilized an age structure model to project future biomass levels and annual surplus production. Their model analysis is sensitive to initial age composition and biomass values and the projected average level of recruitment. They initiated the model with the 1982 age composition that they determined from a length frequency analysis of the 1982 Japanese longline survey. They assumed constant recruitment for age-3 fish and set it 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]). They forecast annual surplus production values for 1984 at 19,200 t and 26,100 t, respectively. These are approximately double the EY range of 10,965-12,630 t for 1982 and 1983. The increase in various indices of the sablefish stockswest of 140° W. long. between the late 1970.'s and 1983-84 support an increase in EY from the low of 8,540 t in the western half of the Gulf.

The trends in the indices for the area east of 140° W. long. suggest that the condition of the resource is stable and has not undergone a strong improvement.

Sasaki (1984b) presents new and revised sablefish biomass estimates derived from additional comparisons of area-swept biomass estimates from trawl surveys and 1983 RPW values for the Gulf. These estimates are 213,800, 509,700, and 643,200 t. Because of the wide discrepancy in these estimates, and the tentative nature of the results from the age-structure model of Funk and Bracken, EY estimates based on Sasaki's biomass figures are tentative.

In the summer of 1984, the United States and Japan cooperated in a Gulf-wide trawl and longline survey. The forthcoming results from this research will hopefully provide an appropriate estimate of current sablefish biomass and the geographic distribution of the stock within the Gulf of Alaska. Until these data are available, the only estimates of EY for the Gulf of Alaska are the range of 10,965 t to 26,100 t.

In past years, the apportionment of EY among INPFC areas was based on historical catch patterns. A more appropriate criterion for apportioning EY is the RPW estimates by INPFC area for the recent longline surveys and the biomass estimates forthcoming from the 1984 trawl survey. Based on the average RPW figures for 1983 and 1984 surveys, the percentages for the Shumagin, Chirikof, Kodiak, Yakutat, and southeastern INPFC areas would be 14.1%, 24.1%, 24.5%, 17.7%, and 19.6%, respectively. This assumes, as proposed by Funk and Bracken (1984), an additional amount of sablefish for the inner waters of the southeastern INPFC area that are not surveyed by the Japanese longline vessels.

REFERENCES

Anonymous. 1973. Allocation of U.S.S.R. and South Korean trawl catches in 1971 and 1972 respectively. By INPFC statistical areas and month. Unpubl. manuscr., 3 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., 7600 Sand Point Way N.E., Bin C15700, Bldg. 4, Seattle, WA 98115. (Document submitted to INPFC.)

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

Balsiger, J., and M. Alton. 1981. Condition of sablefish and pollock in the Gulf of Alaska in 1981. Unpubl. manuscr., 40 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Beamish, R. J., and G. A. McFarlane. 1983. Summary of results of the Canadian sablefish tagging program. In Proceedings of the International Sablefish Symposium, p. 147-183. Lowell Wakefield Fisheries Symposia Series, Univ. Alaska, Fairbanks, Alaska Sea Grant Rep. 83-8.

Berger, J. D., J. E. Smoker, and K. A. King. 1985. Foreign and joint venture catches and allocations in the Pacific Northwest and Alaska fishing areas under MFCMA, 1977-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWAFC. (In press.)

Bracken, B. E. 1982. Sablefish (<u>Anoplopoma fimbria</u>) migration in the Gulf of Alaska based on gulf-wide tag recoveries, 1973-81. Alaska Dep. Fish Game, Inf. Leafl. 199, 24 p.

Dark, T. A. 1983. Movement of tagged sablefish released at abundance index sites off southeastern Alaska, Washington, Oregon, and California during

1978-81. In Proceedings of the International Sablefish Symposium, p. 191-207. Lowell Wakefield Fisheries Symposia Series, Univ. Alaska, Fairbanks, Alaska Sea Grant Rep. 83-8.

Department of Fisheries and Oceans (Canada). 1959-72. British Columbia catch statistics (1958-71). Dep. Fish. Oceans, Fish. Manage., Pacific Region, 1090 W. Pender St., Vancouver, B.C. V5E 2P1.

Department of Fisheries and Oceans (Canada). 1973-79. Catch and effort statistics of the Canadian groundfish fishery on the Pacific coast in (1972-78). Can. Tech. Rep. Fish. Aquat. Sci. Various report numbers and pagination.

Fisheries Research and Development Agency (Republic of Korea). 1975. Exchange data of fishing statistics for the fisheries cooperation between Korea and the United States of America. No. 3: From Jan. 1975 to May 1976. (Data on file at the Northwest and Alaska Fisheries Cent., Natl. Mar. Fish. Serv., 7600 Sand Point Way N.E., Bin C15700, Bldg. 4, Seattle, WA 98115.

Fisheries Research and Development Agency (Republic of Korea). 1976. Fishery statistics of the Republic of Korea for 1976 in the eastern Bering Sea and northeastern Pacific Ocean as provided to the U.S. by the Republic of Korea. (Data on file at the Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., 7600 Sand Point Way N.E., Bin C15700, Bldg. 4, Seattle, WA 98115.

Forrester, C. R., A. J. Beardsley, and Y. Takahashi. 1978. Groundfish, shrimp, and herring fisheries in the Bering Sea and northeast Pacific--historical catch statistics through 1970. Int. North Pac. Fish. Comm., Bull. 37, 147 p.

Forrester, C. R., R. G. Bakkala, K. Okada, and J. E. Smith. 1983. Groundfish, shrimp, and herring fisheries in the Bering Sea and northeast Pacific--historical catch statistics, 1971-76. Int. North Pac. Fish. Comm., Bull. 41, 100 p.

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

Gharrett, A. J., L. N. Wishard, and M. A. Thomason. 1983. Progress in the study of the biochemical genetics of sablefish. In Proceedings of the International Sablefish Symposium, p. 143-146. Lowell Wakefield Fisheries Symposia Series, Univ.. Alaska, Fairbanks, Alaska Sea Grant Rep. 83-8.

LOW, L. L., G. K. Tanonaka, and H. H. Shippen. 1976. Sablefish of the Northeastern Pacific Ocean and Bering Sea. Processed Rep., 115 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Low, L. L. and V. Wespestad. 1979. General production models on sablefish in the North Pacific. Unpubl. rep., 16 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

McFarlane, G. A., and R. J. Beamish. 1983. Overview of the fishery and management strategy for sablefish (Anoplopoma fimbria) off the west coast of Canada. In Proceedings of the International Sablefish Symposium, p. 13-35. Lowell Wakefield Fisheries Symposia Series, Univ. Alaska, Fairbanks, Alaska Sea Grant Rep. 83-8.

Narita, R. E. 1983. Sablefish. In R. G. Bakkala and L. Low (editors), Condition of groundfish resources of the eastern Bering Sea and Aleutian Islands region in 1982., p. 111-125. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-42.

National Marine Fisheries Service. 1980. Foreign fishing activities Bering Sea and Gulf of Alaska. 1976. Unpubl. manuscr., 142 p. Natl. Mar. Fish. Serv., Law Enforcement Branch, Juneau, Alaska.

Okada, K., H. Yamaguchi, T. Sasaki, and K. Wakabayashi. 1982. Trends of groundfish stocks in the Bering Sea and the northeastern Pacific based on additional preliminary statistical data in 1981. Unpubl. manuscr., 80 p. Far Seas Fisheries Research Laboratory, Fisheries Agency of Japan, 1000 Orido, Shimizu 424, Japan.

Parks, N. 1975. Allocation of U.S.S.R. and Republic of Korea groundfish catches in 1973 by halibut conservation areas in the Bering Sea and INPFC statistical areas in the northeastern Pacific Ocean. Unpubl. manuscr., 7 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., 7600 Sand Point Way N.E., Bin C15700, Bldg. 4, Seattle, WA 98115. (Document submitted to INPFC.)

Parks, N. 1976. Allocation of U.S.S.R. and Republic of Korea groundfish catches in 1974 by halibut conservation areas in the Bering Sea and INPFC statistical areas in the northeastern Pacific Ocean. Unpubl. manuscr., 6 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., 7600 Sand Point Way N.E., Bin C15700, Bldg. 4, Seattle, WA 98115. (Document submitted to INPFC.)

Rigby, P. W. 1984. Alaska domestic groundfish fishery for the years 1970 through 1980 with a review of two historic fisheries--Pacific cod (Gadus macrocephalus) and sablefish (Anoplopoma fimbria). Alaska Dep. Fish Game, Tech. Data Rep. 108, 446 p.

Sasaki, T. 1982. Condition of sablefish stocks in the North Pacific. Unpubl. manuscr., 41 p. Fisheries Agency of Japan, Tokyo, Japan.

Sasaki, T. 1983a. Relative abundance and size structure of sablefish in the eastern Bering Sea, Aleutian region and Gulf of Alaska based on the results of Japan-U.S. joint longline survey from 1979 to 1982. In Proceedings of the International Sablefish Symposium, p. 239-253. Lowell Wakefield Fisheries Symposia Series, Univ. Alaska, Fairbanks, Alaska Sea Grant Rep. 83-8.

Sasaki, T. 1983b. Condition of sablefish stocks in recent years in the. eastern Bering Sea, Aleutian region and Gulf of Alaska on the results of field surveys. In Proceedings of the International Sablefish Symposium, p. 255-264. Lowell Wakefield Fisheries Symposia Series, Univ. Alaska, Fairbanks, Alaska Sea Grant Rep. 83-8.

Sasaki, T. 1984a. A prompt report on Japan-U.S. joint longline survey by Anyo maru No. 21 in 1983. Unpubl. manuscr., 21 p. Far Seas Fisheries Reserch Laboratory, Fisheries Agency of Japan, 1000 Orido, Shimizu 424, Japan.

Sasaki, T. 1984b. Condition of sablefish stocks in the eastern Bering Sea, Aleutian region, and Gulf of Alaska in 1983. Unpubl. manuscr., 19 p. Far Seas Fisheries Research Laboratory, Fisheries Agency of Japan, 1000 Orido, Shimizu 424, Japan.

Stauffer, G. 1983. Sablefish. In G. Stauffer (editor), Condition of groundfish resources in the Gulf of Alaska region as assessed in 1983, p. 3-1 to 3-36. NWAFC Processed Rep. 84-02. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112. (Document submitted to the INPFC in October 1983.)

Wespestad, V. G. 1981. Movement of sablefish, *Anoplopoma fimbria*, in the northeastern Pacific Ocean as determined by tagging experiments (1971-80). U.S. Natl. Mar. Fish. Serv., Fish. Bull. 81:415-420.

Wespestad, V., G. K. Thorson, and S. Mizroch. 1978. Movement of sablefish, Anoplopoma fimbria, in the northeastern Pacific Ocean as determined by tagging experiments (1971-1977). Processed Rep., 54 pp. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd E., Settle, Wa 98112.

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

Zenger, H., and S. Hughes. 1981. Changes in relative abundance and size composition of sablefish in the coastal waters of southeast Alaska, 1978-1980. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-7, 27 p.

PACIFIC COD

by

Harold H. Zenger, Jr.

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 1977, the importance of Pacific cod in the Gulf of Alaska groundfish catches has grown, increasing from 2,256 metric tons (t) in 1977 to 36,401 t in 1983 (Table 1). Pacific cod comprised 12.4% of the total Gulf-wide groundfish catch in 1983, down from a high of 16.5% in 1980 (Table 2).

At this time, management of Pacific cod in the Gulf of Alaska has not reached a critical point since the stocks are relatively healthy and the optimum yield (OY) of 60,000 t is well above recent harvest levels. However, as geographic restrictions on foreign longline effort in the central Gulf of Alaska increase (most specifically for sablefish, Anoplopoma fimbria), pressure to increase allocations of Pacific cod to foreign fisheries in the western Gulf may grow accordingly. It may then become necessary to review the proportional distribution of cod catch quotas among the North Pacific Fishery Management Council (NPFMC) eastern, central, and western regulatory areas.

Pacific cod are taken primarily with longlines and trawls. Foreign trawl catches of cod are largely incidental to fisheries for other species, and longlines catch most of the total allowable level of foreign fishing

Table 1 .--Catch (t) of Pacific cod in the Gulf of Alaska, by fishery category, 1971-83a.

Year	Japan	U.S.S.R	Republic of Korea	Poland	Mexico	J.V.	U.S.	Total
1971	461	176	--	--	--	--	44	681
1972	830	2,696	--	--	--	--	65	3,591
1973	2,590	3,395	--	--	--	--	59	6,044
1974	2,951	2,136	--	--	--	--	146	5,233
1975	3,252	2,551	--	--	--	--	130	5,933
1976	3,291	2,995	--	--	--	--	221	6,507
1977	1,243	744	--	--	--	--	269	2,256
1978	8,846	1,141	1,369	14		7	785	12,162
1979	10,428	835	844	127	939	711	985	14,869
1980	30,582	1,942	1,666	55	--	466	612	35,323
1981	27,768	--	7,066	135	--	58	1,061	36,088
1982	24,450	--	2,486	--	--	193	2,250[b]	29,379
1983	28,531	--	1,246	--	--	2,426	4,198	36,401

[a]Foreign catches 1971-76 are foreign-reported catches; foreign catches 1977-83 are best blend estimates.

[b]Erroneously reported as 6,434 t in Zenger (1984) because of a reporting error in the International North Pacific Fisheries Commission Shumagin statistical area.

Sources: Foreign catches 1971-76: Forrester et al. 1983. Foreign catches 1977-83 and joint venture catches 1978-83.: Berger et al. 1985. U.S. catches 1971-80: Rigby 1984. U.S. catches 1981-83: Pacific Fishery Information Network (Pac FIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 S.W. Fifth Avenue, Portland, OR 97201.

Table 2.--Catch (t) of Pacific cod in the Gulf of Alaska, by fishery category and International North Pacific Fisheries Commission (INPFC) statistical area, 1971-83.

Nation and INPFC area	Year						
	1977	1978	1979	1980	1981	1982	1983
Japan							
Shumagin	358	4,073	3,067	6,624	9,032	6,491	8,102
Chirikof	286	3,537	5,598	17,403	14,807	12,318	14,600
Kodiak	353	971	1,414	4,551	2,334	3,571	3,870
Yakutat	231	199	294	1,961	1,517	2,070	1,959
Southeastern	15	66	55	43	78	--	--
Total	1,243	8,846	10,428	30,582	27,768	24,450	28,531
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	--	--	--
Korea							
Shumagin	--	1,361	788	1,627	2,241	539	533
Chirikof	--	8	--	--	4,069	1,850	706
Kodiak	--	--	--	--	25	97	4
Yakutat	--	--	49	39	731	--	3
Southeastern	--	--	7	--	--	--	--
Total	--	1,369	844	1,666	7,066	2,486	1,246
Poland							
Shumagin	--	--	9	9	41	--	--
Chirikof	--	--	118	46	94	--	--
Kodiak	--	14	--	--	--	--	--
Total	-	14	127	55	135	--	--
Mexico							
Shumagin	--	--	100	--	--	--	--
Chirikof	--	--	376	--	--	--	--
Kodiak	--	--	463	--	--	--	--
Total	--	--	939	--	--	--	--

Table 2.--Continued.

Nation and INPFC area	Year						
	1977	1978	1979	1980	1981	1982	1983
U.S./Foreign joint ventures							
Shumagin	--	7	11	13	--	21	469
Chirikof	--	--	17	223	58	167	342
Kodiak	--	--	683	230	--	5	1,615
Total	--	7	711	466	58	193	2,426
United States							
Shumagin	53	64	--	71	265	292	74
Chirikof	16	167	267	49	87	26	27
Kodiak[a]	140	443	606	415	677	1,869	4,078
Yakutat	6	3	27	4	1	38	1
Southeastern	54	108	85	173	31	25	18
Total	269	785	985	612	1,061	2,250[b]	4,198
Grand total	2,256	12,162	14,869	35,323	36,088	29,379	36,401
Percent of total ground-fish catch	1.2	7.2	8.7	16.5	14.0	12.5	12.4

[a] May include small catches from lower Cook Inlet.

[b] Erroneously reported as 6,434 t in Zenger (1984) because of a reporting error in the International North Pacific Fisheries Commission Shumagin statistical area.

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 Cl5700, Building 4, 7600 Sand Point Way N.E., Seattle, WA 98115. U.S. catches 1977-80: Rigby 1984. U.S. catches 1981-83: Pacific Fishery Information Network (PacFIN), 305 State Office Building, 1400 S.W. Fifth Avenue, Portland, OR 97201.

(TALFF) allocation. In direct contrast, the vast majority of domestic and joint venture catches are made with trawls.

Continued use of midwater trawls in the Shelikof Strait pollock fishery should limit incidental cod catches during that period of intensive fishing effort. Directed trawl and longline fisheries for cod are expected to capture other species such as walleye pollock, _Theragra chalcogramma_; rockfish; Pacific halibut; _Hippoglossus stenolepis_; and other flatfishes.

FISHERY STATISTICS

The catch of Pacific cod increased sharply in 1980 (from 14,869 to 35,323 t) and has since remained roughly at that level. Three nations, the United States, Japan, and Republic of Korea (ROK) and a number of foreign joint ventures captured Pacific cod in the Gulf of Alaska during 1983. Landings by U.S. fishermen reached a peak of 4,198 t in 1983, the highest since the salt cod fisheries closed over 30 years ago. Japan harvested 28,531 t or 78% of the all-nation catch as opposed to an 83% share in 1982. The ROK and the combined joint venture fisheries harvested 1,246 and 2,426 t, respectively, in 1983 (Table 1).

As exemplified by the 1982 and 1983 data given above, in recent years Japan has harvested a vast majority of the Pacific cod taken from the Gulf. Since 1979 approximately 50% of that nation's catch has come from the International North Pacific Fisheries Commission (INPFC) Chirikof statistical area. In contrast, U. S. fishermen drew most of their landings from the Kodiak area in 1982 and 1983 (Table. 2). In 1983, 67% of the joint venture landings were taken from the Kodiak area also.

Most U.S. landings were trawl-caught, although longlines, gill nets, and other gear types are currently being 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 Koreans employ trawlers (Table 4). Since 1979 Japanese longliners have landed 91-93% of that nation's annual Gulf-wide cod catch (Table 5).

The combined Shumagin and Chirikof areas have produced from 68 to 85% of the total catch of Pacific cod in the Gulf since 1978 (Table 6). How greatly the variation among those years depends on fishing patterns or on the actual distribution of the species is a problem for further consideration.

Since the Magnuson Fishery Management and Conservation Act (MFCMA) of 1977 went into effect, various regulations have been implemented by the NPFMC that affect cod fisheries in the Gulf of Alaska and have allowed annual catches to reach present high levels. Amendment 2 to the Fishery Management Plan for the Gulf of Alaska Groundfish Fishery (FMP) allowed a year-round directed foreign longline fishery for Pacific cod west of 157° 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. halibut season. Those regulations have allowed more intensive foreign exploitation of an unusually large year class or series of year classes of Pacific cod.

The OY has varied somewhat since the concept was adopted by NPFMC. 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

Table 3.--Annual U.S. landings (t) of Pacific cod in the Gulf of Alaska, by gear type, 1981-84.

	Year			
Gear type	1981	1982	1983	1984[a]
Groundfish trawl	735	2,048	4,002	1,752
Beam trawl	1	<1	-	-
Shrimp trawl	114	6	<1	-
Gill nets	13	27	106	127
Longline	194	164	63	184
Pots	-	-	<1	<1
Troll	2	1	27	<1
Jig	1	4	<1	<1
Gear unknown	-	<1	<1	-
Total	1,060	2,250	4,199	2,063

[a]Partial year's catch reported to 10 August 1984.

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

Table 4.--Catch (t) of Pacific cod in the Gulf of Alaska, by fishery category and vessel type, 1978-83.

Fishery category and vessel type	Year 1978	1979	1980	1981	1982	1983
Japan						
Sm. trawler	433	312	1,525	1,032	702	530
Lg. frz. trawler[a]	346	385	727	825	1,024	1,164
Surimi trawler[b]	1,267	187	558	636	226	195
Longliner	6,800	9,545	27,771	25,274	22,499	26,642
U.S.S.R.						
Lg. frz. trawler	1,140	835	1,942	--	--	--
Korea						
Sm. trawler	--	--	--	988	237	68
Lg. frz. trawler	1,369	844	1,657	6,074	2,249	1,127
Longliner	--	--	9	3	T	51
Poland						
Lg. frz. trawler	14	127	55	135	--	--
Mexico						
Sm. trawler	--	833	--	--	--	--
Lg. frz. trawler	--	56	--	--	--	--
Joint venture						
Mothership	7	711	466	58	193	2,426
Total	11,376	13,885	34,710	35,025	27,130	32,203

[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 Fishery Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, Bin C15700, 7600 Sand Point Way N.E., Building 4, Seattle, WA 98115.

T: Trace

Table 5.--Japanese longline catch (t) tons) of Pacific cod by International North Pacific Fisheries Commission statistical area, and the percentage of the Japanese all-gear catch that was taken. by longline, 1978-83.

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

Source: 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 N.E., Seattle, WA 98115.

Table 6.--Catch (t) of Pacific. cod in the Gulf of Alaska by International North Pacific Fisheries Commission statistical area, 1977-83.

Year	Shumagin	Chirikof	Kodiak	Yakutat	Southeastern	Total
1977	726	358	866	237	69	2,256
1978	5,591	4,707	1,488	202	174	12,162
1979	3,981	6,541	3,829	371	147	14,869
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	7,344	14,361	5,542	2,107	25	29,379
1983	9,178	15,675	9,567	1,963	18	36,401

Source: 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 N.E., Seattle, WA 98115.

at 60,000 t in 1982 (Table 7). The distribution of OY is currently 28%, 56%, and 16% in the western, central, and eastern regulatory areas, respectively. (The western area is the Shumagin INPFC statistical area, the central area is composed of the Chirikof and Kodiak INPFC statistical areas, and the eastern area refers to the combined Yakutat and southeastern INPFC statistical areas.) Proportional distributions of catches to the respective regulatory areas have been relatively steady since 1979 (Table 8), although the Chirikof statistical area has accounted for the largest landings in the central NPFMC regulatory area (Table 6). Catches of Pacific cod in all three regulatory areas were well below the final allocations especially in the eastern area (Tables 7 and 8).

Questions have arisen as to the present distribution of cod abundance in the Gulf. Results of 1981 groundfish trawl surveys showed that 59% of the available biomass was located in the western regulatory area, 39% in the central and 2% in the eastern (Zenger and Cummings 1983). Results of the second triennial Gulf of Alaska groundfish survey (summer 1984) should allow us to comment further on this point in the near future.

Total initial allocations of Pacific cod for 1984 joint ventures. in the Gulf (14,850 t) are approximately six times the total 1983 joint venture catch of 2,426 t. Initial allocations to Domestic Annual Processing (DAP) are almost three times as large as the 1983 U.S. catch in the Gulf of Alaska (Tables 1 and 7). The TALFF allocations, on the other hand, reflect sizeable reductions--from 38,000 t in 1983 to 23,630 t in 1984. The initial TALFF allocation is almost 6,000 t less than the 1983 total foreign catch of Pacific cod.

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, 1977-84.

Year and	Initial				Final			
allocation	West	Central	East	Total	West	Central	East	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	6,548
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[c]								
OY	16,560	33,540	9,900	60,000				
-DAP	500	11,700	120	12,320				
-JVP	250	14,600	0	14,850				
DAH	750	26,300	120	27,170				
RES	3,312	3,708	1,980	9,000				
TALFF	12,498	3,532	7,800	23,830				

[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 1 January 1984.

Table 8.--Catch (t) of Pacific cod in the Gulf of Alaska, by North Pacific Fishery Management Council regulatory area, 1977-83.

Year	Western	Central	Eastern	Total
1977	726	1,224	306	2,256
1978	5,591	6,195	376	12,162
1979	3,981	10,370	518	14,869
1980	8,705	24,498	2,120	35,323
1981	11,579	22,151	2,358	36,088
1982	7,344	19,903	2,132	29,379
1983	9,178	25,242	1,981	36,401

Source: 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 N.E., Seattle, WA 98115.

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-California, British Columbia, Aleutian Island, Bering Sea, and Gulf of Alaska regions are each considered to have their own separate stock. Discussions here concerning the condition of the Gulf of Alaska stock are developed along three lines--resource assessment surveys, size composition, and catch per unit effort (CPUE) of the Japanese longline fishery.

Resource Assessment Surveys

In February 1984 a groundfish survey was conducted aboard the NOAA ship *Miller Freeman* along the edge of the continental shelf between Kodiak Island and the Shumagin Islands. A subsection of this area (lying between Albatross Bank and Chirikof Island) had previously been surveyed (Fig. 1). Comparisons, although useful, are limited by certain considerations. First, the time periods encompassed by the surveys were somewhat variable (Table 9) and gear was not completely standardized. Second, although Pacific cod was often an important catch component, it was not always the target species. Finally, sample patterns also were somewhat variable. The most comparable data sets, therefore, were from the 1979, 1980, and 1984 surveys. Catch rates show an increase between 1979 and 1980 with a decrease in 1984 (Table 9). Biomass estimates fluctuated broadly from year to year as did the confidence intervals around them (Table 10).

Results of the 1984 *Miller Freeman* survey yielded a biomass estimate of 85,126 t of cod in the Albatross Bank to Chirikof Island section

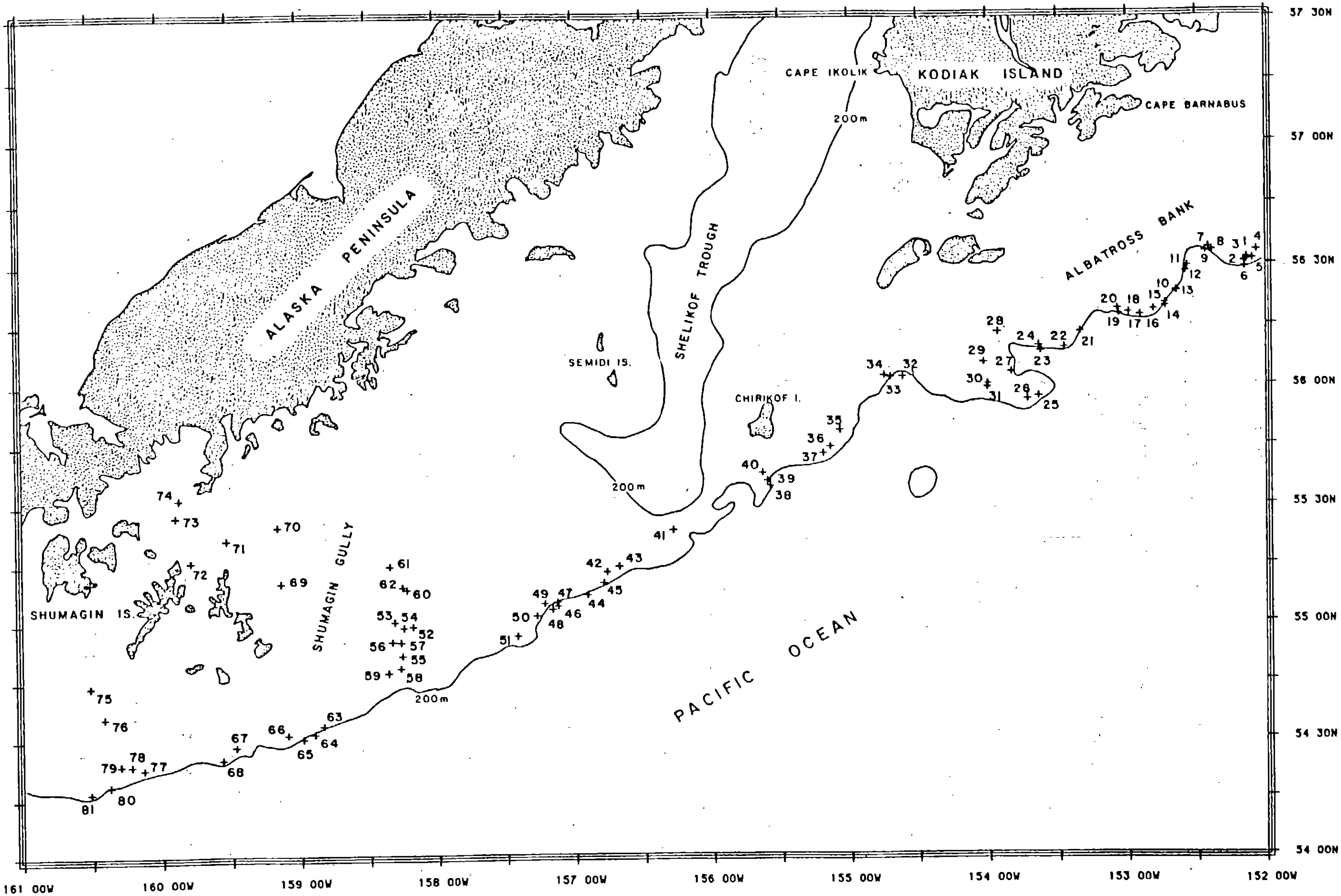


Figure 1.--Stations fished during _Miller Freeman_ Cruise 84-1 in the Gulf of Alaska, 8-29 February 1984.

Table 9.--Catch per unit effort (kilograms per kilometer towed) of Pacific cod from Miller Freeman winter or spring trawl surveys south of Kodiak. Island between Albatross Bank and Chirikof Island, 1977-81 and 1984.

Year	Dates (mo/day)	Depth intervals (meters) 101-200	201-300	301-400	Total
1977	2/7-3/6	28.0	1.6	-	25.1
1978	3/28-4/8	102.1	214.0	0.8	116.4
1979	3/15-4/13	122.8	22.6	-	101.5
1980	2/20-3/7	155.6	111.2	4.6	115.5
1981	4/20-5/4	28.0	8.2	0.6	19.7
1984	2/9-2/15	65.6	65.6	16.6	64.3

Table 10.--Biomass (t) of Pacific cod estimated from Miller Freeman winter or spring trawl surveys south of Kodiak Island, 1977-81 and 1984.

Year	Biomass	90% Confidence interval
1977	25,293	5,980 - 44,605
1978	208,438	0 - 435,674
1979	108,809	63,993 - 153,626
1980	167,465	118,766 - 216,164
1981	22,643	17,724 - 27,561
1984	85,126	40,652 - 129,599

(Figure 1), and 143,849 t (90% confidence limits of 83,370-204;329 t) in the Chirikof Island to Shumagin Islands section. Applying the yield equation of Gulland (1975); $Y = 0.5\ M\ Bo$ where:

Y = yield in metric tons,
M = estimated force of natural mortality acting on the population, and
Bo = estimated virgin biomass,

results in an estimated exploitable biomass of 45,800 t, approximately 20,000 t more than the total catch of Pacific cod from the combined Kodiak and Chirikof areas in 1983.

Size Composition

Size composition of Pacific cod changed considerably over the five consecutive survey years, 1977-81. Figure 2 summarizes size composition data for all six surveys. In 1977 sampled cod were much smaller than in other survey years. This may have been due in part to the lack of sampling along the outside edge of the continental shelf where subsequent surveys expended most effort. In 1979 recruitment of the 1977 year class was noted and during the 1980 survey, the 1978 year class was present in relatively large numbers. Recruitment was apparently weak in 1981 and 1984. Since the area surveyed is small and the rest of the western Gulf went largely unsampled, some reservations must be expressed as to whether these results should be extrapolated to the rest of the cod producing areas in the Gulf. Little is known about the winter distribution of the stocks and their geographical variability. Although the 1984 survey extended to the Shumagin Islands, no previous comparable surveys have been conducted.

The most consistent, relatively long-term source of Pacific cod size composition data from the Gulf of Alaska comes from the Japanese longline

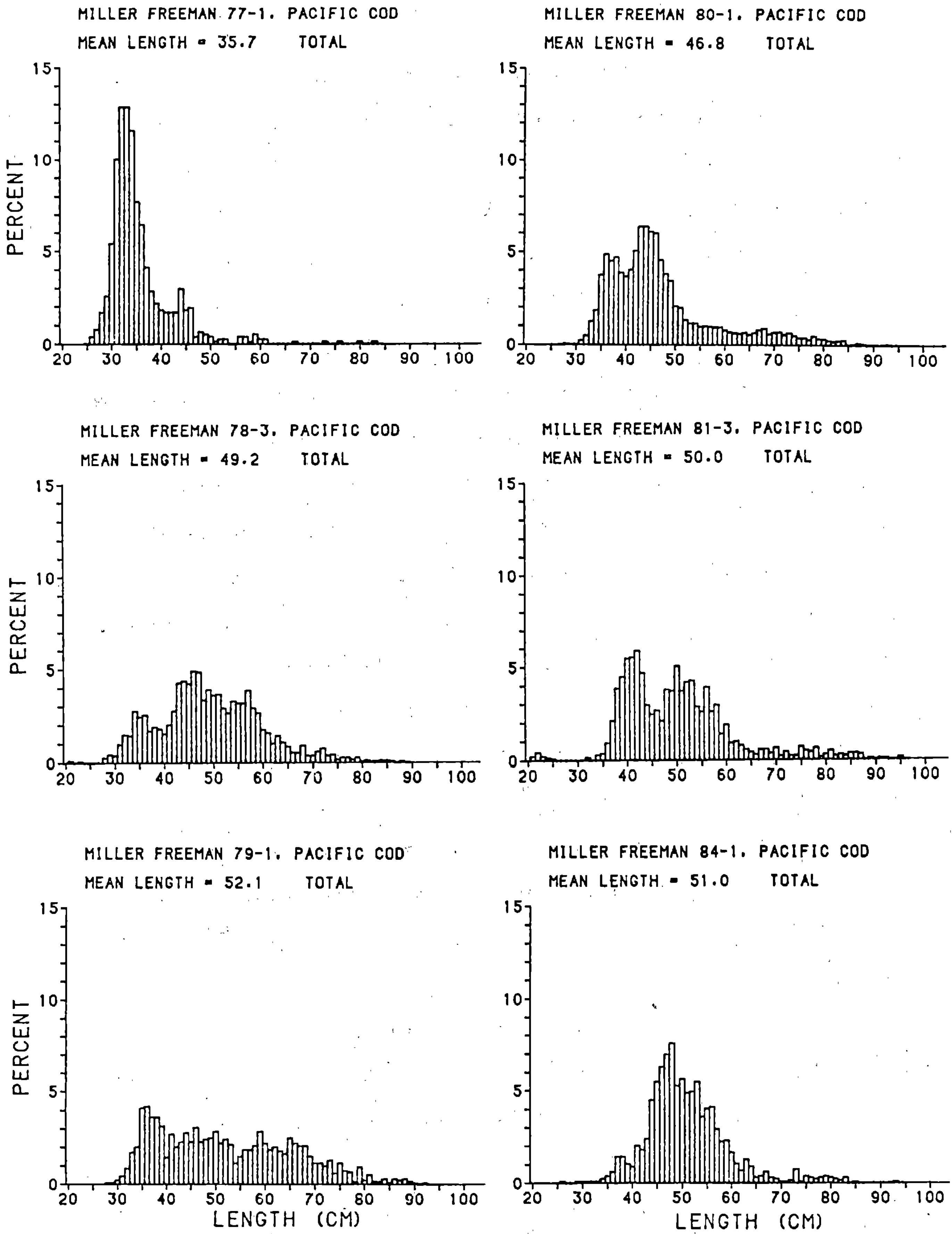


Figure 2.--Length frequencies of Pacific cod captured during winter or spring groundfish surveys in the Albatross Bank-Chirikof Island area,, 1977-81 and 1984.

fishery. Length frequency data collected by the U. S. Foreign Fisheries Observer Program from 1979 to 1983 are summarized by 3-month period in Figure 3. Length frequencies are weighted by the catch of Pacific cod from each quarter year. Resulting histograms show the relative contribution to the total quarterly catch made by each centimeter size group. During the fourth quarter of 1979 a group of fish appeared in the 40-50 cm interval, indicating the presence of the 1977 year class in the fishery. The recruitment of 3 year-old cod became more notable during the following year, and, as the mode moved to the right and strengthened, the 1977 and possibly the 1978 year classes grew into the major contributors to the Japanese longline fishery. In the fourth quarter of 1980 there was a relatively large proportion of 40-50 cm cod once again, although the size of the preceding year class was such that the 1977 and 1978 year classes could not be separated by inspection of the frequency. histograms. In fact, recruitment has occurred every year and indications from the length frequency histograms suggest that the 1977, 1978, and 1980 year classes were relatively strong.

The Alaska Department of Fish and Game (ADF&G) is collecting size composition data from U.S. landings and joint ventures. Figure 4 shows length frequencies of trawl-caught Pacific cod for the first, second, and fourth quarters of 1983.[1/]

During the 1984 Gulf of Alaska triennial groundfish survey, 6-8 cm Pacific cod were found along Shelikof Trough northeast of Chirikof Island (Fig. 1) in what appeared to be relatively dense semipelagic schools.

[1/] Personal communication with James Blackburn, Alaska Department of Fish & Game, P.O. Box 686, Kodiak, AK 99615.

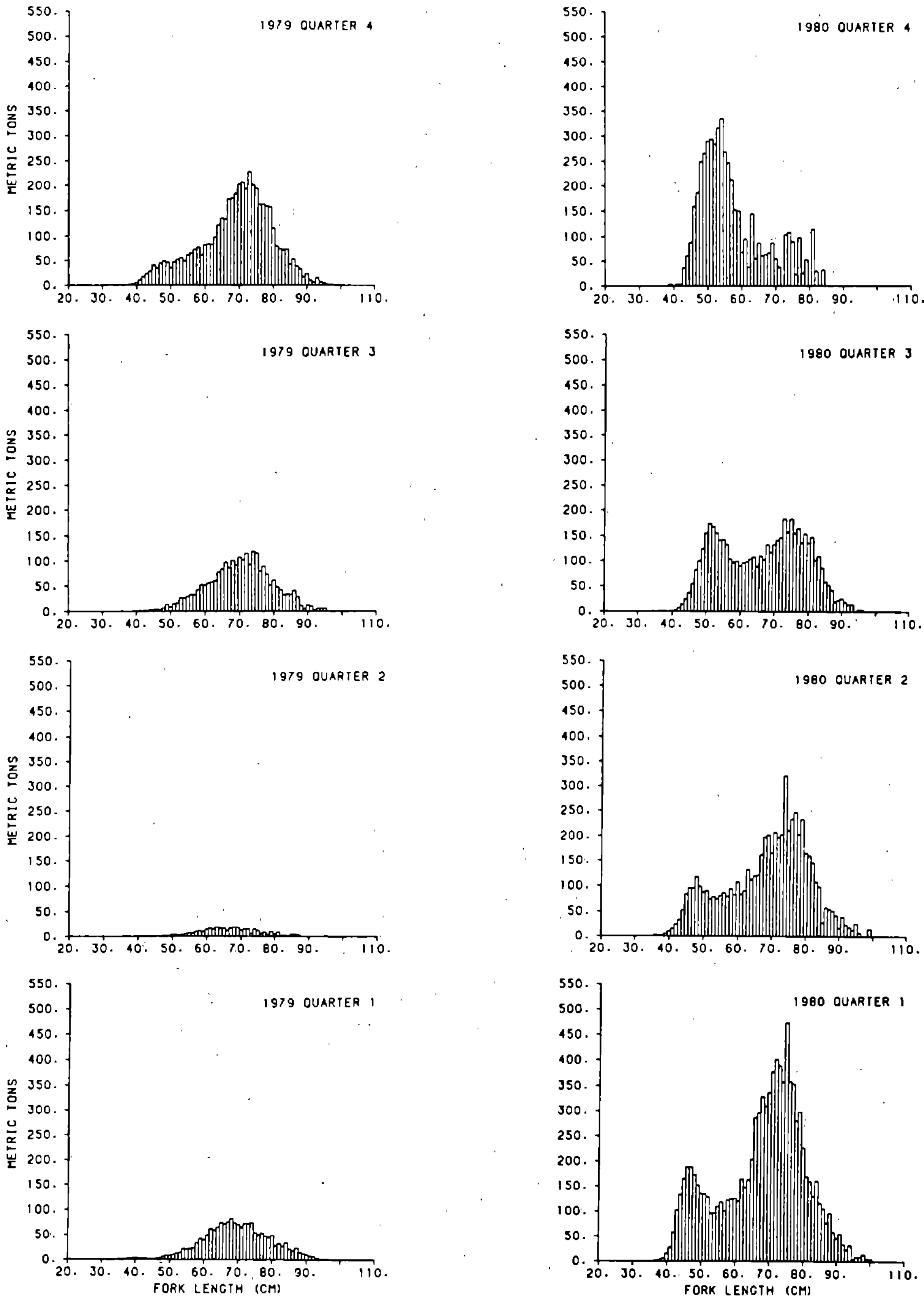


Figure 3.--Length frequencies expressed as metric tons of Japanese longline catches of Pacific cod per centimeter of fork length, by quarter, 1979-82. (Catch estimates and length frequencies furnished by the U.S. Foreign Fisheries Observer Program, Seattle, Washington.)

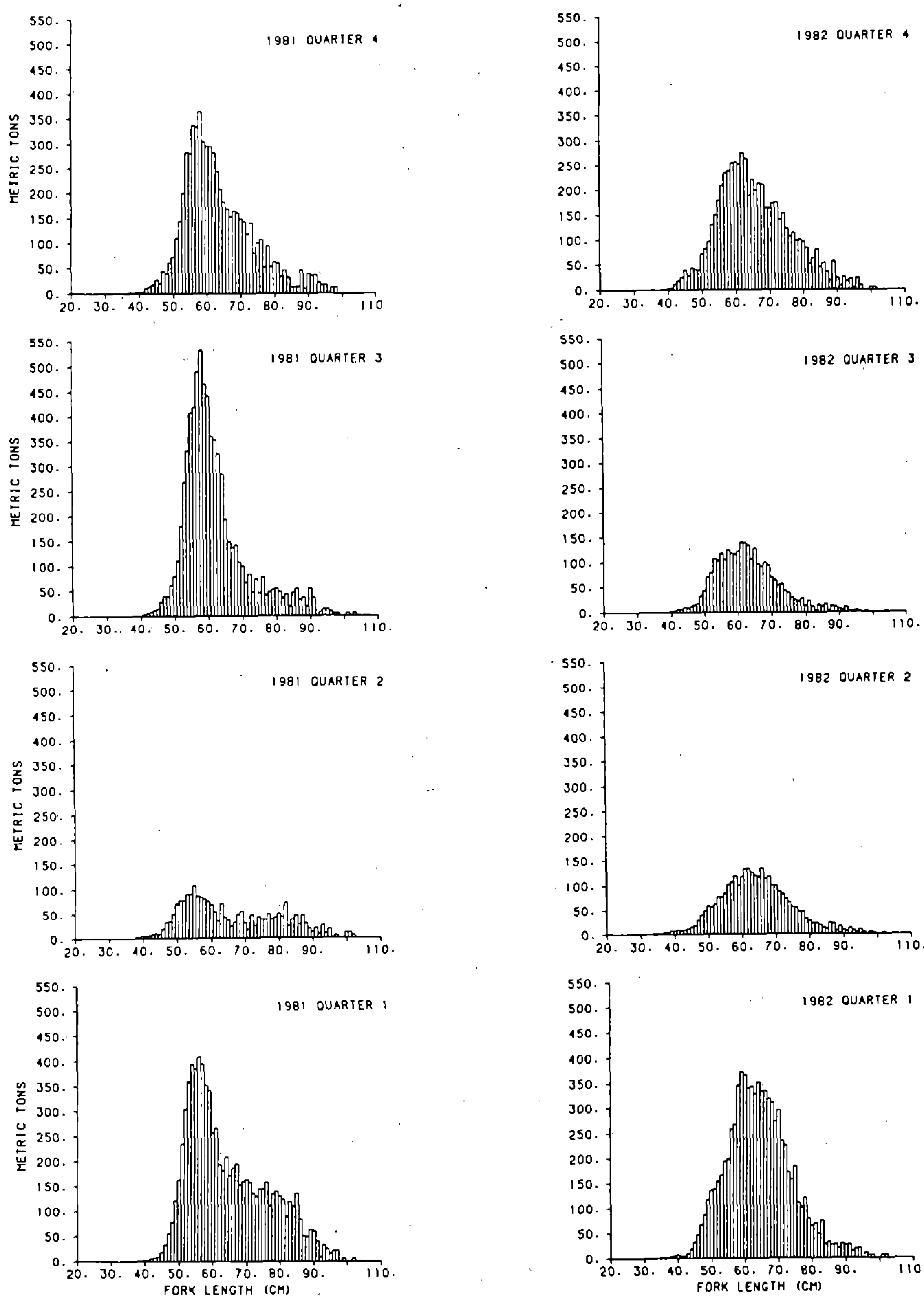


Figure 3.--Continued.

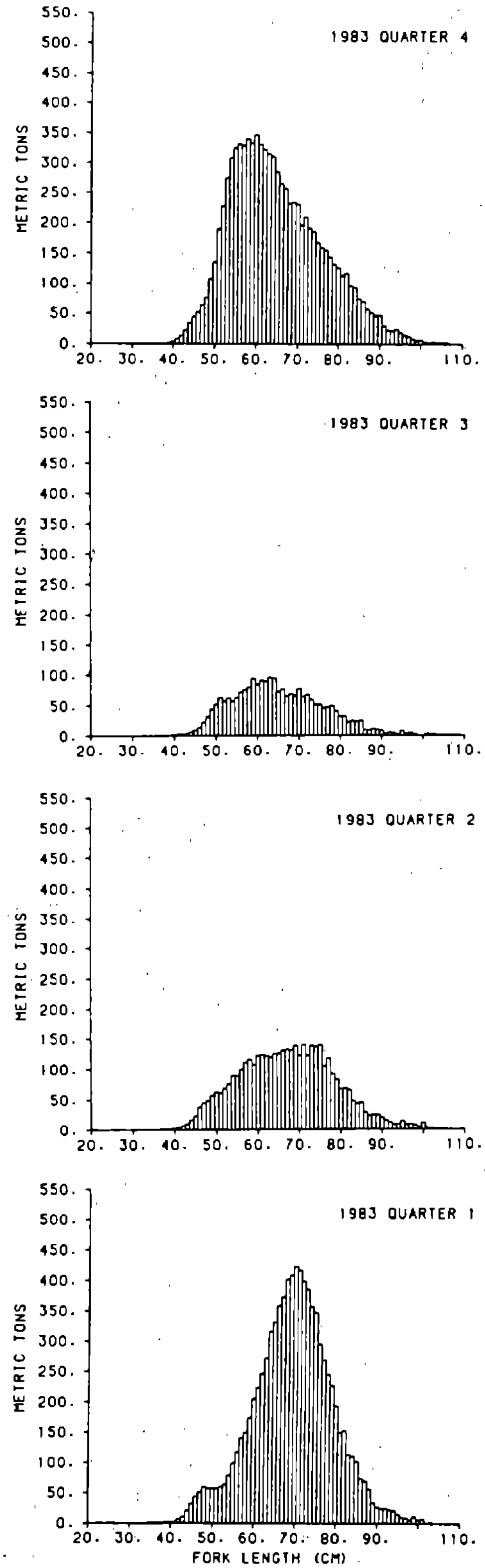


Figure 3.--Continued.

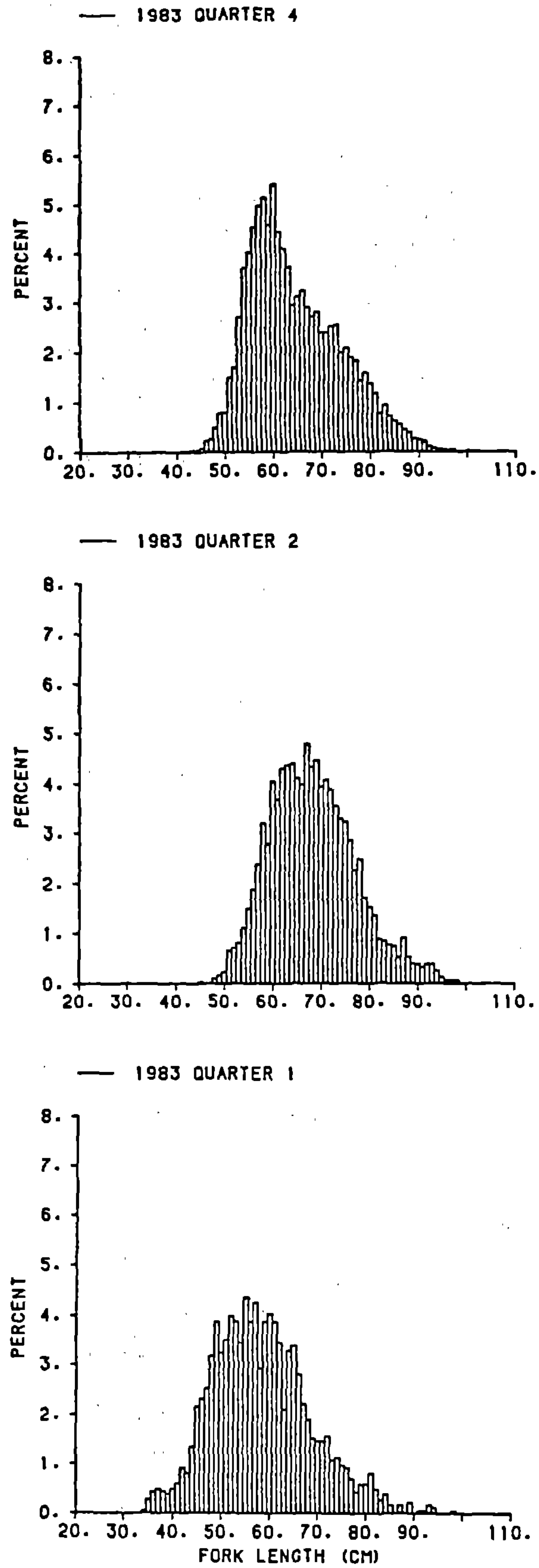


Figure 4.--Length frequencies of Pacific cod sampled from U.S. trawl landings at Kodiak, Alaska, and from joint venture catches near Kodiak Island, by quarter for 1983 (James Blackburn, Alaska Department of Fish and Game, P.O. Box 686, Kodiak, AK 99615. Pers. commun.).

This previously undocumented phenomenon could not be examined further since plankton trawls were notavailable. The finding may show that a major nursery area for age-0 Pacific cod and possibly walleye pollock is in the region. An attempt should be made to include that area in future plans for the ongoing investigations of juvenile groundfish.

Catch per Unit Effort

Japanese longline catch per unit effort also gives a recent picture of relative abundance of Pacific cod. In previous reports, 500 m was the limit used to separate directed effort for cod from that for sablefish. Closer examination shows that there is a relatively small amount of catch and effort from the 300 to 500 m depth interval and that depths less than 300 m encompass most of the Japanese longline effort that is directed at Pacific cod (Table 11).

Based on U.S. foreign observer data for 1979-83, the CPUE (tons/1,000 hooks) of cod taken in less than 300 m shows an increasing trend through 1982 and a slight decrease in 1983 in the Shumagin area, increases through 1983 in the Chirikof area, and in the Kodiak area, a decreasing trend through 1981, followed by a relatively large increase through 1983 (Table 12).

Ranked CPUE (kg/day) by species captured by the Japanese longline fishery for Pacific cod is contained in Table 13. Cod always ranked highest with Pacific halibut or sablefish second.

In 1979 Low et al. reported maximum sustainable yield (MSY) as 88,000-177,000 t and in 1982 MSY was reported as 95,000-190,000 t based on various Gulf of Alaska groundfish surveys that were performed in 1980 and 1981 (Zenger and Cummings 1983). When the results of the 1984 Gulf

Table 11.--Catch per unit effort (metric tons per 1,000 hooks) of Pacific cod by depth and International North Pacific Fisheries Commission statistical area in the Gulf of Alaska,. 1979-83.

Year/ Depth (meters)	Area			
	Shumagin	Chirikof	Kodiak	Yakutat
1979				
100-199 m	0.5718	0.5807	0.8334	0.1934
200-299 m	0.6099	0.7370	0.4127	NS[a]
300-399 m	NS	0	0.1589	NS
400-499 m	NS	0.1414	0	NS
1980				
100-199 m	0.6225	0.5468	0.4036	NS
200-299 m	0.6707	0.6721	0.5693	NS
300-399 m	0.0478[b]	1.0672[b]	NS	NS
400-499 m	NS	NS	NS	0
1981				
100-199 m	0.6882	0.6459	0.3538	NS
200-299 m	0.7099	0.5535	0.4123	NS
300-399 m	NS	NS	NS	NS
400-499 m	NS	NS	NS	NS
1982				
100-199 m	0.8228	0.6897	0.4556	0.0297
200-299 m	0.6884	0.6396	NS	NS
300-399 m	NS	NS	NS	NS
400-499 m	0.1792	NS	NS	NS
1983				
0-99 m	0.8455	NS	NS	NS
100-199 m	0.7344	0.7645	0.4442	NS
200-299 m	0.4452	0.6623	0.6235	0.3280
300-399 m	0.2205	NS	0.6141[b]	NS
400-499 m	0	0	NS	NS

[a]NS: No sample

[b]Very small sample

Source: 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 N.E., Seattle, WA 98115.

Table 12.--Catch per unit effort (CPUE) for Japanese longliners derived from samples collected by the U.S. Foreign Fisheries Observer Program in the International North Pacific Fisheries Commission (INPFC) Shumagin, <Chirikof; and Kodiak statistical areas, for fishing depths shallower than 300 meters, 1979-83.

Year/ INPFC area	Total estimated sample catch (metric tons)	Total hooks fished (x1000)	CPUE for total sample (t/1000 hooks)	Mean depth per set (m)
1979				
Shumagin	573.7	982.0	0.5842	217
Chirikof	798.5	1,265.4	0.6310	199
Kodiak	135.3	197.9	0.6837	178
Combined areas	1,507.5	2,445.3	0.6165	
1980				
Shumagin	580.6	905.7	0.6411	192
Chirikof	1,031.9	1,644.2	0.6276	210
Kodiak	126.6	251.0	0.5044	213
Combined areas	1,739.1	2,800.9	0.6209	
1981				
Shumagin	911.2	1,318.6	0.6910	159
Chirikof	1,013.0	1,611.0	0.6288	168
Kodiak	49.4	136.9	0.3608	158
Combined areas	1,973.6	3,066.5	0.6436	
1982				
Shumagin	701.2	883.2	0.7939	166
Chirikof	1,149.1	1,675.3	0.6859	159
Kodiak	129.4	284.0	0.4556	149
Combined areas	1,979.7	2,842.5	0.6965	
1983				
Shumagin	3,512.6	4,817.6	0.7291	140
Chirikof	6,881.3	9,237.4	0.7449	162
Kodiak	257.0	430.0	0.5977	214
Combined areas	10,650.9	14,485.0	0.7353	

Source: 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 N.E., Seattle, WA 98115.

Table 13.--Ranked catch per unit effort (CPUE), in kilograms per 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, 1979-83.

	Area and CPUE					
Year	Shumagin	kg/d	Chirikof	kg/d	Kodiak	kg/d
1979						
	Pacific cod	6,038	Pacific cod	9,506	Pacific cod	2,706
	Pac. halibut	103	Sablefish	339	Pac. halibut	303
	Sculpin	66	Pac. halibut	142	Sablefish	101
	Sablefish	63	Arrowtooth fl.	96	Arrowtooth fl.	31
1980						
	Pacific cod	9,841	Pacific cod	10,117	Pacific cod	9,040
	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	4,936
	Sablefish	1,199	Sablefish	1,116	Sablefish	1,352
	Pac. halibut	444	Pac. halibut	917	Pac. halibut	795
	Arrowtooth fl.	124	Arrowtooth fl.	250	Sculpin	116
1982						
	Pacific cod	8,154	Pacific cod	9,738	Pacific cod	4,044
	Sablefish	625	Pac. halibut	718	Pac. halibut	699
	Pac. halibut	255	Sablefish	343	Sablefish	330
	W. pollock	79	W. pollock	102	Skates	109
1983						
	Pacific cod	9,597	Pacific cod	11,585	Pacific cod	6,947
	Sablefish	968	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

Source: 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 N.E., Seattle, WA 98115.

of Alaska triennial groundfish survey are analyzed, the former MSY range may be updated., We should add that indices of abundance taken from the largest portion of the Gulf of Alaska cod fishery suggest that the stocks are healthy and were largely unchanged in the past several years.

RECENT RESEARCH RESULTS

A major weakness of using length frequencies to extract information on abundance by year class is that in this case there was virtually no reliable age data to complement the size data. Cod scales have proven to be poor indicators of age; and otoliths are subject to considerable error in interpretation of annuli. However, a scientist working at the Northwest and Alaska Fisheries Center has found that spines from the first dorsal fin give very clear readings of what appear to be annuli. The technique will require verification and NMFS will be tagging cod and removing dorsal spines at tagging and later attempting to recover sufficient numbers of specimens to ascertain the accuracy of the spine aging techniques. Tag and recovery data will also be used to study cod movements.

REFERENCES

Bakkala, R., S. Westrheim, K. Okada, C. Zhang, and E. Brown. 1981. Overall distribution of Pacific cod in the North Pacific ocean. Unpubl. manuscr., 11 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112. (Document submitted at the 1981 Annual Meeting of the INPFC.)

Berger, J. D., J. E. Smoker, and K. A. King. 1985. Foreign and joint venture catches and allocations in the Pacific Northwest and Alaska fishing areas under MFCMA, 1977-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWAFC. (In press).

Forrester, C. R., R. G. Bakkala, K. Okada, and J. E. Smith. 1983. Groundfish, shrimp, and herring fisheries in the Bering Sea and northeast Pacific--historical catch statistics, 1971-1976. Int. North Pac. Fish. Comm., Bull. 41, 100 p.

Gulland, J. A. 1975. Manual of methods for fisheries resource survey and appraisal. Part 5. Objectives and basic methods. Food Agric. Organ. U.N., Rome, FAO Fish. Tech. Pap. 145, 29 p.

Low, L. L., M. Alton, V. Westpestad, and E. Brown. Condition of groundfish stocks in the Gulf of Alaska. Unpubl. manuscr., 43 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112. (Document submitted at the 1979 Annual Meeting of the INPFC.)

Rigby, P. W. 1984. Alaska domestic groundfish fishery for the years 1970 through 1980 with a review of two historic fisheries -- Pacific cod (Gadus macrocephalus) and sablefish (Anoplopoma fimbria). Alaska Dep. Fish Game, Tech. Data Rep. 108, 446 p.

Zenger, H. H. Jr. 1984. Pacific cod In G. Stauffer (editor), Condition of groundfish resources in the Gulf of Alaska region as assessed in 1983, p. 3-1 to 3-36. NWAFC Processed Rep. 84-02. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Bin C15700, Bldg. 4, Seattle, WA 98115.

Zenger, H. Jr., and N. Cummings. 1983. Pacfic cod. In D. Ito and J. Balsiger (editors), Condition of groundfish resources in the Gulf of Alaska in 1982, p.87-109. U. S. Dep. Commer. NOAA Tech. Memo. NMFS F/NWC-52.

THIS PAGE INTENTIONALLY LEFT BLANK

ATKA MACKEREL

by

Lael L. Ronholt

INTRODUCTION

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

Foreign nations historically have been the principal harvesters of Atka mackerel. Soviet fleets dominated the fishery 1972-80, and those from the Republic of Korea (ROK) 1981-83. A joint venture fishery operated for the first time in 1983, with U.S. fishermen delivering to ROK processors in the Shumagin area. Catches are presented by nation and year in Table 1. Estimates of optimum yield (OY) also are presented for each year beginning with 1977 when the Magnuson Fishery Conservation and Management Act MFCMA went into effect.

Since 1974, landings of Atka mackerel in the Gulf have ranged from 6,759 to 27,776 metric tons (t). Catches peaked in 1975, declined through 1979, increased again in 1980 and 1981, and then declined sharply in 1982, before increasing moderately in 1983. In terms of the species or groups of species by which foreign landings are summarized, Atka mackerel decreased in importance from second in 1978 to last in 1982, but then increased again to third in 1983.

The Kodiak area was the heaviest producer in the early years of the fishery-- providing two thirds of the catch in 5 of the 7 years 1974-80 (Table 2). In 1978 and again in recent years 1981-83, the adjacent Chirikof area was the primary producer.

Table 1.--Catch (t) of Atka mackerel in the Gulf of Alaska, by fishery category, 1974-83. Optimum Yield (OY) also 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	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	20,000
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	--	18,727	28,700[b]
1982	--	2,087	4,672	--	--	--	6,759	28,700
1983	--	2,806	8,664	--	--	790	12,260	28,700

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

[b]Optimum yield (OY) for 1981 is sometimes given (elsewhere) 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.

Sources: 1974-76: Forrester et al. 1983; 1977-83: Berger et al. 1985.

Table 2.--Catches (t) of Atka mackerel in the Gulf of Alaska, by nation and International North Pacific Fisheries Commission statistical area, 1974-83.

Year		Area					
		Shumagin	Chirikof	Kodiak	Yakutat	Southeastern	Total
1974	U.S.S.R.	4,742	2,748	10,041	-	-	17,531
	Japan	-	-	-	-	-	a
							17,531
1975	U.S.S.R.	2,132	743	23,688	1,213	-	27,776
	Japan	-	-	-	-	-	a
							27,776
1976	U.S.S.R.	1,552	4,394	13,211	776[b]	-	19,933
	Japan	-	-	-	-	-	a
							19,933
1977	U.S.S.R.	69	2,057	17,120	0	0	19,246
	Japan	-	-	-	-	-	a
	Poland	-	-	209	-	-	209
							19,455
1978	U.S.S.R.	184	17,320	883	0	0	18,387
	Japan	243	265	338	125	165	1,136
	ROK	61	2	0	0	0	63
							19,586
1979	U.S.S.R.	5	708	9,552	0	0	10,265
	Japan	322	8	227	11	0	568
	ROK	81	0	0	0	0	81
	Mexico	11	4	21			36
							10,950
1980	U.S.S.R.	899	90	9,484	0	0	10,473
	Japan	35	179	1,511	171	T	1,896
	ROK	736	0	0	0	0	736
	Poland	48	9	0	0	0	57
							13,162
1981	Japan	699	1,331	1,369	212	25	3,636
	ROK	2,551	11,147	46	1,066	0	14,811
	Poland	221	59	0	0	0	280
							18,727
1982	Japan	1,922	77	87	1	0	2,087
	ROK	1,241	3,431	0	0	0	4,672
							6,759
1983	Japan	1,498	1,243	65	T	0	2,806
	ROK	1,096	7,568	0	0	0	8,664
							11,470

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

T: Trace.

Sources: 1974-76: Forrester et al. 1983; 1977-83: 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 N.E., Seattle, WA 98115.

In 1903, 11,470 t of Atka mackerel were taken in the directed foreign fisheries-- 8,664 t (76%) by ROK and 2,806 t (24%) by Japan. The ROK harvested 91% of its catch with large freezer trawlers and 9% with small trawlers while Japan took 75% of its catch with large freezer trawlers, 16% with small trawler and 9% with surimi trawlers. The Chirikof area produced 8,811 t of the catc (77%), followed by the Shumagin and Kodiak areas with 2,594 (23%) and 65 t (l%), respectively. Less than a half ton was taken in the Yakutat area.

CONDITION OF THE STOCKS

From the onset, the United States has managed the Atka mackerel resource on the premise that there are separate subpopulations (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, although tentative, show that samples from the two regions are distinct morphologically, and meristically.

Current efforts to measure 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, for example, 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. Moreover, very little CPUE data exists from the Gulf of Alaska. Age composition, still another commonly-used tool, also is of little value for studying the condition of the Gulf of Alaska Atka mackerel stock because of differences stemming from the use of scales by Soviet scientists and otoliths by U.S. scientists (Levada 1979a; Levada 1979b; and Fadeev and Kharin 1981).

On the other hand, catch data can be used--even without accompanying effort data--to assess the general condition of the Atka mackerel stock in the Gulf of Alaska, particularly when supported by associated biological data. Note, for example, the drastic decline of the catches in the Kodiak area from an average 12,297 t 1974-80 to an average of just 522 t 1981-83, including a historical low of 65 t in 1983 (Table 2 and Fig. 1). That the recent small catches are indicative of reduced biomass is substantiated by reports from Soviet research cruises. In 1981 the research vessel <u>Shantar</u>, 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 <u>Mys Dalniy</u> were unable to obtain samples of Atka mackerel at the usual stations.

Catch data are too sporadic in the adjacent Chirikof area to make similar long-term comparisons. It is noteworthy, however, that larger catches there in the last 2 years have not offset the lower catches in the Kodiak area. Catches in the Shumagin area have been stable between 2,500 and 3,500 t 1981-83, but this is more reflective of the total allowable level of foreign fishing (TALFF) for the area (roughly 4,000 t) than of stock abundance.

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 Soviets themselves 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 length of Atka mackerel taken in the commercial fishery in the Kodiak area has increased substantially between 1971-77, when 80% were 28-34 cm long, and 1981-83, when 88% were 38-45 cm long (Figs. 2 and 3). During the early years of the fishery,

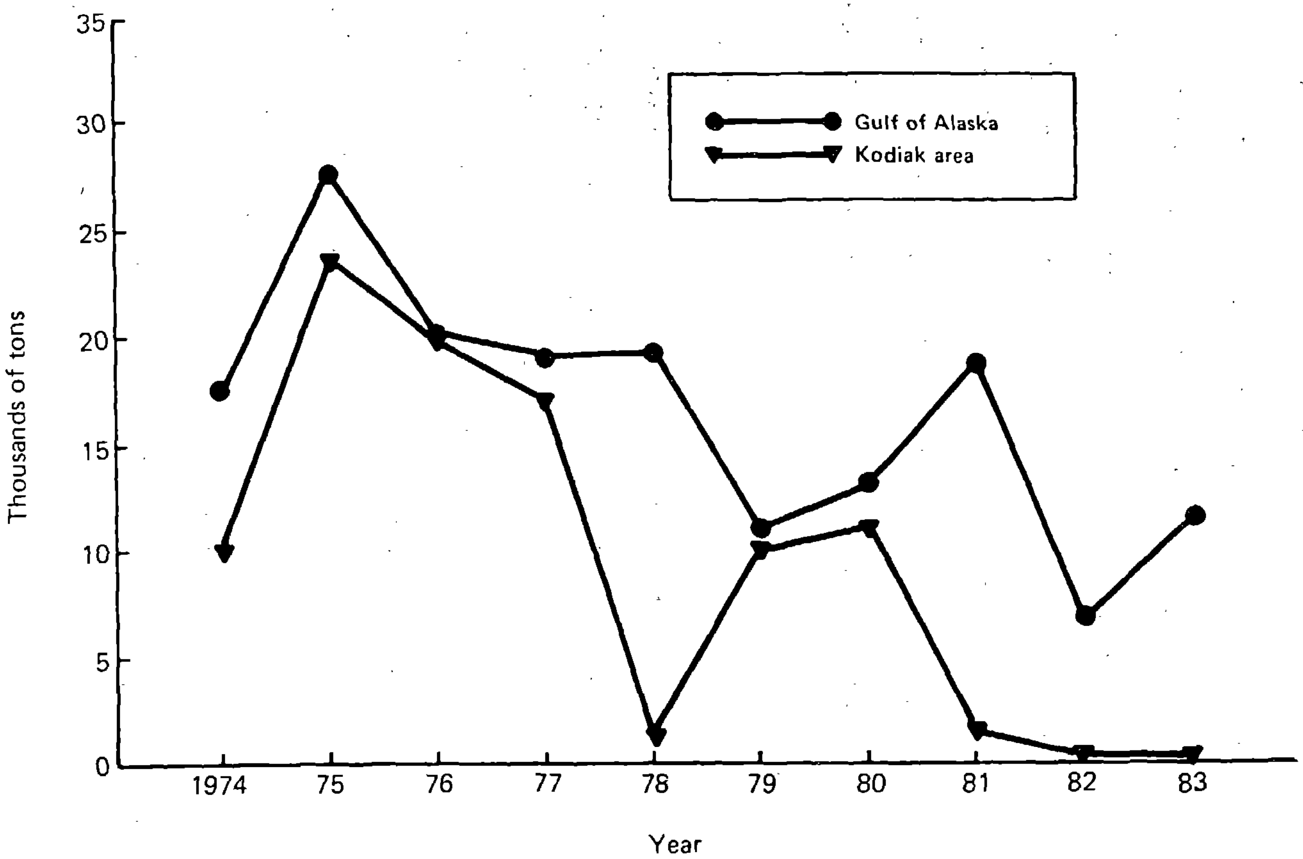


Figure 1.--Catch of Atka mackerel in the Kodiak area and in the Gulf of Alaska as a whole, 1974-83, in tons.

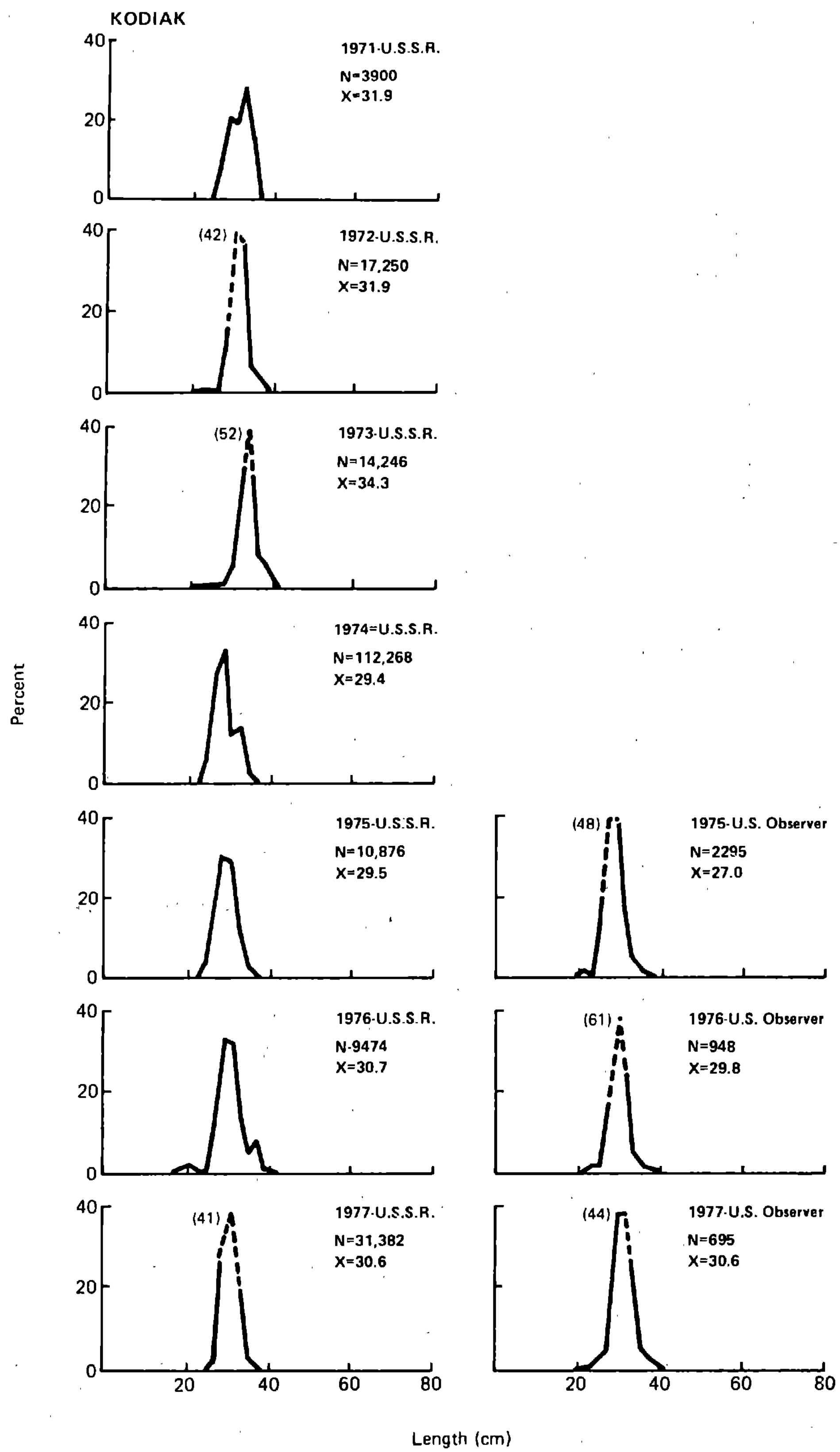


Figure 2.--Length frequency distribution of Atka mackerel in the Kodiak area, 1971-77 (Soviet fishery or U.S. Foreign Fisheries Observer Program data),

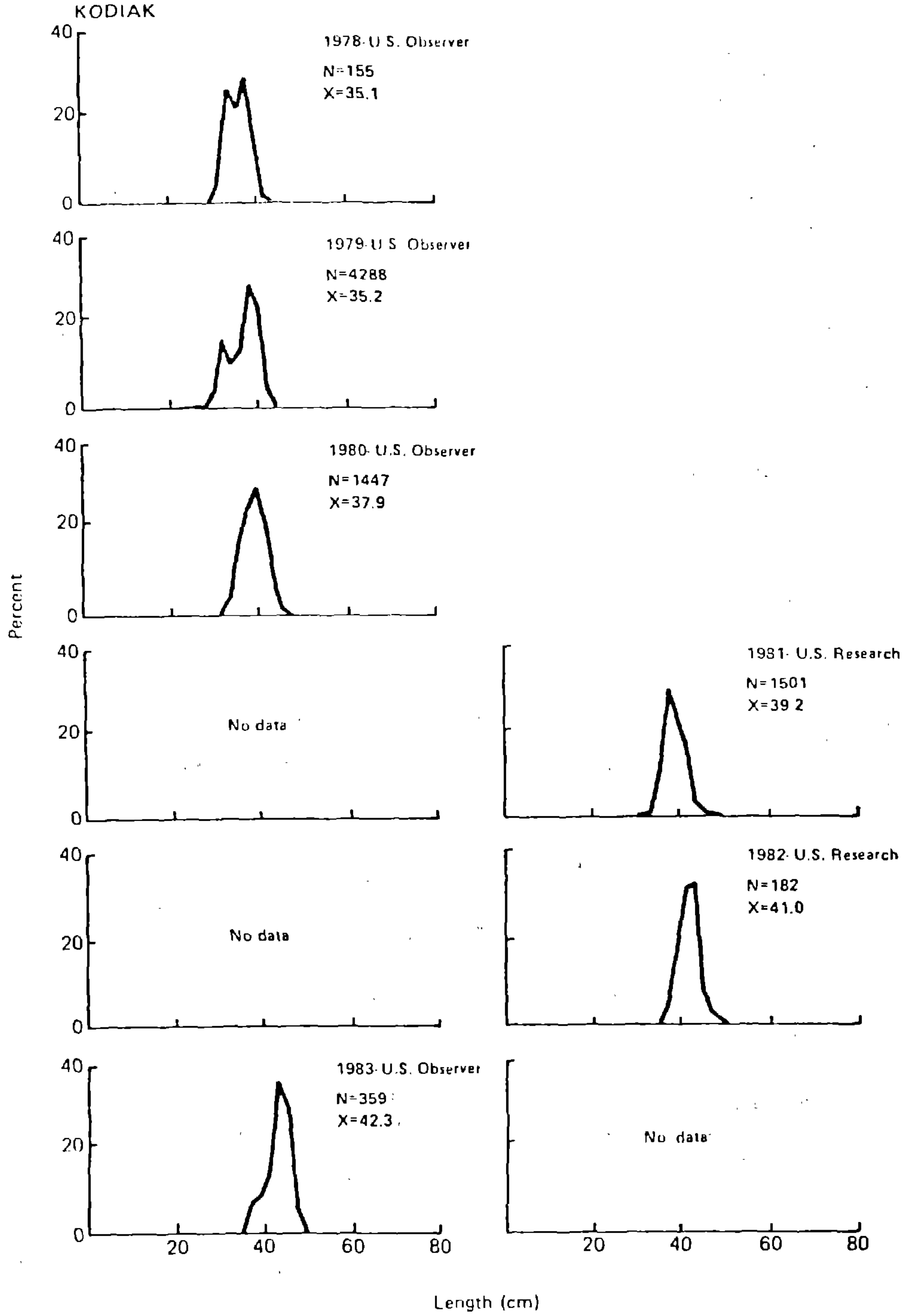


Figure 3.--Length frequency distribution of Atka mackerel in the Kodiak area, 1978-83 (U.S. Foreign Fisheries Observer Program or U.S. resource survey data).

mean length of the samples fluctuated between 27 and 34 cm, indicating that the recruitment of young fish consistently was good. The gradual increase of the mean and modal lengths and the ab ence of year-class pulses at the lower margin of the length frequency curve in recent years suggest, on the other hand, that recruitment may be insufficient to maintain the stock at the current level, 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 the survey work of the Soviet research vessel Shantar in the Kodiak area in 1981.

Length frequency data from the Chirikof area are available from the observer program, 1978 and 1981-83, and from the ROK commercial harvest, 1981-83, (Fig. 4). In the Chirikof area, as in the Kodiak area, the mean length of samples taken in 1981-83 has hovered around 40 cm. There is some recruitment of small fish in the observer program samples in 2 of the 3 years, but none in the ROK fishery samples.

Samples from the Shumagin area provided by the Observer Program, 1980-83; the ROK commercial fishery, 1981-83 (Fig. 5); and the U.S.-ROK joint venture fishery, 1983 (Fig. 6) similarly display mean lengths around 40 cm. Samples collected in the Shumagin area as part of cooperative U.S.-U.S.S.R. research cruises in 1982 and 1983 (Fig. 6) are made up of much smaller fish. Whether this difference is a function of, fishing technique, timing, or location is unknown.

POTENTIAL YIELD

Estimates of Maximum Sustainable Yield (MSY)

Early estimates of MSY necessarily were based on rather vague information and assumptions. Soviet hydroacoustic surveys in the Aleutian area in 1977

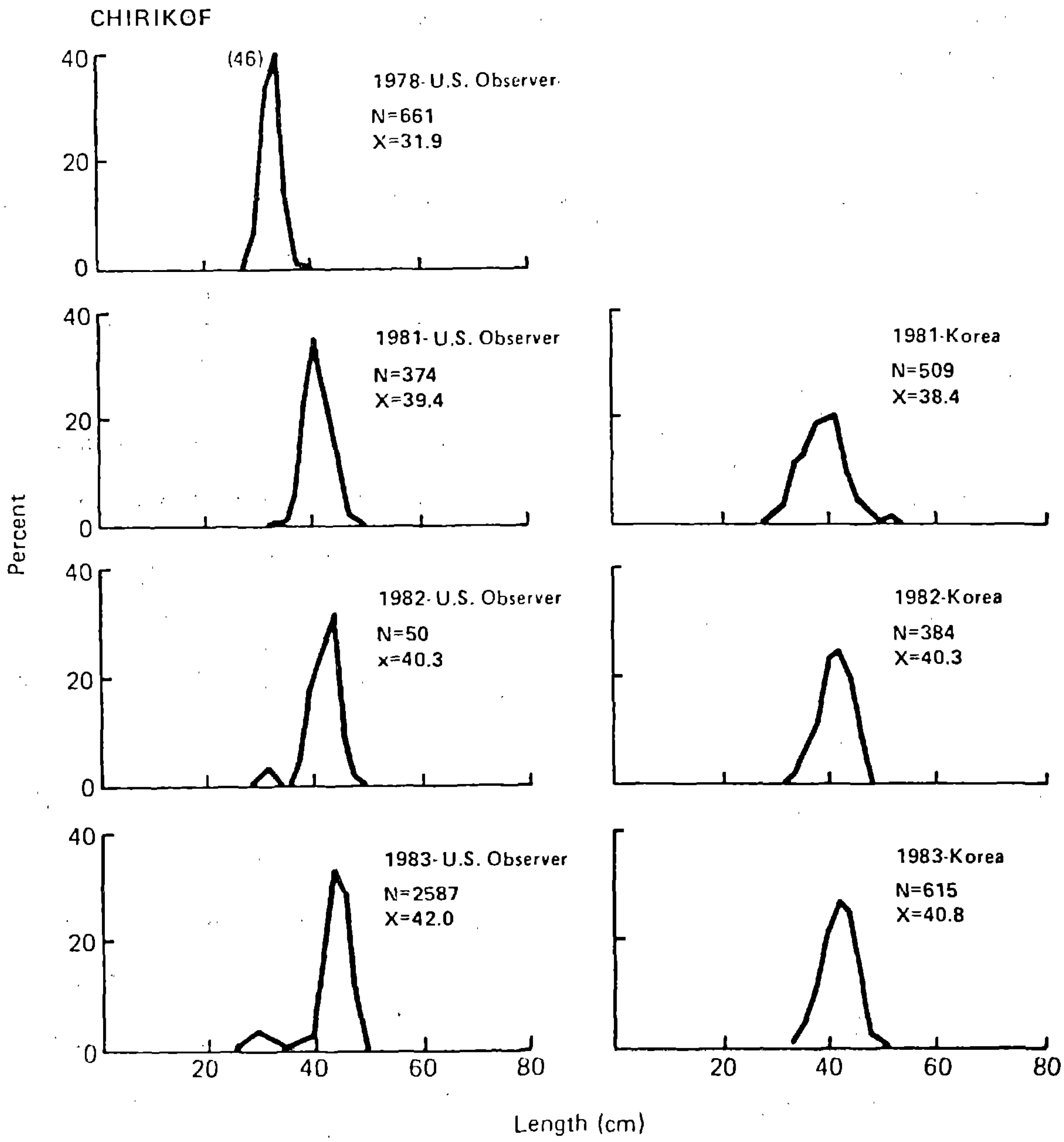


Figure 4.--Length frequency distribution of Atka mackerel in the International North Pacific Fisheries Commission Chirikof statistical area, 1978-83 (U.S. Foreign Fisheries Observer P&gram or Republic of Korea fishery data).

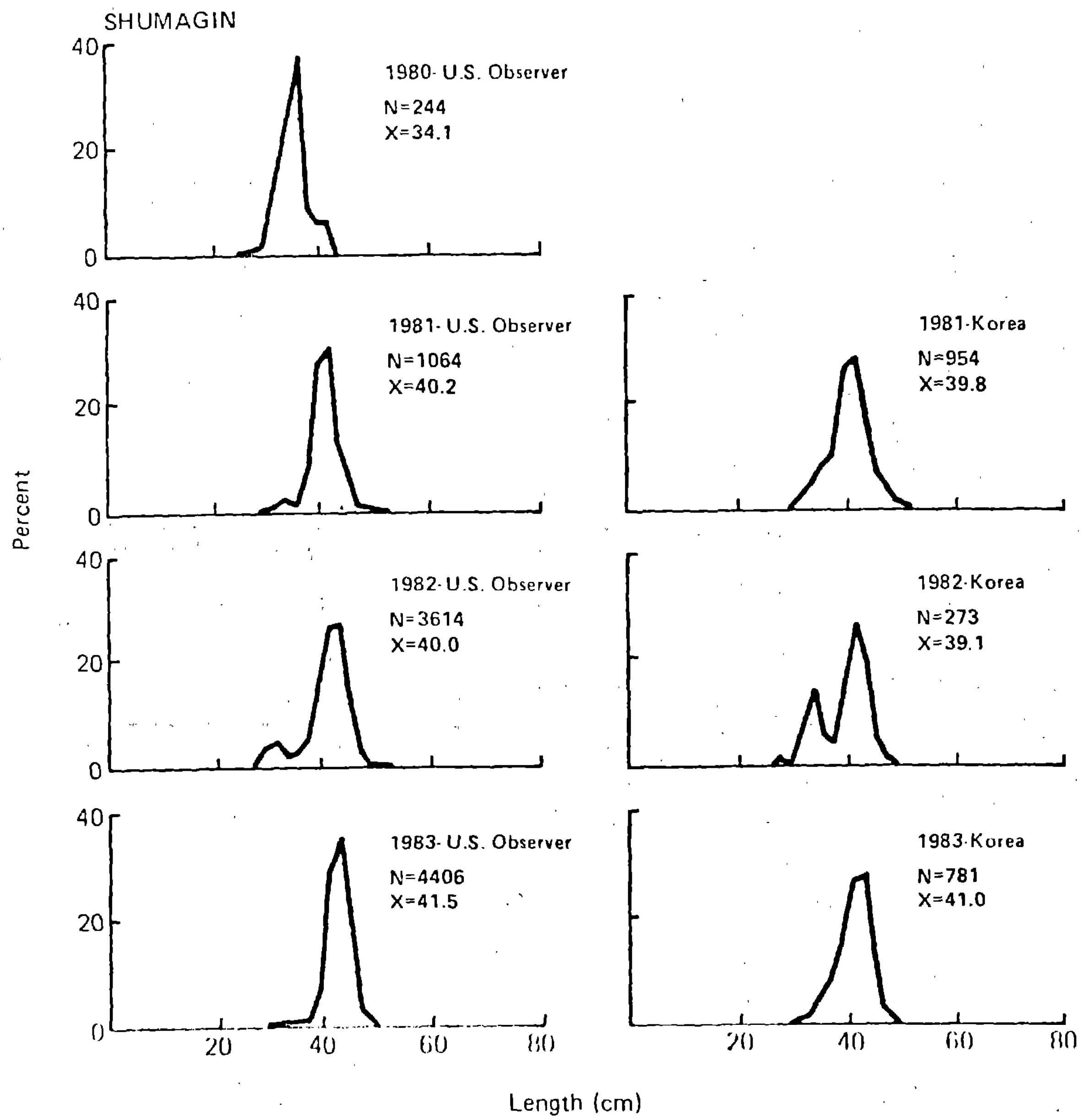


Figure 5.--Length frequency distribution of Atka mackerel in the International North Pacific Fisheries Commission Shumagin statistical area, 1980-83 (U.S. Foreign Fisheries Observer Program or Republic of Korea fishery data).

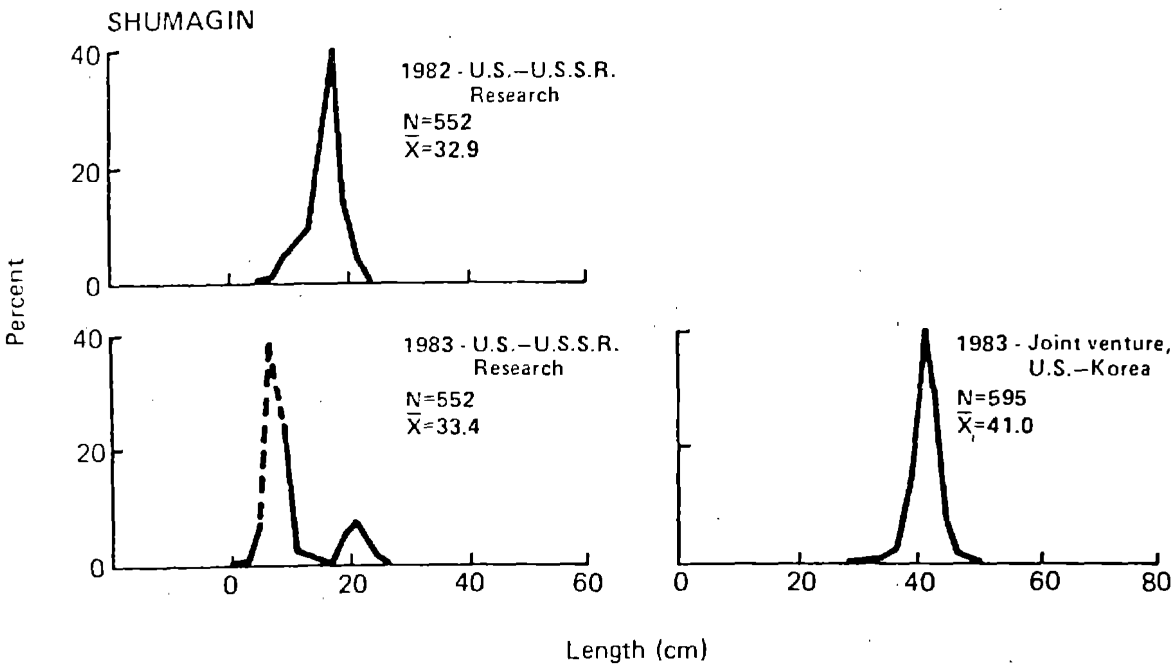


Figure 6.--Length frequency distribution of Atka mackerel in the International North Pacific Fisheries Commission Shumagin statistical area, 1982-83 (U.S.-U.S.S.R. cooperative research or U.S.-Republic of Korea joint venture fishery data).

found eight concentrations of Atka mackerel with an estimated biomass of 110,000 t. Trawl surveys indicated that there was at least as large a biomass in the Gulf of Alaska. The predominant sizes of fish available to the trawls were greater than 30 cm, which are 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). The biomass of Atka mackerel estimated there (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 quite well with the estimated biomass of 110,000 t that had been assumed 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 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 another approach. Employing a surplus production model based on fishery data to circumvent problems with age determination, he estimated that between 1975 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 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 S-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 (32,447 t) reported by Fadeev (1979) is used in conjunction with (a) values of 0.4 or 0.5 and (M) = 0.6, MSY is estimated at 7,787 and 9,734 t/respectively.

Levada (1979b) reports that Atka mackerel were found only 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 of the 1970's may reflect a "population explosion" and accompanying geographic expansion of the stock. Based on this hypothesis, long-term MSY probably should be reduced.

Estimates of Equilibrium Yield (EY)

The EY has until now been set at MSY (33,000 t based on the early Soviet work). However, the decline of the catch in the historically important Kodiak area and the apparent lack of recruitment indicate that MSY is no longer attainable and that EY should be set lower than MSY.

Estimates of Acceptable Biological Catch (ABC)

The Fishery Management Plan (North Pacific Fishery Management Council 1984) sets ABC at 28,700 t, or 87% of EY. Present data, however, indicate that the biomass of Atka mackerel in the Gulf of Alaska has declined sharply. Increasing mean CPUE's in the Soviet commercial fishery 1975-79, viewed in conjunction with increasing biomass and increasing mean length during that period indicate that one or more larger than normal year classes moved through the fishery. Fadeev and Kharin (1981) later noted that 89% of the commercial samples from the Gulf of Alaska in 1980 were from two year classes. Mean length was 38.0 cm--the largest in a 10-year series (Table 3). Without strong recruitment, the stock would be expected to decline as the dominant age groups leave the fishery, and judging from the low catches of 1982 and 1983 the stock did decline sharply.

It is recommended, therefore, that ABC be lowered to provide protection for the stock until there is evidence of such strong new year classes.

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

Year	Mean CPUE (t/hr)	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, Bin Cl5700, Building 4, 7600 Sand Point Way N.E., Seattle, WA 98115; and 1980: Fadeev and Kharin 1981.

REFERENCES

Alverson, D. L., and W. T. Pereyra. 1969. Demersal fish explorations in the northeastern Pacific Ocean--an evaluation of exploratory fishing methods and analytical approaches to stock size and yield forecast. J. Fish. Res. Board Can. 26(8): 1985-2001.

Berger, J. D., J. E. Smoker, and K. A. King. 1985. Foreign and joint venture catches and allocations in the Pacific Northwest and Alaskan fishing areas under MFCMA, 1977-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWFC (In press).

Efimov, Y. N. 1981. Stock condition and assessment of maximum sustainable yield of Atka mackerel in the Gulf of Alaska. Symposium on determining effective effort and calculating yield in groundfish fisheries, and on Pacific cod biology and population dynamics. Int. North Pac. Fish. Comm., Bull. 42: 82-84.

Fadeev, N. S. 1979. An analysis of the biomass of pollock, cod and Atka mackerel in the Gulf of Alaska as a consequence of a trawl survey in April-May 1979 on th R/V Akademik Berg. Unpubl. manuscr., 13 p. Pacific Scientific Research Institute of Fisheries and Oceanography (TINRO), Vladivostok, U.S.S.R. (Document submitted at the U.S.-U.S.S.R. Bilateral Meeting, 1979.)

Fadeev, N. S., and V. E. Kharin. 1981. Fisheries, size-and-age composition and spawning terms of Atka mackerel on Albatross Bank (Gulf of Alaska). Unpubl. manuscr., 11 p. Pacific Scientific Research Institute of Fisheries and Oceanography (TINRO), Vladivostok, U.S.S.R. (Document submitted at the U.S.-U.S.S.R. Bilateral Meeting, 1981.)

Forrester, C. R., R. G. Bakkala, K. Okada, and J. E. Smith. 1983. Groundfish, shrimp, and herring fisheries in the Northeast Pacific--historical catch statistics, 1971-76. Int. North Pac. Fish. Comm., Bull. 41: 100 p.

Gulland, J. A. 1969. Manual of methods for fish stock assessment. Part 1. Fish population analysis. Food Agric. Organ. U.N., Rome, FAO Man. Fish. Sci. 4, 154 p.

Levada, T. P. 1979a. Comparative morphological study of Atka mackerel. Unpubl. manuscr., 7 p. Pacific Scientific Research Institute of Fisheries and Oceanography (TINRO), Vladivostok, U.S.S.R. (Document submitted at the U.S.-U.S.S.R. Bilateral Meeting, 1979.)

Levada, T. P. 1979b. Some data on biology and catch of Atka mackerel. Unpubl. manuscr., 13 p. Pacific Scientific Research Institute of Fisheries and Oceanography (TINRO), Vladivostok, U.S.S.R. (Document submitted at the U.S.-U.S.S.R. Bilateral Meeting, 1980.)

North Pacific Fishery Management Council. 1984. Fishery management plan for the Gulf of Alaska groundfish fishery. Unpubl. manuscr., 200 p. North Pac. Fish. Manage. Counc., P.O. Box 103136, Anchorage, AK 96813.

PACIFIC OCEAN PERCH

by

Herbert H. Shippen

INTRODUCTION

General Distribution

Pacific ocean perch, as the term is currently employed by the North Pacific Fishery Management Council's (NPFMC) Gulf of Alaska Groundfish Management. Plan (FMP), includes five species of the genus *Sebastes*:

S. *alutus*, Pacific ocean perch,

S. *polyspinis*, northern rockfish,

S. *aleutianus*, rougheye rockfish,

S. *borealis*, shortraker rockfish, and

S. *zacentrus*, sharpchin rockfish.

Each species has its own distinct range extending well beyond the Gulf of Alaska but all co-occur in the Gulf where they are commercially exploited throughout. According to Eschmeyer and Herald (1983) the depths at which the various species are likely to be found are as follows: S. *alutus*--55 to 640 m, S. *polyspinis*--70 to 360 m, S. *aleutianus*--180 to 730 m, S. *borealis*--to 305 m, and S. *zacentrus*--90 to 320 m.

Of the five species which make up the Pacific ocean perch species group, S. *alutus* has been the most widely studied with respect to its distribution and biology; but relatively little is known about the biology of the others. Unless specifically stated otherwise, discussions here will be in terms of the five-species Pacific ocean perch complex.

Relative Importance

Fisheries surveys of the northeastern Pacific Ocean during the 1950's and early 1960's identified S. alutus as the dominant rockfish and a prominent member of the demersal community. Alverson et al. (1964) called this species "the dominant form in the aggregate species catch at depths from 100 to 149 fathoms" (180-270 m). Surveys from 1963 to 1966 in the Gulf of Alaska, indicated that S. alutus made up 90% of the total rockfish catch (Westrheim 1970).

In 1961, a resource assessment survey of the Gulf of Alaska by the International Pacific Halibut Commission (IPHC) and the U.S. Bureau of Commercial Fisheries (BCF) found S. alutus to be highly abundant. In the 101-200 m depth zone, S. alutus ranked fourth in abundance after arrowtooth flounder, Atheresthes stomias, Pacific cod, Gadus macrocephalus, and snow (Tanner) crab, Chinoecetes bairdi. In the 201-400 m depth zone, S. alutus was second after arrowtooth flounder (Table 1).

Similar surveys conducted by the National Marine Fisheries Service (NMFS) (formerly the Bureau of Commercial Fisheries [BCF]) during 1973-76 indicated a marked decrease in the abundance of S. alutus relative to the 1961 survey. During 1973-76, the catch per hour of S. alutus in the 101-200 m depth zone was 12% of its 1961 level and 4% in the 201-400 m zone.

During the interval between the surveys of 1961 and 1973-76, intensive trawl fisheries targeting on Pacific ocean perch in the Gulf of Alaska were conducted by the U.S.S.R. and Japan (Okada 1982).

Table 1 .--Relative abundance (catch per hour) of Sebastes alutus in Gulf-wide summer surveys of bottomfish resources.

	Depth zone m			
	101-200		201-400	
Survey period	kg/h	rank[c]	kg/h	rank[c]
1961[a]	50.1	4	75.6	2
1973-76[b]	6.1	13	3.4	15

[a]International Pacific Halibut Commission-Bureau of Commercial Fisheries surveys, 1961.

[b]National Marine Fisheries Service surveys, 1973-76.

[c]Ranking within 15 major species caught by bottom trawls.

Source : Ronholt et al. 1978.

Critical Management Issues

Catch per unit effort (CPUE) trends from the 1961 IPHC-BCF and 1973-76 NMFS Gulf of Alaska surveys suggested that the abundance of S. *alutus* was only a fraction of its former level. Furthermore, there has been little evidence in recent years of significant recruitment to the fishable population. The population of S. *alutus* appears to have been severely depleted and shows little sign of significant recovery in the immediate future.

Effective 1 June, 1982 the NPFMC amended the FMP to reduce the catch of Pacific ocean perch--particularly in the eastern Gulf of Alaska. These actions included the following:

1. closing the area east of 140°W. long. to all foreign fishing,
2. deleting U.S. sanctuaries east of 140°W. long. (no longer necessary with a ban on foreign fishing),
3. permitting foreign mid-water fishing only, year-round between 140° and 147°W. long., and
4. reducing the Acceptable Biological Catch (ABC) for Pacific ocean perch in the NPFMC eastern regulatory area (east of 147°W. long.) from 29,000 to 875 metric tons (t).

It was anticipated that these changes would eliminate Pacific ocean perch as a target species and would contribute to the rebuilding of the Pacific ocean perch population in the eastern Gulf of Alaska.

Multispecies Nature of the Fisheries

Pacific ocean perch in the Gulf of Alaska are caught in a multispecies fishery involving other rockfishes, and various roundfishes, flatfishes, sharks, and rays. The more commonly caught "other rockfishes" are:

S. brevispinis, silvergray rockfish,

S. ciliatus, dusky rockfish,

S. crameri, darkblotched rockfish,

S. entomelas, widow rockfish,

S. flavidus, yellowtail rockfish,

S. proriger, redstripe rockfish,

S. babcocki, redbanded rockfish,

S. variegatus, harlequin rockfish, and

S. reedi, yellowmouth rockfish.

In addition to the rockfishes in the genus Sebastes, thornyhead rockfish, Sebastolobus spp., are frequently taken, especially the shortspine thornyhead, Sebastolobus alascanus.

Among the more common roundfishes and flatfishes taken in fisheries targeting on Pacific ocean perch are walleye pollock, Theragra chalcogramma; sablefish, Anoplopoma fimbria; Atka mackerel, Pleurogrammus monopterygius; various sculpins; rex sole, Glyptocephalus zachirus; rock sole, Lepidopsetta bilineata; Dover sole, Microstomus pacificus; and arrowtooth flounder.

The relative abundance of the five species within the Pacific ocean perch complex varies by area (Table 2). Of the species found throughout the Gulf (S. alutus, S. aleutianus, and S. borealis), S. alutus are the most common. The distributions of the remaining two species, S. polyspinis and S. zacentrus are more restricted; S. polyspinis being more or less limited to the International North Pacific Commission (INPFC) Chirikof and Kodiak statistical areas and S. zacentrus to the Yakutat and southeastern areas.

Table 2.--Distribution by weight Of the five rockfish species (Sebastes) designated as Pacific ocean perch in the Gulf of Alaska, by International North Pacific Fisheries Commission statistical area, as found in trawl surveys, 1981-82[a].

	Chirikof area						Kodiak area											
Year-------	1981		1981		1982		1981		1981		1981		1981		1982		1982	
Vessel-----	SHANTAR		MILLER FREEMAN		MYS DALNIY		SHANTAR		MILLER FREEMAN		OCEAN HARVESTER		OH DAE SAN		MYS DALNIY		OH DAE SAE	
Cruise No.-	81-1		81-3		82-1		81-1		81-3		81-1		81-1		82-1		82-1	
Species	kg/hr	%	kg/hr	%	kg/hr	%	kg/hr	%	kg/hr	%	kg/hr	%	kg/hr	%	kg/hr	%	kg/hr	%
S. alutus	17.6	29.8	13.0	59.6	39.2	76.0	126.3	62.7	6.6	42.9	43.3	27.8	245.5	64.1	42.9	54.6	65.7	38.4
S. polyspinis	17.7	30.0	8.5	39.0	3.2	6.3	38.4	19.1	8.2	54.5	55.7	35.8	93.0	24.5	6.8	8.7	17.1	10.0
S. aleutianus	13.7	23.2	0.3	1.4	5.6	9.3	16.6	8.2	0.1	0.6	19.8	12.7	31.4	8.2	11.3	14.4	28.9	16.9
S. borealis	10.1	17.1	0.0	0.0	5.0	8.4	20.1	10.0	0.3	2.9	36.8	23.6	13.2	3.4	17.5	22.3	0.0	0.0
S. zacentrus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	59.2	34.6
Total	59.1	100.0	21.8	100.0	53.0	100.0	201.4	100.0	15.4	100.0	155.7	100.0	383.1	100.0	78.5	100.0	170.9	100.0

	Yakutat area				Southeastern area							
Year-------	1981		1981		1981		1981		1981		1982	
Vessel-----	OCEAN HARVESTER		PAT SAN MARIE		MILLER FREEMAN		PAT SAN MARIE		OCEAN HARVESTER		MILLER FREEMAN	
Cruise No.-	81-1		81-2		81-7		81-2		81-1		82-1	
Species	kg/hr	%	kg/hr	%	kg/hr	%	kg/hr	%	kg/hr	%	kg/hr	%
S. alutus	201.0	85.6	370.9	85.0	88.7	80.1	132.0	78.1	160.5	81.6	215.5	84.7
S. polyspinis	1.9	0.8	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. aleutianus	11.0	4.7	28.7	6.6	5.5	5.0	2.8	1.7	2.5	1.3	11.6	4.6
S. borealis	11.0	4.7	14.7	3.4	13.2	11.9	1.3	0.8	9.4	4.8	17.8	7.0
S. zacentrus	10.0	4.3	21.3	4.9	3.3	3.0	33.0	19.4	24.4	12.4	9.6	3.8
Total	234.9	100.0	436.1	100.0	110.7	100.0	169.1	100.0	196.8	100.0	254.5	100.0

[a]Vessels, trawls, fishing methods, depths sampled, etc. may vary so these data are not directly comparable in all aspects.

FISHERY STATISTICS

Historical Catches

Commercial fisheries by the United States and Canada for Pacific ocean perch began in the late 1940's off the Pacific northwest coast (Major and Shippen 1970).

Soviet fisheries for Pacific ocean perch started in the 1950's in the Aleutian Islands and Bering Sea regions and expanded into the central Gulf of Alaska in 1960. A fleet of 160 Soviet ships operated in the eastern Gulf of Alaska in 1965 (Chitwood 1969). A substantial part of the Soviet catch was Pacific ocean perch, but prior to 1973 no records were provided by the Soviet Union except as part of a general rockfish catch.

Japan, which began trawling in the Gulf of Alaska in 1963 (Chitwood 1969), has provided catch records for Pacific ocean perch since 1964. The catch peaked at 63,000 t in 1966 and declined to about 20,000 t in 1977 (Table 3).

The Republic of Korea (ROK) began fishing in the Gulf of Alaska in 1966 (Chitwood 1969), but records of the ROK catch of Pacific ocean perch are unavailable for years prior to 1976. The ROK took nearly half the Pacific ocean perch caught in the Gulf of Alaska in 1978, but have taken relatively little since.

Poland, Mexico, and the United States also have participated in the fishery for Pacific ocean perch in the Gulf of Alaska, but their catches have been minor in comparison to the amounts taken by the Soviet, Japanese and ROK fleets. Similarly, joint venture fisheries took relatively small catches of Pacific ocean perch in 1979-82. The. joint venture catch jumped to 1,975 t in 1983, however, which was roughly 27% of the Gulf total.

Table 3.--Pacific ocean perch catch (t) from the Gulf of Alaska by nation, fishery category, and International North Pacific Fisheries Commission statistical area, 1964-83.

		Area					
Nation	Year	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern	Total
Japan	1964	1,610	1,150	10,614	11	0	10,700
U.S.S.R.		-	-	-	-	-	230,000
Total		-	-	-	-	-	240,700
Japan	1965	9,171	12,555	20,839	33	0	38,800
U.S.S.R.		-	-	-	-	-	306,000
Total		-	-	-	-	-	344,800
Japan	1966	14,373	21,068	28,368	422	718	63,000
U.S.S.R.		-	-	-	-	-	135,800
Total		-	-	-	-	-	198,800
Japan	1967	5,834	6,937	17,922	13,625	9,162	53,510
U.S.S.R.		-	-	-	-	-	66,500
Total		-	-	-	-	-	120,010
Japan	1968	1,216	2,481	8,236	30,874	12,163	54,970
U.S.S.R.		-	-	-	-	-	45,200
Total		-	-	-	-	-	100,170
Japan	1969	2,027	5,772	11,346	18,404	16,090	53,639
U.S.S.R.		-	-	-	-	-	18,800
Total		-	-	-	-	-	72,439
Japan	1970	504	5,592	11,366	10,602	16,317	44,381
U.S.S.R.		-	-	-	-	-	-
U.S.		0	0	4	0	533	537
Total		-	-	-	-	-	44,918
Japan	1971	2,800	5,033	12,125	14,159	13,960	48,077
U.S.S.R.		-	-	-	-	-	29,700
Total		-	-	-	-	-	77,777
Japan	1972	4,233	2,837	11,439	15,481	16,628	50,618
U.S.S.R.		-	-	-	-	-	24,011
Total		-	-	-	-	-	74,629
Japan	1973	4,796	5,678	9,505	17,087	10,307	47,373
U.S.S.R.		-	-	-	-	-	5,275
Total		-	-	-	-	-	52,648
Japan	1974	4,082	3,497	8,096	10,690	10,615	36,980
U.S.S.R.		-	-	-	-	-	10,962
Total		-	-	-	-	-	47,942
Japan	1975	4,158	3,996	10,016	8,420	7,541	34,131
U.S.S.R.		2,624	1,238	9,150	302	0	13,314
Total		6,782	5,234	19,166	8,722	7,541	47,445

Table 3.--Continued.

Nation	Year	Area					
		Shumagin	Chirikof	Kodiak	Yakutat	South-eastern	Total
Japan	1976	4,557	3,645	8,730	9,625	8,796	35,353
U.S.S.R.		1,671	1,535	4,905	402	0	8,513
ROK		1,339	26	177	45	28	1,615
Total		7,567	5,206	13,812	10,072	8,824	45,481
Japan	1977	1,567	2,531	4,977	5,428	4,744	19,247
USSR		450	579	541	108	4	1,682
ROK		560	T	0	0	0	560
U.S.		0	0	0	0	12	12
Total		2,577	3,110	5,518	5,536	4,760	21,501
Japan	1978	429	430	1,203	1,337	1,149	4,548
U.S.S.R.		193	280	82	7	8	570
ROK		3,021	25	0	0	3	3,049
Poland		0	0	4	0	0	4
U.S.		0	0	0	0	5	5
Total		3,643	735	1,287	1,344	1,165	8,176
Japan	1979	652	116	832	1,714	4,083	7,397
U.S.S.R.		30	122	908	5	0	1,065
ROK		193	0	0	498	134	825
Poland		2	3	0	0	0	5
Mexico		67	18	372	0	0	457
U.S.		0	0	99	5	1	105
J. venture		1	5	26	25	10	67
Total		945	264	2,237	2,247	4,228	9,921
Japan	1980	169	553	2,507	4,649	2,912	10,770
U.S.S.R.		290	123	826	0	0	1,239
ROK		353	0	0	55	0	408
Poland		29	1	0	0	0	30
U.S.		0	0	2	0	2	4
J. venture		0	12	8	0	0	20
Total		842	668	3,343	4,704	2,914	12,471
Japan	1981	741	1,495	1,882	3,927	2,297	10,342
ROK		463	862	16	444	0	1,785
Poland		29	13	0	7	0	49
U.S.		0	0	7	0	0	7
J. venture		1	0	0	0	0	1
Total		1,234	2,370	1,905	4,378	2,297	12,184
Japan	1982	1,407	3,009	2,722	17	0	7,155
ROK		339	490	2	0	0	831
U.S.		0	0	2	0	0	2
J. venture		0	3	0	0	0	3
Total		1,746	3,502	2,726	17	0	7,991
Japan	1983	530	2,244	2,216	18	0	5,008
ROK		141	266	0	0	0	407
U.S.		7	0	8	0	0	15
J. venture		1,934	7	34	0	0	1,975
Total		2,612	2,517	2,258	[illegible]	0	[illegible]

Table 3.--Continued.

---

[a]Definition of Pacific ocean perch (POP): Japan 1964-77: Sebastes alutus; U.S.S.R. 1964-72: Sebastes spp; U.S.S.R. 1973-77: S. Alutus; ROK (1976-77): S. alutus; all foreign nations and joint ventures 1978-83: S. alutus, S. polypinus, S. aleutianus, S. borealis, and S. zacentrus; U.S.: S. alutus.

[b]Definition of symbols: (0): no catch (whether there was fishing is unknown); (-): no data (whether there was fishing is unknown).

Sources : Japan 1964-66: Okada 1982; Japan 1967-77: Fishery Agency of Japan; U.S.S.R. (1964-70): Okada 1982; U.S.S.R. 1971-76: Forrester et al. 1978; U.S.S.R. 1977: personal communication with Jerald Berger, U.S. Foreign Fishery Observer Program, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Building 4, Seattle, WA 98115; ROK 1976-77: Office of Fisheries, ROK; all foreign nations and joint ventures 1978-83: Berger et al. 1985; U.S. 1970-80: Rigby 1984; U.S. 1981-83: Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 S.W. Fifth Avenue, Portland, OR 97201.

Current Catches

Catches by INPFC area, month, vessel class, and nation are shown for 1983 in Tables 4 and 5. The 1983 catch by Japan was about 70% that of the 1982 catch, largely because of the smaller catches in the Shumagin and Chirikof areas. The 1983 ROK catch was about half that of 1982. Contributing to these smaller catches, in turn, were the smaller allocations awarded to foreign nations (Japan and ROK) in the NPFMC regulatory areas in 1983 (Table 6). The U.S. domestic fleet took 15 t in 1983; the joint venture fisheries 1975 t.

Japan received most (83%) of the total allowable level of foreign fishing (TALFF) for Pacific ocean perch in 1983 and ROK received the remainder (Table 7). Of the four vessel types participating in the 1983 fishery, only two--the large freezer trawlers and the small trawlers--took significant amounts of Pacific ocean perch (Table 8).

Most Pacific ocean perch from the Gulf of Alaska were taken in summer and fall (Tables 4 and 5). This seasonal distribution was influenced by NPFMC regulations that prohibit or restrict trawl fishing during the early part of the calendar year to protect the domestic fishery for Pacific halibut, *Hippoglossus stenolepis*.

CONDITION OF THE STOCKS

Stock Units

Identification of subpopulations of Pacific ocean perch and their migration patterns is hampered by the inability of the fish to survive the rigors of capture and tagging, especially the decompression in being removed from depth to the surface. For this reason, scientists studying migrations of Pacific ocean perch have had to base their conclusions on apparent changes

Table 4.--Japanese catch (t) of Pacific ocean perch in the Gulf of Alaska by month, International North Pacific Fisheries Commission statistical area, and vessel class, 1983[a].

Area and vessel class	Month 1	2	3	4	5	6	7	8	9	10	11	12	Total
Shumagin													
Small Trawler	--	--	--	--	--	52.15	21.41	8.90	15.56	12.18	0.08	--	110.28
Surimi Trawler	0.50	--	0.00	--	--	5.07	19.13	1.00	5.32	--	0.34	--	31.36
Lg Frz Trawler	--	--	--	--	--	107.30	179.89	75.82	8.59	1.80	--	--	373.40
Longliner	0.70	0.60	2.00	0.97	4.54	1.17	0.69	0.10	0.22	0.18	2.19	1.60	14.96
Total	1.20	0.60	2.00	0.97	4.54	165.69	221.12	85.82	29.69	14.16	2.61	1.60	530.00
Chirikof													
Small Trawler	--	--	--	--	--	68.12	53.02	6.38	18.68	128.94	56.26	--	331.40
Surimi Trawler	0.10	--	--	--	--	0.27	0.00	--	2.60	19.75	2.23	0.05	25.00
Lg Frz Trawler	--	--	--	--	--	486.54	523.77	206.44	76.30	445.74	132.79	--	1,871.58
Longliner	0.00	0.64	0.63	0.47	1.40	3.16	1.55	0.36	0.20	0.13	2.19	4.85	15.58
Total	0.10	0.64	0.63	0.47	1.40	558.09	578.34	213.18	97.78	594.56	193.47	4.90	2,243.56
Kodiak													
Small Trawler	--	--	--	--	--	60.49	99.90	286.13	132.94	257.70	162.60	--	999.76
Surimi Trawler	--	--	--	--	--	1.52	0.40	0.16	--	--	--	--	2.08
Lg Frz Trawler	--	--	--	--	--	334.20	269.74	131.75	102.60	241.80	123.33	--	1,203.42
Longliner	0.30	0.00	0.00	0.00	0.00	2.00	0.01	0.10	0.10	0.20	1.50	6.34	10.55
Total	0.30	0.00	0.00	0.00	0.00	398.21	370.05	418.14	235.64	499.70	287.43	6.34	2,215.81
Yakutat													
Small Trawler	--	--	--	--	--	--	0.00	--	--	--	0.00	--	0.00
Surimi Trawler	--	--	--	--	--	--	--	--	--	--	--	--	--
Lg Frz Trawler	--	--	--	--	--	--	--	--	--	--	--	--	--
Longliner	0.00	--	0.30	--	0.50	1.00	--	0.10	0.30	5.30	5.00	5.40	17.90
Total	0.00	--	0.30	--	0.50	1.00	0.00	0.10	0.30	5.30	5.00	5.40	17.90
All regions													
Small Trawl	--	--	--	--	--	180.76	174.33	302.31	167.18	398.82	218.94	--	1,442.34
Surimi Trawler	0.60	--	0.00	--	--	6.86	19.53	1.16	7.92	19.75	2.57	0.05	58.44
Lg Frz Trawler	--	--	--	--	--	927.77	973.40	414.01	187.49	689.35	256.12	--	3,448.14
Longliner	1.00	1.24	2.93	1.44	6.44	7.33	2.25	0.66	0.82	5.81	10.88	18.19	58.99
Grand Total	1.60	1.24	2.93	1.44	6.44	1,122.72	1,169.51	718.14	363.41	1,113.73	488.51	18.24	5,007.91

[a]Definition of symbols: (--): no fishing; (0): fishing but no catch.

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 N.E., Seattle, WA 98115.

Table 5.--Republic of Korea catch (t) of Pacific ocean perch in the Gulf of Alaska by month, International North Pacific Fisheries Commission statistical area, and vessel class, 1983.[a]

Area and vessel class	Month 1	2	3	4	5	6	7	8	9	10	11	12	Total
Shumagin													
Small trawler	--	--	--	--	--	0.00	0.00	3.54	0.00	0.00	2.58	--	6.12
Surimi trawler	--	--	--	--	--	--	--	--	--	--	--	--	--
Lg. freezer trawler	--	--	--	0.00	--	1.86	42.86	23.85	30.09	17.71	17.60	--	133.97
Longliner	--	--	--	0.00	0.56	--	0.00	0.00	--	--	0.00	--	0.56
Total	--	--	--	0.00	0.56	1.86	42.86	27.39	30.09	17.71	20.18	--	140.65
Chirikof													
Small trawler	--	--	--	--	--	0.00	0.00	--	--	3.70	1.54	--	5.24
Surimi trawler	--	--	--	--	--	--	--	--	--	--	--	--	--
Lg. freezer trawler	--	--	--	0.00	0.00	7.10	24.60	56.40	29.72	80.31	62.65	--	260.78
Longliner	--	--	--	--	--	--	--	--	0.00	--	--	--	0.00
Total	--	--	--	0.00	0.00	7.10	24.60	56.40	29.72	84.01	64.19	--	266.02
Kodiak													
Small trawler	--	--	--	--	--	--	--	--	--	--	--	--	--
Surimi trawler	--	--	--	--	--	--	--	--	--	--	--	--	--
Lg. freezer trawler	--	--	--	--	--	--	--	--	--	--	--	--	--
Longliner	--	--	--	0.00	0.00	--	--	0.00	--	0.00	0.14	--	0.14
Total	--	--	--	0.00	0.00	--	--	0.00	0.00	0.00	0.14	--	0.14
Yakutat													
Small trawler	--	--	--	--	--	--	--	--	--	--	--	--	--
Surimi trawler	--	--	--	--	--	--	--	--	--	--	--	--	--
Lg. freezer trawler	--	--	--	--	--	--	--	--	--	--	--	--	--
Longliner	--	--	--	--	0.43	--	--	--	0.90	0.00	0.13	--	1.46
Total	--	--	--	--	0.43	--	--	--	0.90	0.00	0.13	--	1.46
All regions													
Small trawler	--	--	--	--	--	0.00	0.00	3.54	0.00	3.70	4.12	--	11.36
Surimi trawler	--	--	--	--	--	--	--	--	--	--	--	--	--
Lg. freezer trawler	--	--	--	0.00	--	8.96	67.46	80.25	59.81	98.02	80.25	--	394.75
Longliner	--	--	--	0.00	0.99	--	0.00	0.00	0.90	0.00	0.27	--	2.16
Grand Total	--	--	--	0.00	0.99	8.96	67.46	83.79	60.71	101.72	84.64	--	408.27

[a] Definition of symbols: (--):-no fishing;. (0): fishing but no catch.

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 N.E., Seattle, WA 98115.

Table 6.--Equilibrium yield, optimum yield, foreign catch allocation, and foreign catch (t) of Pacific ocean perch in the Gulf of Alaska by North Pacific Fishery, Management Council regulatory area, 1982 and 1983.

Area	Equilibrium yield	Optimum yield	Foreign catch allocation	Foreign catch
1982				
Western	5,300	2,700	2,555	1,746
Central	15,700	7,900	7,745	6,225
Eastern	29,000	875	775	17
Total	50,000	29,167	23,806	7,988
1983				
Western	5,300	2,700	1,170	672
Central	15,700	7,900	6,279	4,726
Eastern	29,000	875	290	19
Total	50,000	11,475	7,739	5,416

Sources: Equilibrium yield and optimum yield: North Pacific Fishery Management Council 1984. Foreigncatch allocation and foreign catch: 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 N.E., Seattle, WA 98115.

Table 7.--Pacific ocean perch allocations (t) by foreign nation and North Pacific Fisheries Management Council regulatory area in 1983.

Nation	Area			Total	
	Western	Central	Eastern	Allocation	(%)
Japan	791	5,429	222	6,442	83.2
Republic of Korea	379	850	68	1,297	16.8
Total	1,170	6,279	290	7,739	100.0
Percent	15.1	81.1	3.7	100.0	

Table 8.--Japanese and Korean catch (t) of Pacific ocean perch in the Gulf of Alaska in 1983, by vessel class.

Vessel class	Japan		Republic of Korea		Total	
	t	%	t	%	t	%
Small trawler	1,442.34	28.8	11.36	2.8	1,453.70	26.8
Surimu trawler	58.44	1.2	--	--	58.44	1.1
Large freezer trawler	3,448.14	68.9	394.75	96.7	3,842.89	71.0
Sablefish longliner	58.99	1.2	2.16	0.5	61.15	1.1
Total	5,007.91	92.5	408.27	7.5	5,416.18	100.0

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

in abundance or population characteristics. Recently, biochemical methods have been employed to study subpopulations.

On the basis of changes in distribution and sex ratio, Lyubimova (1963, 1965) hypothesized that female Pacific ocean perch spend the summer and early fall foraging in the western part of the Gulf of Alaska near Unimak Pass. During September and October, they leave that area after mating and migrate to the southeastern part of the Gulf where they winter and gestate for spawning the following spring.

Another Soviet scientist, however, reviewed much of the same evidence as Lyubimova and came to somewhat different conclusions: 1) Pacific ocean perch do not make extreme seasonal migrations along the shelf, 2) seasonal movements of Pacific ocean perch are largely between deep and shallow bottoms within a limited geographical area, and 3) Pacific ocean perch form a series of local populations which are only partially intermixed (Fadeev 1968). Fadeev cautioned that because of localized populations and slow growth rates, fishing activities should be carefully distributed so as to avoid exceeding the reserves of each local group.

Based on year-class strength and size composition, Westrheim (1970) identified Dixon Entrance as the boundary between the Gulf of Alaska and British Columbia subpopulations. Similarly, Chikuni (1975) hypothesized four stocks of Pacific ocean perch: 1) Gulf of Alaska; 2) eastern Pacific (British Columbia to California); 3) Aleutian Islands; and 4) eastern slope (Bering Sea to Kurile Islands).

Biochemical genetic evidence, on the other hand, does not support the idea that S. alutus are divided into sharply defined geographic stocks. Some stock structuring is evident, according to Wishard and Gunderson (1981), but there are no sharp boundaries. Rather, Pacific ocean perch seem to be differentiated along a continuum. It is really little more than a matter of practical convenience then, that the five-species Pacific ocean perch complex in the Gulf of Alaska is managed as a separate stock.

Age Composition

During the early 1960's, before the period of intense fishing of Pacific ocean perch by Japan and the U.S.S.R., the dominant age group in the catch was 6 to 9 years. About three-fourths of the catch was calculated to be age 10 or younger (Lyubimova 1964).

Otoliths from S. *alutus* for age interpretation have been collected by U.S. observers on foreign ships since 1976. These otoliths have been interpreted by a technical staff at the Northwest and Alaska Fisheries Center. A review of the age structure of Pacific ocean perch catches collected between 1976 and 1980 suggests that few, if any, year classes of notable strength have been recruited to the fishable part of the population in those years. In the Shumagin area, the 345 otoliths examined from 1977 indicated no markedly successful year classes in the catch. In the next year, 1978, there was some increase in the 6- to 8-year-olds, but these year classes were virtually depleted by 1979 (Fig. 1). In the Chirikof area, remnants of year classes from the 1960's were evident in 1978, together with a fair showing of 7- to 9-year-olds. The scanty data from 1980, however, suggest that little remained of these year classes by that time. In the Kodiak area, specimens from the 1971 and older year classes appeared in the 1976 catch, and this body of fish was present in 1977 and 1978. In 1979 and 1980, however, these previously strong year classes had declined, and no younger year classes were evident.

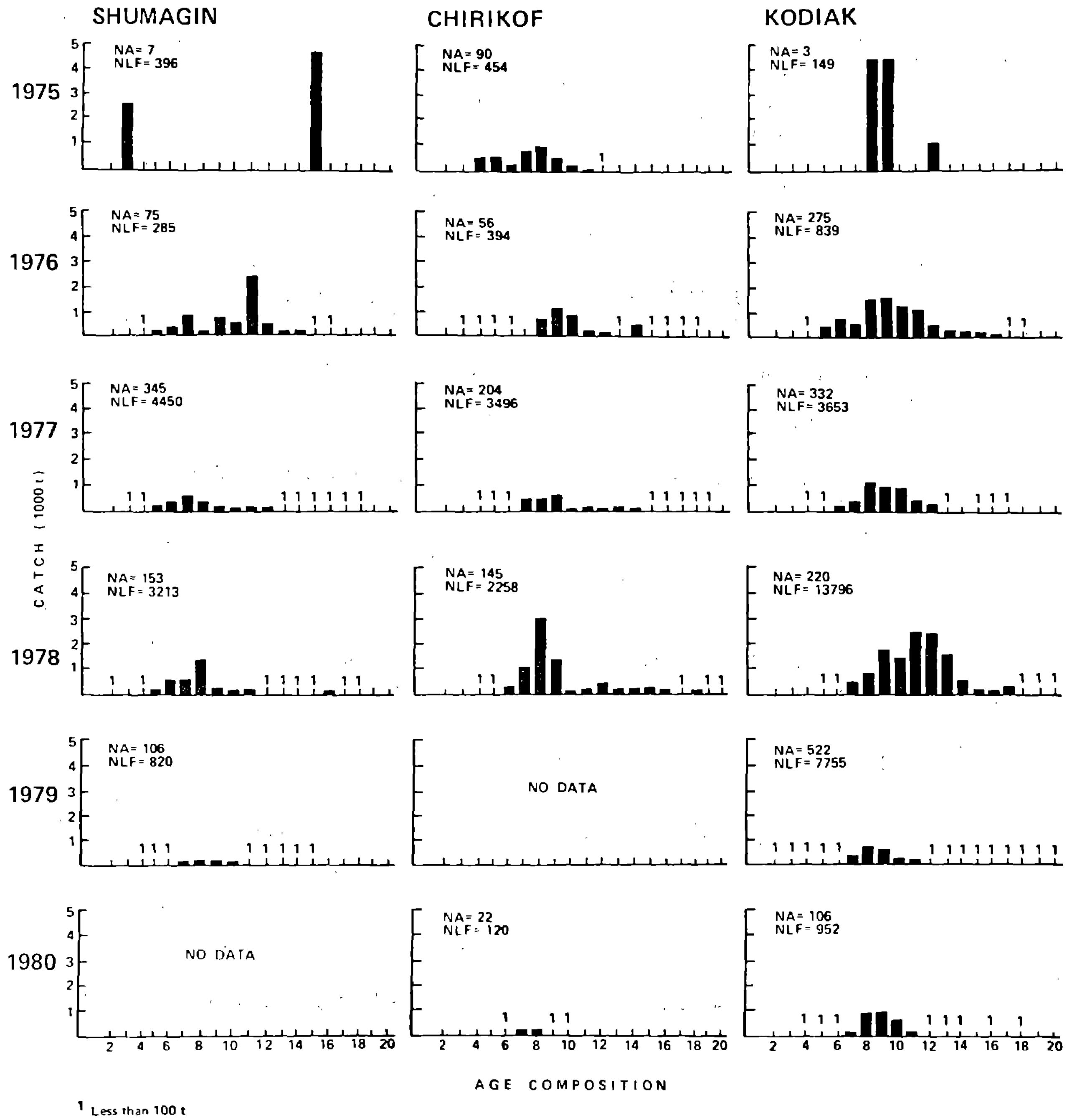


Figure 1.--Age composition of Pacific ocean perch, S. alutus, captured in the Gulf of Alaska by foreign trawlers, 1975-80. NA is the number in the age sample; NLF is the number in the length frequency sample.

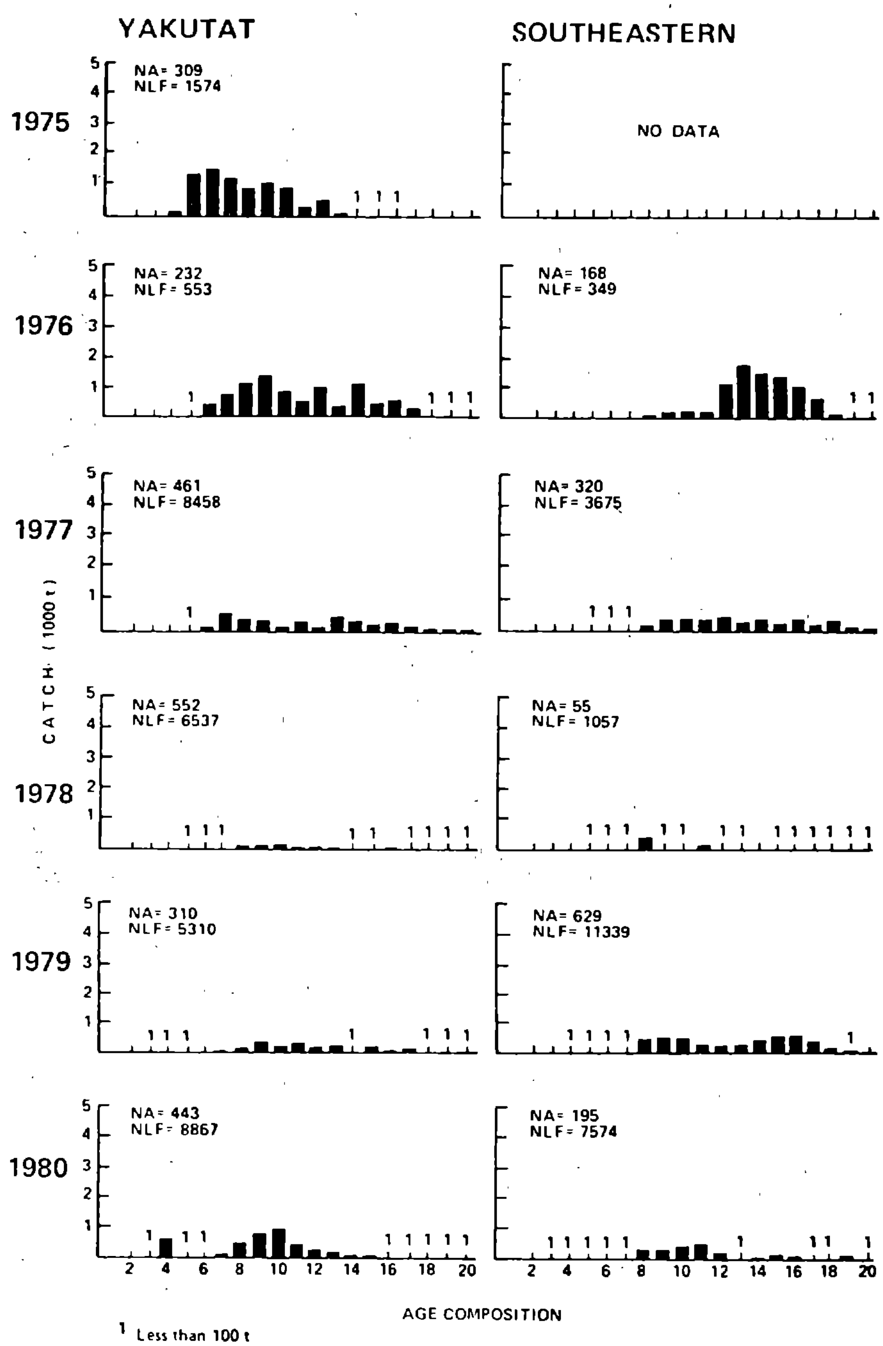


Figure 1 .--Continued.

In the Yakutat area, the fishery in the 1975-77 had representatives from the 1963-70 year classes, but these fish appeared to be gone in 1978 and 1979. Some modest recruitment of Pacific ocean perch seems to have occurred in 1980 in the Yakutat area. In the southeastern area, the fishery in 1976 was dominated by 12- to 17-year-olds. This group of fish was apparently depleted during the next 2 years and was virtually gone by 1978. Modest numbers of Pacific ocean perch from the 1962-71 year classes appeared in 1979 in the southeastern area, but they declined substantially in the 1980 catch. There is no evidence from the 1980 data of any successful year class after 1971. Otolith samples collected since 1980 are waiting to be aged pending further research on aging techniques.

Length Composition

Length composition information on S. alutus has been collected in the Gulf of Alaska by U.S. observers stationed aboard foreign ships. Except for a tendency for specimens from the southeastern area to be larger, there have been no trends in these data (Table 9). In 1983, however, a Gulf-wide trend toward increased mean length occured which may indicate improved recruitment into the fishable stock.

Research Survey Results

Demersal resource assessment surveys to depths of 400 m were conducted over the entire Gulf of Alaska in 1961 and again in 1973-76. Results of these surveys, conducted before and after a period of intense fishing for Pacific ocean perch during the mid-1960's, document a substantial decrease in the relative abundance of this species (Table 10).

Table 9.--Mean size composition (fork length in cm) in the *Sebastes alutus* catch from the Gulf of Alaska by International North Pacific Fisheries Commission statistical area, as determined from samples collected by U.S. observers, 1975-83.

Sex and area	Year								
	1975	1976	1977	1978	1979	1980	1981	1982	1983
Males									
Shumagin	30.2	30.7	29.2	29.6	32.1	-	31.6	30.9	32.0
Chirikof	28.5	30.4	31.1	30.9	31.4	33.2	28.2	30.4	33.0
Kodiak	31.4	31.1	32.5	32.8	33.8	34.2	33.4	32.0	34.4
Yakutat	31.2	33.6	33.5	34.3	34.3	33.9	33.9	-	-
Southeastern	36.6	36.0	34.8	33.9	35.8	36.1	36.3	-	-
Females									
Shumagin	30.3	30.6	29 1	29.8	32.4	-	32.4	31.2	32.6
Chirikof	29.1	30.0	31.2	31.3	31.1	30.8	28.3	30.7	33.7
Kodiak	32.2	31.0	33.1	33.5	33.1	34.9	34.0	32.9	37.0
Yakutat	31.2	33.7	34.5	35.4	35.6	35.1	35.1	-	-
Southeastern	37.4	37.7	35.8	34.8	37.4	37.5	37.7	-	-

Table 10.--Average catch per unit effort (CPUE) for S. alutus in the Gulf of Alaska, 1961 and 1973-76, by region and depth zone.

	1961 CPUE (kg/h)		1973-76 CPUE (kg/h)	
Region	101-200 m	201-400 m	101-200 m	201-400 m
Fairweather	7.4	149.7	2.9	0.0
Yakutat	66.3	85.0	4.6	6.2
Prince William	48.8	80.1	10.9	1.5
Kenai	80.4	31.8	4.7	0.0
Kodiak	25.2	2.9	2.4	11.7
Shelikof	2.4	10.5	1.4	1.0
Chirikof	135.0	67.8	18.3	0.4
Shumagin	29.3	431.4	-	-
Sanak	7.2	228.6	0	53.5
Weighted average	50.1	75.6	6.1	3.4

Source: Ronholt, et al. 1978.

Surveys of rockfish resources suggest that there have been some increases in the relative abundance of S. alutus in recent years. In the summer of 1978 the catch per hour for S. alutus remained at the low levels experienced in 1973-76, but some improvement is evident in surveys conducted in 1979 and 1981 (Table 11).

Commercial Fishery Records

Statistical information from Japanese trawl fisheries in the Gulf of Alaska documented a general decline in Pacific ocean perch CPUE since the inception of the fishery in 1964 until the present (Fig. 2). The overall catch rate for the 1982 Japanese fishery was 0.15 metric tons per hour (t/h) in the western and central regions, unchanged from the 1980 and 1981 values. For the Gulf of Alaska as a whole the commercial catch per hour during the 3-year period from 1964 to 1966 was about 5.5 t/h, but during the recent 3-year period, 1979-81, it had declined to about 0.3 t/h. It should be recognized, however, that more fishing effort was directed toward Pacific ocean perch during the early years of this fishery than has been the case more recently. The decline in the catch rate for 1982 is in part the result of the closure of the southeastern area where rockfish, including Pacific ocean perch, were principal target species.

Based on a cohort analysis of the catch-at-age data for the Gulf of Alaska foreign fishery from 1963 to 1979, Ito (1982) concluded that the exploitable stock of S. alutus decreased 92% during the period from 1963 to 1976 and that year-class size underwent a continuous long-term decline. He noted that this decline in estimated stock abundance paralleled the nominal catch-per-trawl-hour over the same period as shown in Fig. 2. Apparently,

Table 11.--Relative abundance of *Sebastes alutus* (catch in kg/h) in resource assessment surveys, 1978-81.

Year	Area	No. of station samples	Relative abundance (kg/h)	Reference
1978	Southeastern	74	53	a
	Yakutat	100	4	a
	Kodiak	53	4	a
	Chirikof	24	4	a
1979	Kodiak	73	114	
	Chirikof	55	98	
	Shumagin	43	131	
	Southeastern	15	84	
1981	Yakutat-1[b]	63	335	
	Yakutat-2[b]	59	193	
	Cape Ommaney[b]	72	143	
	Kodiak[b]	17	80	

[a]Feldman and Rose 1981.

[b]The 1981 surveys were confined to index sites which were areas of recorded high production by commercial fisheries. and thus are not directly comparable to earlier surveys.

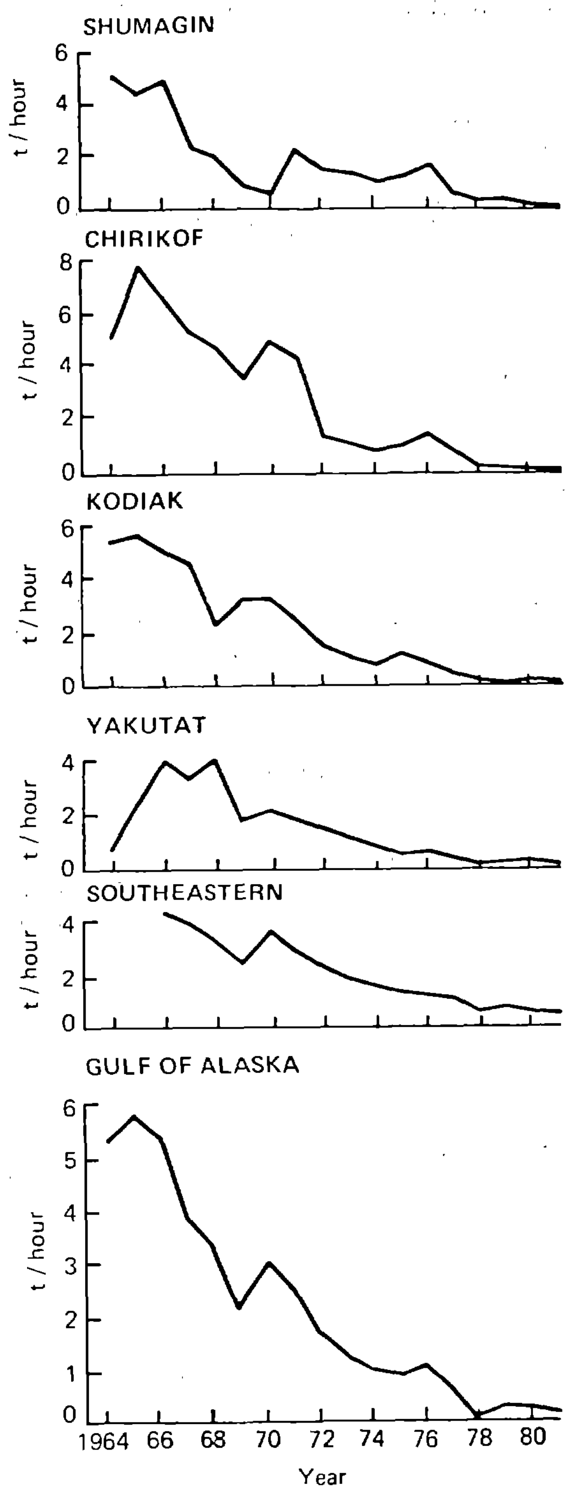


Figure 2.--Catch per unit effort by Japan for Pacific ocean perch in the Gulf of Alaska trawl fisheries, 1964-81.

the annual harvest in each of these 14 years exceeded the annual surplus production preventing any increase in abundance.

POTENTIAL YIELD

Estimates of Maximum Sustainable Yield (MSY)

The FMP defines MSY as the largest average catch that can be taken continuously from a stock under current environmental conditions. At the time of the implementation of the FMP in 1978, it was estimated that MSY for Gulf of Alaska Pacific ocean perch was 125,000 t, but it was recognized that stock levels were well below the numbers that might produce this level. Chikuni (1975) estimated the potential MSY for the Pacific ocean perch in the Gulf of Alaska at about 150,000 t, but he also added a reservation that stocks must first recover from their present low levels.

Estimates of Equilibrium Yield (EY)

The FMP defines EY as the annual or seasonal harvest that allows the stock to be maintained at approximately the same level of abundance over a period of several years apart, from the effects of the environment. As of September 1979, the plan placed the Gulf-wide EY for Pacific ocean perch at 50,000 t, .a level well below the estimated 125,000 t MSY, but which still has not resulted in a detectable increase in recruitment.

Acceptable Biological Catch (ABC)

The ABC may be set lower than MSY to help rebuild depleted fish stocks. In the Gulf of Alaska, ABC for Pacific ocean perch originally was set at 50,000 t, the same as EY. The ABC for 1981-85 was apportioned to the three

NPFMC regulatory areas as follows: western, 5,300 t; central, 15,700 t; and eastern, 29,000 t. The basis for the relative. apportionment was the distribution of the Pacific ocean perch catch by Japan, 1973-75.

Optimum yield (OY) may deviate from ABC for economic, social, or ecological objectives; and in the case of Pacific ocean perch in the Gulf of Alaska, the OY was set for 1981 at 29,167 t, apportioned as follows to the three regulatory areas: western, 3,150 t; central, 9,127 t; and eastern, 16,800 t. In 1982 and 1983 OY was 2,700 t in the western area, 7,900 in the central area and 875 t in the eastern area. The reported amounts actually caught by the foreign fisheries were significantly less than the allocations in 1982 and 1983 in all areas of the fishery (Table 6).

Recent Studies

Balsiger et al. (1985) employed stock reduction analysis (SRA) as a means of assessing the status of Pacific ocean perch stocks. Estimates of MSY were calculated from the SRA equations. High estimates of MSY were calculated assuming a constant recruitment, and middle estimates were calculated assuming a moderate stock-recruitment relationship. In either case, the range of estimates of MSY (17,200 to 30,900 t) was a substantial reduction from the 125,000 t MSY and the 50,000 t EY that had been used in the original Fishery Management Plan.

Assuming that the stock has declined to between 11.2% and 30.8% of virgin biomass and that a moderate stock-recruitment relationship prevails ($r = 0.05$ for the Cushing parameter) then current biomass would be predicted to be between 152,000 and 508,000 t (Balsiger et al. 1985). By projecting 152,000 and 508,000 t into the future using the Deriso delay-difference equation, fishing mortalities of $F = 0.05$ and $F = 0.04$ (for current biomasses of 152,000 t and 508,000 t, respectively), were estimated to stabilize future biomass. Calculating exploitation rates corresponding to these values of F [exploitation rate = F(1.0.- exp(-F+M))/(F+M)], and then multiplying these exploitationrates by the estimates of current biomass, results in estimates of EY for 1985 between 7,232 and 19,432 t[1/].

COMMENT ON THE CURRENT CONDITION OF PACIFIC OCEAN PERCH STOCKS IN THE GULF OF ALASKA

There continues to be little firm evidence of any significant improvement in the condition of Pacific ocean perch stocks. Recruitment to the fishable stocks is sporadic and transient. The catches for 1982 and 1983 were less than one-sixth of the allocated ABC. Because of the slow growth rate of the individual fish and apparent slow recruitment, it may be some years before any significant change in the status quo can be expected.

[1/]Personal communication with Gary Stauffer, Northwest and Alaska Fisheries Center, 7600 Sand Point Way N.E., Seattle, WA 98115.

REFERENCES

Alverson, D. L.; A. T. Pruter, and L. L. Ronholt. 1964. A study of demersal fishes and fisheries of the northeastern Pacific Ocean. H. R. MacMillan Lectures in Fisheries, Inst. Fish., Univ. Brit. Columbia, Vancouver, B.C., 190 p.

Balsiger, J. W., D. H. Ito, D. K. Kimura, D. A. Somerton, and J. M. Terry. 1985. Biological and economic assessment of Pacific ocean perch (Sebastes alutus) in waters off Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-72, 210 p.

Berger, J. D., J. E. Smoker, and K. A. King. 1985. Foreign and joint venture catches and allocations in the Pacific northwest and Alaskan fishing areas under MFCMA, 1977-84. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC. (In press.)

Chikuni. S. 1975. Biological study of the population of Pacific ocean perch in the North Pacific. Bull. Far Seas Fish. Res. Lab. (Shimizu) 12, 119 p.

Chitwood. P. E. 1969. Japanese, Soviet, and South Korean fisheries off Alaska, development and history through 1966. U.S. Fish Wildl. Serv., Circ. 310, 34 p.

Eschmeyer, W. N., and E. S. Herald. 1983. A field guide to Pacific coast fishes of North America. Houghton Mifflin Co., Boston, 336 p.

Fadeev, N. S. 1968. O migratsivakh tikhookeanskogo morskogo okunya (Migrations of Pacific ocean perch). Izv. Tikhookean. Nauchno-issled. Inst. Rybn. Khoz. Okeanogr. 65:170-177. In Russian. (Transl. available Can. Fish. Oceans, Biol. Stn., St. John's, Newfoundland, as Fish. Res. Board Can. Transl. Ser. 1447, 14 p.)

Feldman, G. C., and C. S. Rose. 1981. Trawl survey of groundfish resources in the Gulf of Alaska, summer 1978. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-13, 44 p.

Forrester, C. R., R. G. Bakkala, K. Okada, and J. E. Smith. 1983. Groundfish, shrimp, and herring fisheries in the northeast Pacific--historical catch statistics, 1971-76. Int. North Pac. Fish. Comm., Bull. 41: 100 p.

Ito, D. H. 1982. A cohort analysis of Pacific ocean perch stocks from the Gulf of Alaska and Bering Sea Regions. NWAFC Processed Rep. 82-15, 157 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Lyubimova, T. G. 1963. Osnovnye cherty biologii i raspredeleniya tikhookean-sogo morskogo okunya (Sebastodes alutus Gilbert) v zalive alyaska (Basic aspects of the biology and distribution of Pacific ocean perch (Sebastodes alutus Gilbert) in the Gulf of Alaska). Tr. Vses. Nauchno.-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 48 (Izv. tikhookean. Nauchno-issled. Inst. Morsk. Ryb. Khoz. Okeanogr. 50):293-303. In Russian. (Trahsl. by Isreal Program Sci. Transl., 1968, p. 308-318 in Soviet fisheries investigations in the northeast Pacific, Part 1, available U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51203.)

Lyubimova, T. G. 1964. Biologicheskaya kharakteristika stada morskogo okunya Sebastodes alutus G. zaliva alyaska (Biological characteristics of the school of Pacific rockfish (Sebastodes alutus G.) in the Gulf of Alaska). Tr. Vsses. Nauchno.-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 53 (Izv. Tikhookean. Nauchno.-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 52):213-221. In Russian. (Transl. by Isreal Program Sci. Transl., 1968, p. 208-216 in Soviet fisheries investigations in the northeast Pacific, Part 3, available U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51205.

Lyubimova, T. G. 1965. Osnovnye etapa zhiznennogo tsikla morskogo okunya Sebastodes alutus Gilbert V Zal. alyaska (Main stages in the life cycle of rockfish Sebastodes alutus Gilbert in the Gulf of Alaska.) Tr. Vses. Nauchno .-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 58 (Izv. Tikhookean. Nauchno.-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 53) :95-120. In Russian. (Transl. by Isreal Program Sci. Transl., 1968, p. 85-111 in Soviet fisheries investigations in the northeast Pacific, Part 4, available U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, VA, as TT67-51206.

Major; R. L., and H. H. Shippen. 1970. Synopsis of biological data on Pacific ocean perch, Sebastodes alutus. U.S. Dep. Commer., Circ. 347, 38 p.

North Pacific Fishery Management Council. 1984. Fishery management plan for groundfish in the Gulf of Alaska. Unpubl. manuscr., 200 p. North Pac. Fish. Manage. Counc., P.O. Box 103136, Anchorage, AK 96813.

Okada, K. 1982. Condition of pollock, Pacific cod, Pacific ocean perch, rockfishes, and flatfish stocks in the Gulf of Alaska. Unpubl. manuscr., 6 p. Far Sea Fisheries Research Laboratory, Fisheries Agency of Japan, 1000 Krodo, Shimizu 424, Japan.. (Document submitted to the INPFC.)

Rigby, P. W. 1984. Alaska domestic groundfish fishery for, the years 1970 through 1980 with a review of two historic fisheries--Pacific cod (Gadus macrocephalus) and sablefish (Anoplopoma fimbria). Alaska Dep. Fish Game, Tech. Data Rep. 108, 446 p.

Ronholt, L. L., H. H. Shippen, and E. S. Brown. 1978. Demersal fish and shellfish resources of the Gulf of Alaska from Cape Spencer to Unimak Pass, 1948-1976 (a historical review). 4 volumes. Unpubl. manuscr., various pagination. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Westrheim, S. J. 1970. Survey of rockfishes, especially Pacific ocean perch, in the northeast Pacific ocean, 1963-66. J. Fish. Res. Board Can. 27: 1781-1809.

Wishard, L., and D. Gunderson. 1981. Geographic variation in Pacific ocean perch (*Sebastes alutus*) based on biochemical genetic evidence. Unpubl. manuscr., 42 p. Fisheries Research Institute, College of Fisheries, University of Washington, Seattle, WA 98195.

THIS PAGE INTENTIONALLY LEFT BLANK

THORNYHEAD ROCKFISH

by

Herbert H. Shippen

INTRODUCTION

General Distribution

Two similar species commonly are referred to as 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 thornyhead, which is the more common of the two, also is the larger of the two species--attaining lengths up to 75 cm.

Multispecies Nature of the Fisheries

Although the flesh of thornyheads is highly regarded by fishermen, the species ordinarily are not the target objects of fisheries--rather they are taken 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, *Zachirus glyptocephalus;* Dover sole *Microstomas pacificus*; shortraker rockfish, *Sebastes borealis*; rougheye rockfish, *Sebastes aleutianus*; and grenadiers (family *Macrouridae*).

FISHERY STATISTICS

Historical Catches

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

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 was estimated at 1,163 (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) area (Table 1).

Current Catches

The 1983 catches of thornyhead rockfish by foreign nations are arrayed by area, month, and vessel class in Tables 2 (Japan) and 3 (ROK). Of the 716 metric tons (t) taken by foreign nations, Japan took 95%; ROK 5%. Most were taken in the fall and summer, reflecting the seasons of best fishing weather and also the effects of U.S. management policies which restrict trawling in the spring as a measure to protect the domestic fishery for Pacific halibut.

Of the four classes of vessels that caught thornyheads in the Gulf of Alaska in 1983, small trawlers took about one-half the catch and large freezer trawlers and sablefish longliners took about one-quarter each (Table 4).

Table 1 .--Catch (t) of thornyhead rockfish in the Gulf of Alaska by nation and International North Pacific Fisheries Commission statistical area, 1980-83.

		Area					
Year	Nation	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
	Total	158	194	307	57	-	716

ROK: Republic of Korea

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 N.E., Seattle, WA 98115.

Table 2.--Catch (t) of thornyhead rockfish in the Gulf of Alaska by Japan, 1983, (by month, International North Pacific Fisheries Commission statistical area, and vessel type).

Area and type of vessel	Month												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
Shumagin													
Small trawler	-	-	-	-	-	65	3	0	15	8	0	-	91
Surimi trawler	0	-	0	-	-	0	0	1	5	-	1	-	7
Large freezer trawler	-	-	-	-	-	6	3	1	2	3	-	-	15
Longliner	2	1	1	1	5	9	4	2	3	0	3	6	37
Total	2	1	1	1	5	80	10	4	25	11	4	6	150
Chirikof													
Small trawler	-	-	-	-	-	69	18	3	7	23	4	-	124
Surimi trawler	0	-	-	-	-	0	0	-	1	4	0	0	5
Large freezer trawler	-	-	-	-	-	3	10	7	8	6	7	-	41
Longliner	2	1	1	1	4	5	2	2	0	0	1	4	23
Total	2	1	1	1	4	77	30	12	16	33	12	4	193
Kodiak													
Small trawler	-	-	-	-	-	2	31	55	29	21	2	-	140
Surimi trawler	-	-	-	-	-	0	1	0	-	-	-	-	1
Large freezer trawler	-	-	-	-	-	23	5	10	14	18	26	-	96
Longliner	3	0	2	1	8	10	2	4	1	2	8	9	50
Total	3	0	2	1	8	35	39	69	44	41	36	9	287
Yakutat													
Small trawler	-	-	-	-	-	-	0	-	-	-	-	-	0
Surimi trawler	-	-	-	-	-	-	-	-	-	-	-	-	-
Large freezer trawler	-	-	-	-	-	-	-	-	-	-	0	-	0
Longliner	1	-	2	-	5	9	2	1	3	6	8	17	54
Total	1	-	2	-	5	9	2	1	3	6	8	17	54
All areas													
Small trawler	-	-	-	-	-	136	52	58	51	52	6	-	355
Surimi trawler	0	-	0	-	-	0	1	1	5	4	1	0	13
Large freezer trawler	-	-	-	-	-	32	18	18	24	27	33	-	152
Longliner	8	2	6	3	22	33	10	9	7	8	20	36	164
Total	8	2	6	3	22	201	81	86	87	91	60	36	683

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 N.E., Seattle, WA 98115.

Table 3.--Catch (t) of thornyhead rockfish in the Gulf of Alaska by the Republic of Korea, 1983, (by month, International North Pacific Fisheries Commission statistical area, and vessel type).

Area and type of vessel	Month 1	2	3	4	5	6	7	8	9	10	11	12	Total
Shumagin													
Small trawler	-	-	-	-	-	0	0	0	1	0	0	-	1
Surimi trawler	-	-	-	-	-	-	-	-	-	-	-	-	-
Large freezer trawler	-	-	-	0	-	0	0	0	0	2	1	-	3
Longliner	-	-	-	2	0	-	1	2	-	-	1	-	6
Total	-	-	-	2	0	0	1	2	1	2	2	-	10
Chirikof													
Small trawler	-	-	-	-	-	0	0	-	-	0	0	-	0
Surimi trawler	-	-	-	-	-	-	-	-	-	-	-	-	-
Large freezer trawler	-	-	-	0	-	0	0	2	0	0	1	-	3
Longliner	-	-	-	-	-	-	-	-	0	-	-	-	0
Total	-	-	-	0	-	0	0	2	0	0	1	-	3
Kodiak													
Small trawler	-	-	-	-	-	-	-	-	-	-	-	-	-
Surimi trawler	-	-	-	-	-	-	-	-	-	-	-	-	-
Large freezer trawler	-	-	-	-	-	-	-	-	-	-	-	-	-
Longliner	-	-	-	2	1	-	-	2	2	10	4	-	21
Total	-	-	-	2	1	-	-	2	2	10	4	-	21
Yakutat													
Small trawler	-	-	-	-	-	-	-	-	-	-	-	-	-
Surimi trawler	-	-	-	-	-	-	-	-	-	-	-	-	-
Large freezer trawler	-	-	-	-	-	-	-	-	-	-	-	-	-
Longliner	-	-	-	-	2	-	-	-	1	0	1	-	4
Total	-	-	-	-	2	-	-	-	1	0	1	-	4
All areas													
Small trawler	-	-	-	-	-	0	0	0	1	0	0	-	1
Surimi trawler	-	-	-	-	-	-	-	-	-	-	-	-	-
Large freezer trawler	-	-	-	0	-	0	0	2	0	2	2	-	6
Longliner	-	-	-	4	3	-	1	4	3	10	6	-	31
Total	-	-	-	4	3	0	1	6	4	12	8	-	38

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 N.E., Seattle, WA 98115.

Table 4.--Catch (t) of thornyhead rockfish in the Gulf of Alaska by Japan and Republic of Korea (ROK), 1983 (by vessel type).

Type of vessel	Japan		ROK		Total	
	Catch	Percent	Catch	Percent	Catch	Percent
Small trawler	355	52.0	1	2.6	356	49.4
Surimi trawler	12	1.8	--	--	12	1.7
Large freezer trawler	152	22.3	6	15.8	158	21.9
Longliner	164	24.0	31	81.6	195	27.0
Total	683	100.0	38	100.0	721	100.0

Joint venture fisheries took an additonal 12 t of thornyheads in the Gulf of Alaska in 1983. Most came from the Shumagin statistical area; the remainder from the Kodiak area.

CONDITION OF THE STOCKS

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

There is very little information with which to evaluate the condition of the thornyhead resource in the Gulf of Alaska.. 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.

Data from resource assessment surveys are available only for 1979 and 1981 (Tables 5 and 6) and offer no hint as to the condition of the stock. It can be seen in Tables 5 and 6, however, that thornyheads are found in greatest number at bottom depths of 200 m or more.

Change in mean length also was examined as a possible indicator of changing stock condition. Note in Table 7 that thornyheads were smaller in 1982 and 1983 than in 1980 and 1981, regardless of sex or area. The significance of the decreases is masked, however, by the fact that the samples in 1980 and 1981 essentially were from longline fisheries operating at bottom depths greater than 500 m while those in 1982 and 1983 were from trawl fisheries operating in areas where the bottom depths were less than 400 m.

Table 5.--Catch per unit effort of thornyhead rockfish in the U.S. bottom trawl survey in the Gulf of Alaska, May 26-August 30, 1979 (by International North Pacific Fisheries Commission statistical area).

Depth (m)	Area									
	Shumagin		Chirikof		Kodiak		Yakutat		Southeastern	
	kg/hr	Stations	kg/hr	Stations	kg/hr	Stations	kg/hr	Stations	kg/hr	Stations
110-150	0.5	5	0	4	0	1	--	0	--	0
151-200	1.5	15	1.3	18	3.0	24	--	0	7.3	1
201-250	60.2	12	6.9	18	32.4	24	5.2	7	28.1	3
251-300	82.5	11	40.3	14	44.9	19	--	0	78.0	2
301-500	--	0	72.6	1	31.7	5	--	0	110.7	9
110-500	38.5	43	15.5	55	25.5	73	5.2	7	83.0	15

Table 6.--Catch per unit effort of thornyhead rockfish in the U.S. bottom trawl survey in the eastern Gulf of Alaska, May 23-August 21, 1981 (by Intetinational North Pacific Fisheries Commission statistical area).

	Area			
Depth (m)	Yakutat, 5/25-6/10 (kg/hr)	Yakutat, 6/29-7/9 (kg/hr)	Kodiak, 7/11-19 (kg/hr)	Southeastern, 6/9-17 (kg/hr)
101-200	1.4	2.3	4.5	2.5
201-300	5.6	54.0	159.9	56.1
301-400	67.3	188.9	129.3	49.9
>400	--	--	90.3	--
All depths	15.4	29.9	107.2	30.2

Table 7.--Mean fork length in centimeters of thornyhead rockfish in the Gulf of Alaska, by International North Pacific Fisheries Commission statistical area, as determined, from samples measured by U.S. observers, 1980-83.

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

POTENTIAL YIELD

Estimates of Maximum Sustainable Yield (MSY)

The Fishery Management Plan of the North Pacific Fishery Management Council sets MSY for thornyhead rockfish at 3,750 t (North Pacific Fishery Management Council 1984). The estimate is admittedly based on scant information, to which the present report can add little.

Estimates of Equilibrium Yield (EY)

Because it is felt that MSY is presently attainable, EY is set at MSY.

Acceptable Biological Catch (ABC)

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

REFERENCES

Alverson, D. L., A. T. Pruter, and L. L. Ronholt. 1964. A study of demersal fishes and fisheries of the northeastern Pacific Ocean. H. R. MacMillan Lectures in Fisheries, Inst. Fish., Univ. Brit. Columbia, Vancouver, B.C., 190 p.

Chitwood, P. E. 1969. Japanese, Soviet, and South Korean fisheries off Alaska, development and history through 1966. U.S. Fish Wildl. Serv., Circ. 310, 34 p.

North Pacific Fishery Management Council. 1984. Fishery management plan for groundfish in the Gulf of Alaska. Unpubl. manuscr., 200 p. North Pac. Fish. Manage Counc., P.O. Box 103136, Anchorage, AK 96813

Wall, J., R. French, R. Nelson Jr., and D. Hennick. 1978. Data from the observations of foreign fishing fleets in the Gulf of Alaska, 1977. Unpubl. Manuscr., 28 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112. (Document Submitted to the INPFC.)

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 account for approximately 99% of the catch of the nonhalibut complex of flatfishes, are arrowtooth flounder, *Atheresthes stomias*, flathead sole, *Hippoglossoides elassodon*, rock sole, *Lepidopsetta bilineata*, rex sole, *Glyptocephalus zachirus*, and Dover sole, *Microstomus pacificus*. As a matter of practical convenience, the nonhalibut complex of flatfishes inhabiting the Gulf of Alaska is considered to be a single stock and is managed accordingly.

FISHERY STATISTICS

The annual catches of Gulf of Alaska flatfish (nonhalibut species combined), 1978-83, are presented in Table 1, by nation and International North Pacific Fisheries Commission (INPFC) statistical area. Japan and the Republic of Korea (ROK), which have historically dominated the catch of these species, continued to do so in 1983. Both Japan and ROK took approximately the same amount of flatfish from the Gulf in 1983 as they did in 1982 (about 6,500 metric tons [t] and 2,500 t, respectively); The overall foreign catch of Gulf of Alaska flatfish in both 1982 and 1983 was down about 5,000 t from the 1978-81 average--a decrease mostly attributable to the closure in 1982 of the eastern Gulf to foreign bottom trawling.

Table 1.--Catch (t) of flatfish in the Gulf of Alaska, by fishery category and International North Pacific Fisheries Commission statistical area, 1978-83.

Area	Japan	U.S.S.R.	Rep. of Korea	Poland	Mexico	Joint venture	U.S.	Total
Shumagin								
1978	2,268	0	270	0	0	5	6	2,549
1979	2,202	26	557	15	17	7	0	2,824
1980	336	976	1,710	0	0	11	0	3,033
1981	1,229	0	1,984	11	0	0	0	3,224
1982	804	0	608	0	0	6	0	1,418
1983	753	0	1,267	0	0	171	0	2,191
Chirikof								
1978	2,268	188	26	0	0	0	4	2,459
1979	488	107	0	4	19	0	1	619
1980	936	40	0	0	0	106	0	1,082
1981	1,349	0	2,300	4	0	18	0	3,671
1982	1,270	0	1,628	0	0	12	0	2,910
1983	2,860	0	1,375	0	0	62	0	4,297
Kodiak								
1978	3,809	8	0	13	0	0	82	3,912
1979	4,100	231	0	0	77	62	54	4,524
1980	5,086	823	0	0	0	92	46	6,047
1981	2,099	0	7	0	0	0	77	2,183
1982	4,472	0	146	0	0	0	71	4,689
1983	3,224	0	0	0	0	2,459	87	5,770
Yakutat								
1978	2,955	0	0	0	0	0	0	2,955
1979	3,238	5	47	0	0	1	7	3,298
1980	4,071	0	24	0	0	0	0	4,095
1981	2,573	0	735	0	0	0	0	3,308
1982	57	0	1	0	0	0	0	58
1983	50	0	1	0	0	0	0	51
Southeastern								
1978	2,536	0	0	0	0	0	760	3,296
1979	2,341	0	1	0	0	0	322	2,664
1980	1,495	0	0	0	0	0	94	1,589
1981	2,153	0	0	0	0	0	327	2,480
1982	0	0	0	0	0	0	203	203
1983	0	0	0	0	0	0	351	351

Table 1 .--Continued.

All areas	Japan	U.S.S.R.	Rep. of Korea	Poland	Mexico	Joint venture	U.S.	Total
1978	13,809	196	296	13	0	5	852	15,171
1979	12,369	369	605	19	113	70	384	13,929
1980	11,924	1,839	1,734	0	0	209	140	15,846
1981	9,403	0	5,026	15	0	18	404	14,866
1982	6,603	0	2,383	0	0	18	274	9,278
1983	6,887	0	2,643	0	0	2,692	438	12,660

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 N.E., Bin C15700 Building 4, Seattle, WA 98115.

U.S. Catches (1978-80): Rigby 1984.

U.S. Catches (1981-83): Pacific Fishery Information Network (PacFIN), Pacific Marine Fisheries Commission, 305 State Office Building, 1400 S.W. fifth Avenue, Portland, OR 97201.

The United States processed catch remained low at 438 t in 1983. Most was taken in a southeastern Alaska fishery dominated by starry flounder, Platichthys stellatus. Less than 100 t of flatfish were processed in the Kodiak and Shumagin areas combined.

The catch of flatfishes by joint venture fisheries, on the other hand, increased dramatically in 1983. Whereas this element of the catch had been negligible in recent years, it rose to nearly 2,700 t in 1983, making up more than 20% of the total catch. More than 90% of the joint-venture catch, of flatfish was taken in the Kodiak area, with lesser amounts being taken in the Shumagin and Chirikof areas.

Although Gulf of Alaska flatfish are managed as a separate single stock, it is appropriate to monitor the species individually since they have a variety of distributions and life histories. For the major nonhalibut species of flatfish, accordingly, the 1978-83 catch data are grouped by area in Table 2. Viewed in this way, the most notable change over the years has been the increased catch of certain species, particularly rock sole, in the Kodiak area.

Also noteworthy in this regard is the difference in species composition between the foreign and joint venture fisheries which came to light in 1983 (Table 3). Historically (with the exception of 1982 when uncertainties surrounding the allocation of walleye pollock, Theragra chalcogramma, may have directed additional effort to selected flatfishes other than arrowtooth flounder) the latter species has dominated the foreign catch of flatfish in the Gulf. Arrowtooth flounder is the most abundant nonhalibut flatfish in the Gulf, occurring in all areas and in all depth strata, although it is somewhat more abundant in strata deeper than 100 m. Arrowtooth flounder

Table 2.--Catch (t) of flatfish in the Gulf of Alaska by species, and International North Pacific Fisheries Commission statistical area, 1978-83.

		Area					
Species	Years	Shumagin	Chirikof	Kodiak	Yakutat	South-eastern	Total
Arrowtooth flounder	1978-81[a]	2,266	1,529	3,095	3,109	2,007	12,006
	1982	1,068	2,606	2,284	4	0	5,962
	1983	1,579	3,911	3,711	44	0	9,245
Rock sole	1978-81	297	54	58	7	2	418
	1982	196	23	80	0	0	299
	1983	323	13	698	0	0	1,034
Flathead sole	1978-81	45	183	165	103	2	498
	1982	63	108	1,025	40	0	1,236
	1983	63	79	434	0	0	576
Rex sole	1978-81	101	117	419	58	86	781
	1982	36	105	818	0	0	959
	1983	94	95	407	8	0	604
Dover sole	1978-81	48	53	358	105	32	596
	1982	30	56	364	6	0	456
	1983	39	113	197	6	0	355

[a]Average of catches 1978-81.

Sources: 1978: Wall et al. 1979; 1979: Wall et al. 1980; 1980: Wall et al. 1981; 1981: Wall et al. 1982; 1982: Nelson et al. 1983; and 1983: Berger et al. 1984.

Table 3.--Species composition of 1983 Gulf of Alaska flatfish catch by fishery category.

Species	Foreign (%)	Joint venture (%)
Arrowtooth flounder (*Atheresthes stomias*)	85	41
Rock sole (*Lepidopsetta bilineata*)	3	28
Flathead sole (*Hippoglossoides elassodon*)	2	15
Rex sole (*Glyptocephalus zachirus*)	4	6
Dover sole (*Microstomus pacificus*)	4	1
Greenland turbot (*Reinhardtius hippoglossoides*)	2	0
Butter sole (*Isopsetta isolepis*)	0	5
Starry flounder (*Platichthys stellatus*)	0	2
Yellowfin sole (*Limanda aspera*)	0	2

also move off bottom more than other species of flatfish and have the lowest commercial value. For reasons of its sheer abundance off bottom in deeper depth strata, it is therefore not surprising that arrowtooth flounder (despite its low value) dominates the catch of flatfish taken incidentally in foreign fisheries that characteristically deploy a lot of effort off bottom in deep strata near the edge of the continental shelf. In the joint venture fishery, on the other hand, arrowtooth flounder are less dominant and some of the other nonhalibut flatfishes are proportionally more abundant than in the. foreign fisheries, particularly rock sole and flathead sole. Joint venture fisheries operate over the continental shelf, usually in shallower waters where flatfishes other than arrowtooth flounder are more likely to be found. Further, because of their greater commercial value; these species become the target objects of joint venture bottom trawling.

MAXIMUM SUSTAINABLE YIELD, EQUILIBRIUM YIELD, OPTIMUM YIELD, AND THE ALLOCATION OF CATCH

The maximum sustainable yield (MSY) of the flatfish complex in the Gulf of Alaska has been estimated at 67,000 t, based on an estimated exploitable biomass of 772,000 t (North Pacific Fishery Management Council 1984). The biomass estimate, calculated from data collected during a series of trawl surveys in the early 1970's, tends to be conservative in that it was derived on the assumption that the catchability coefficient equals 1.0 (that all flatfish in the trawl's path were caught. If the catchability coefficient was only 0.5, for example, the estimates of biomass and MSY would double. These same trawl data, it should be pointed out, were also used to allocate

MSY to the various management areas within the Gulf. Results of a more recent series of trawl surveys (1978-81) were incomplete in that they did not completely cover the flatfish habitat and could not be used, therefore, as a basis forupdating the estimates of MSY or the way that MSY was distributed to the management areas. A more comprehensive survey of the central and western Gulf in the summer and fall of 1984 will be used to update these estimates.

Because the flatfish stocks of the Gulf of Alaska have only been lightly exploited, equilibrium yield (EY) is considered to equal MSY. Optimum yield (OY) on the other hand, was reduced to 50% of EY in order to protect the stocks of Pacific halibut. Allocation of OY by regulatory area is shown in Table 4. A notable change for 1984 is the shift of the bulk of the quota in the central management area from the foreign to the U.S. domestic fisheries. The sum of the foreign and reserve quotas in 1984 is 1,000 to 1,500 t short of the foreign catch in recent years. Accordingly, in 1984 the flatfish quota may be reached for the first time.

Table 4.--Allocation (t) of the Gulf of Alaska flatfish quota, 1982-84.

Year and area	Domestic harvest	Foreign harvest	Reserve	Optimum yield
1982-1983				
Eastern	1,360	5,360	1,680	8,400
Central	1,120	10,640	2,940	14,700
Western	700	7,620	2,080	10,400
Total	3,180	23,620	6,700	33,500
1984				
Eastern	300	6,420	1,680	8,400
Central	8,720	3,040	2,940	14,700
Western	10	8,310	2,080	10,400
Total	9,030	17,770	6,700	33,500

Source : North Pacific Fishery Management Council 1982-84..

REFERENCES

Berger, J., J. Wall, and R. Nelson, Jr. 1984. Summary of U.S. observer sampling of foreign and joint-venture fisheries in the northeast Pacific Ocean and eastern Bering Sea, 1983. Unpubl. manuscr., 211 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Bin C15700, Bldg. 4, Seattle, WA 98115. (Document submitted to the INPFC in October 1984.)

Nelson; R. Jr., J. Wall, and J. Berger. 1983. Summary of U.S. observer sampling of foreign and joint-venture fisheries in the northeast Pacific Ocean and eastern Bering Sea, 1982. Unpubl. manuscr., 224 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Bin C15700, Bldg. 4, Seattle, WA 98115. (Document submitted to the INPFC in October 1983.)

North Pacific Fishery Management Council. 1982-84. Fishery management plan for the Gulf of Alaska groundfish fishery. (Yearly.) Unpubl. manuscr., various pagination. North Pac. Fish. Manage. Counc., P.O. Box 103136, Anchorage, AK 99510.

Rigby, P. W. 1984. Alaska domestic groundfish fishery for the years 1970 through 1980 with a review of two historic fisheries--Pacific cod (Gadus macrocephalus) and sablefish (Anoplopoma fimbria). Alaska Dep. Fish Game, Tech. Data Rep. 108, 446 p.

Wall, J., R. French, and R. Nelson, Jr. 1979. Observations of foreign fishing fleets in the Gulf of Alaska, 1978. Unpubl. manuscr., 60 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Bin C15700, Bldg. 4, Seattle, WA 98115. (Document submitted to the INPFC in September 1979.)

Wall, J., R. French, and R. Nelson, Jr. 1980. Observations of foreign fishing fleets in the Gulf of Alaska, 1979. UnpubI. manuscr., 78 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Bin C15700, Bldg. 4, Seattle, WA 98115. (Document submitted to the INPFC in September 1980.)

Wall, J., R. French, and R. Nelson, Jr. 1981. Observations of foreign fishing fleets in the Gulf of Alaska, 1980. Unpubl. manuscr., 60 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Bin C15700, Bldg. 4, Seattle, WA 98115. (Document submitted to the INPFC in September 1981.)

Wall, J., R. Nelson, Jr., and J. Berger. 1982. Observations of foreign fishing fleets in the Gulf of Alaska, 1981. Unpubl. manuscr., 72 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way N.E., Bin C15700, Bldg. 4, Seattle, WA 98115. (Document submitted to the INPFC in September 1982.)

THIS PAGE INTENTIONALLY LEFT BLANK

SQUID

by

Thomas Wilderbuer

The abundance and potential yield of squid in the Gulf of Alaska has 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 1984). Catches, which primarily are by foreign trawlers in the central and western Gulf, have fallen far short of the 5,000 t OY, however, averaging just 550 t 1978-83 (Table 1). Most squid are taken incidentally in fisheries that target on other species.

Table 1.--Catch (t) of squid in the Gulf of Alaska, by fishery category, 1978-83.

Year	Japan	Rep. of Korea	Poland	U.S.S.R.	Mexico	Foreign total	OY	JV	Total catch
1978	186	133	1	2		322	2,000	--	322
1979	259	143	9	1	13	425	5,000	--	425
1980	697	107	T	37		841	5,000	T	841
1981	554	562	19			1,135	5,000	T	1,135
1982	202	76				278	5,000	16	294
1983	252	15				267	5,000	4	271

T: Trace.

Source: Berger et al. 1985.

REFERENCES

Berger, J. D., Smoker, J. E., and K. A. King. 1985. Foreign and joint venture catches and allocations in the Pacific Northwest and Alaska fishing areas under MFCMA, 1977-84. U.S. Dep. Comer., NOAA Tech. Memo. NMFS F/NWFC

North Pacific Fishery Management Council. 1984. Fishery management plan for the Gulf of Alaska groundfish fishery. Unpubl. manuscr., 200 p. North Pac. Fish. Manage. Counc, P.O. Box 103136 , Anchorage, AK 99510.

ACOUSTIC-MIDWATER TRAWL SURVEYS OF SPAWNING WALLEYE POLLOCK IN THE SHELIKOF STRAIT REGION, 1980-81 AND 1983-84

by

Martin O. Nelson and Edmund P. Nunnallee

INTRODUCTION

Echo integrator-midwater trawl surveys of walleye pollock, *Theragra chalcogramma,* in the Gulf of Alaska were initiated in 1980 and, except for 1982, have been conducted each year since. The surveys, which have taken place primarily in March and early April, have focused on the Shelikof Strait spawning stock. They have also involved special efforts to determine the distribution of spawning pollock in other areas, including the east side of Kodiak Island and the area between Shelikof Strait and Unimak Pass in 1983, and part of the central Gulf region in 1984 (Amatuli Trench to Middleton Island, Prince William Sound, and Blying Sound-Resurrection Bay). Only a few small concentrations of spawning pollock have been located by the surveys outside the Shelikof Strait region, but this may be partly due to the limited scope, particularly the restricted temporal coverage, of these surveys.

Each year, the primary objective of the Shelikof Strait survey has been to obtain an age-specific estimate of the size of the midwater (off-bottom) component of the pollock stock during that part of the spawning period when the abundance of adult fish is at a maximum. This report provides a brief description of survey and analysis methods, presents the basic results (biomass estimates and population age and length distributions) for each year (1980, 1981, 1983, and 1984) and briefly discusses sources of error and future research needs.

SURVEY AND ANALYSIS METHODS

All survey data used for this report were collected aboard the National Oceanic and Atmospheric Administration (NOAA) ship Miller Freeman, a 66 m stern trawler. Acoustic data were obtained using a 38 kHz echo sounder with its transducer mounted in a towed body. The body was deployed at a depth of 5 to 20 m and towed at speeds of 8-10 kn. Echo integration and initial data handling and storage were done in real time using a digital integrator interfaced to a microcomputer, except in 1980 when the echo data were tape recorded for laboratory analysis. All echo integrator data were scaled to estimates of absolute density by assuming the average target strength (i.e., the target strength of the average scattering cross section) of pollock in the length range encountered on the surveys is -31.3 dB/kg. The use of this value, which is discussed later in this report, is based on the results of Bering Sea pollock target strength measurements reported by Traynor and Williamson (1983).

Midwater trawl hauls were made to obtain species composition data and, especially, pollock biological samples. Except for a few hauls made during the 1984 survey, all midwater sampling was done with a Diamond 1000 trawl equipped with a cable netsounder system. This trawl has stretched mesh sizes ranging from 81 cm to 8.9 cm (codend) and, except in 1980, it was used with a 3.8 cm mesh codend liner. The vertical mouth opening of the trawl ranged from about 12 to 20 m depending on depth or amount of cable and towing speed. The duration of trawl hauls varied according to the availability of the echo sign and the efficiency of the trawl setting or aiming operation. For each haul, the total catch (weight and number) was estimated for each species. Pollock length composition by sex, was estimated for each catch from a random sample of 150-350 specimens. Other biological data or samples (individual weights, otoliths, maturity stage) were obtained from most pollock catches by subsampling from the length composition sample.

Survey operations were conducted 24 hours per day since significant daily variation in the vertical distribution and detectablity of the pollock was not observed. A zig-zag trackline pattern, which typically ran across the Sheilkof Strait approximately between the 90 m isobaths, was used for each survey (Figs. 1-3). Echo integrator density estimates (kg/m^3) were recorded at either 1 or 5 minute intervals along survey transects for each nonoverlapping 10 or 20 m depth stratum between the transducer and a depth of approximately 3-5 m above bottom. Each survey's geographic coverage was partly determined by real time observations of the distribuiton of pollock echo sign.

Pollock biomass was estimated by multiplying average density per unit surface area (kg/m^2) by area (either the total survey area or each of selected subareas). Following procedures similar to those described by Traynor (1984), age specific biomass and population estimates were calculated from length frequency data and survey specific length-weight relationships and age-length keys[1/]. The variance of mean density per unit surface area Var (d) was calculated using the method investigated by Williamson (1982). The variance of each biomass estimate (B) was calculated as Var (B) = A^2 Var (d), where A is an estimate of surface area. The associated 95% confidence interval was calculated as B + 1.96 (Var (d))2.

[1/]In 1980, otoliths were not collected from the midwater trawl catches and the age data are based on otoliths collected during a March bottom trawl survey.

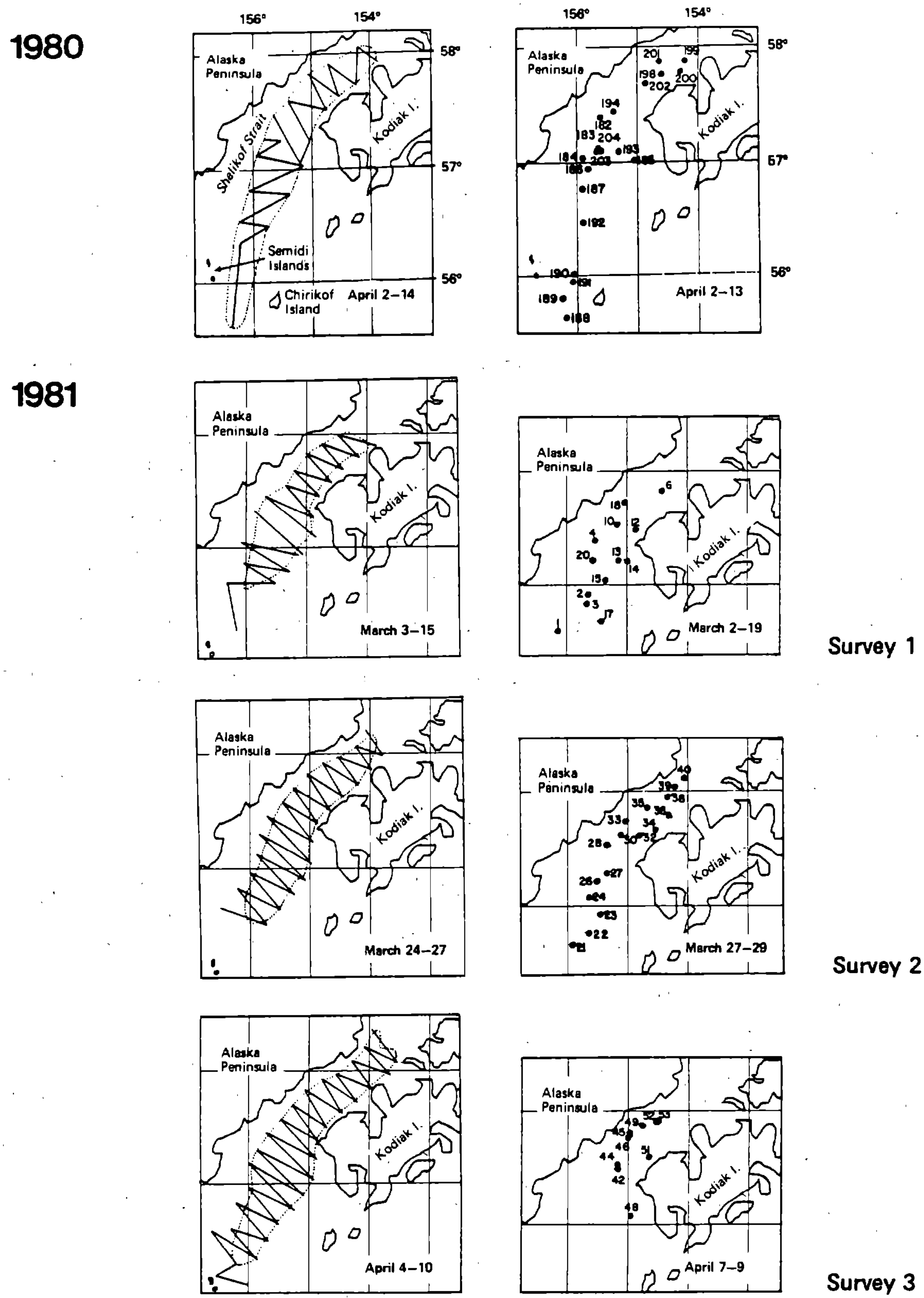


Figure 1.--Acoustic survey tracklines and midwater trawl stations for the 1980 and 1981 Shelikof Strait surveys.

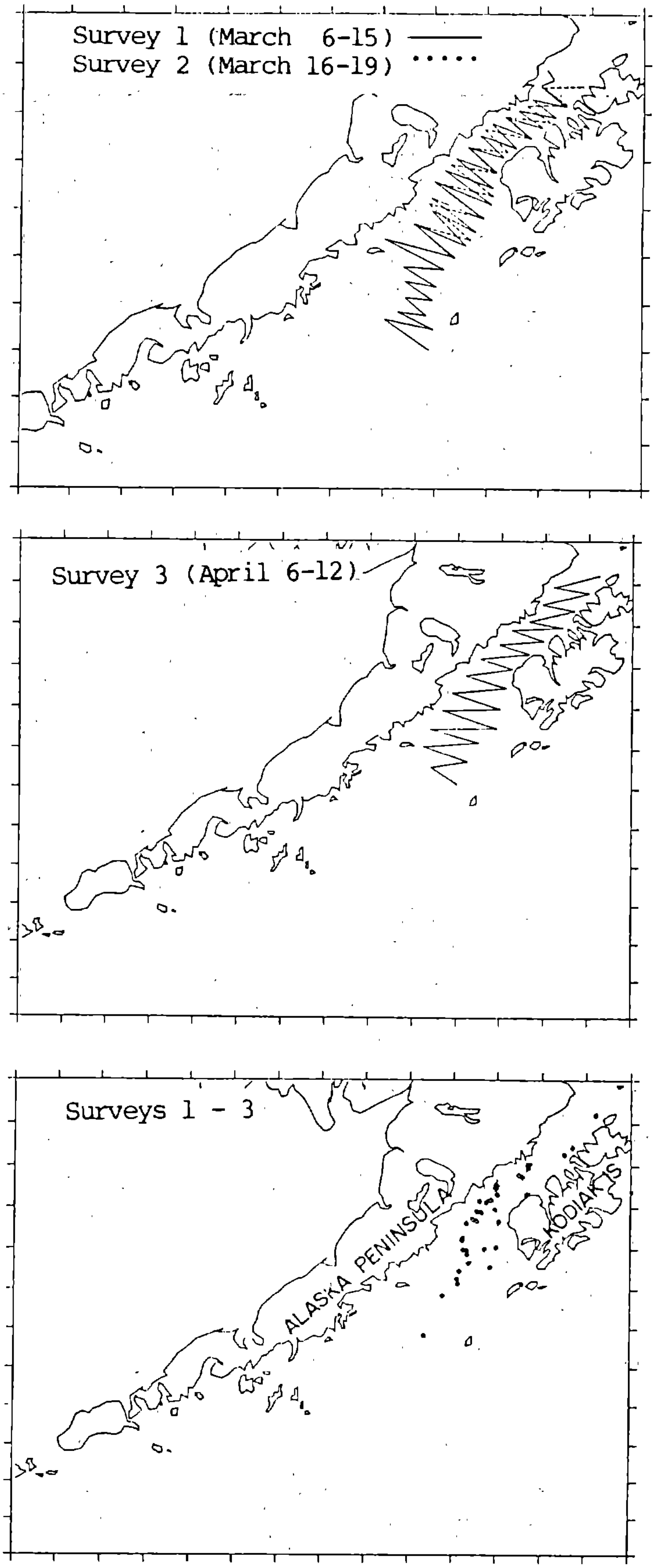


Figure 2.--Acoustic survey tracklines and midwater trawl stations for the 1983 Shelikof Strait surveys.

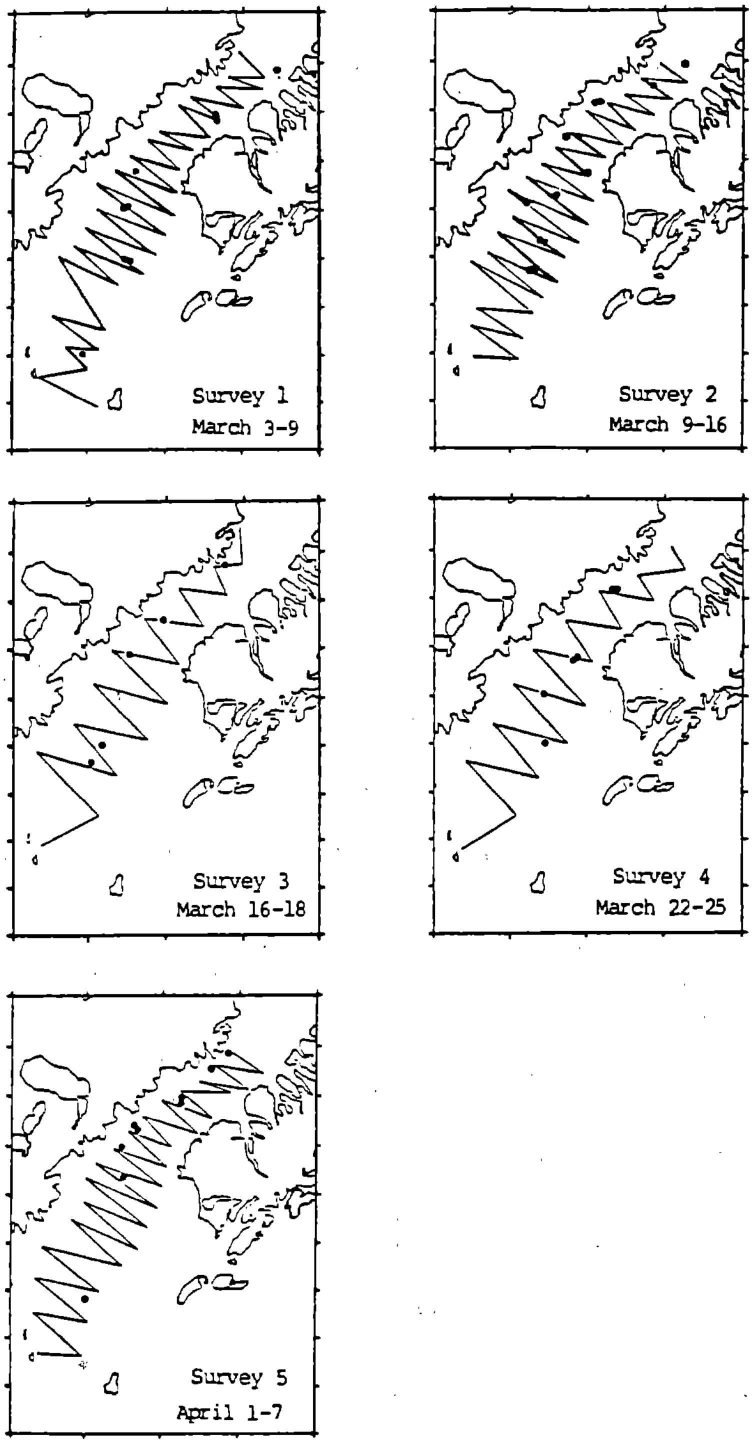


Figure 3.--Acoustic survey tracklines and midwater trawl stations for the 1984 Shelikof Strait surveys.

RESULTS

With the exception of 1980 (when a single survey took place late in the spawning period), the survey effort in Shelikof Strait has been similar among years, i.e., during each year (1981, 1983, and 1984) a series of surveys has been completed between the first week of March and the second week of April. The number of surveys in 1981, 1983, and 1984 was 3, 3 and 5, respectively[2/]. The sampling effort, as indicated by the acoustic survey trackline patterns and numbers/geographic distributions of midwater trawl hauls, is shown in Figs. 1-3. During each of the four years pollock have comprised more than 94% of the total catch, by weight, in midwater trawl hauls (Table 1).

The surveys have demonstrated that their timing is especially important because of the changes in abundance, geographical distribution, schooling behavior and biological characteristics of the pollock stock that occur during February-April. The echo integration survey estimates of density, distribution and abundance (Table 2), as well as other survey and fishery information, suggest that the total biomass of adult fish in the Shelikof-Chirikof Island region has typically reached a maximum during the first 2 or 3 weeks of March, just prior to the time of greatest spawning activity. Spawning, as indicated by changes in maturity, has usually reached a peak in late March (Table 3). Similar information on time of spawning has been obtained from ichthyoplankton surveys (Dunn et al. 1984). Large changes in average pollock density (and the total area inhabited by

---

[2/] In 1983, a fourth acoustic-midwater trawl survey was partially completed during March 25-April 3 by the NOAA ship Chapman. Because of the restricted geographic coverage of this survey, the pollock abundance. etimates determined from it are not comparable to the other surveys and are not included in this report.

Table 1.--Summary of catch data for midwater trawl hauls made during Shelikof Strait acoustic surveys in 1980, 1981, 1983, and 1984.

	Total catch							
	1980		1981		1983		1984	
	kg	%	kg	%	kg	%	kg	%
Walleye pollock	20,396	97.4	26,050	97.9	73,873	94.5	76,710	96.6
Pacific cod	334	1.6	236	0.9	1,799	2.3	290	0.4
Eulachon	108	0.5	133	0.5	2,333	3.0	360	0.5
Other species	96	0.4	193	0.7	184	0.2	411	0.5
Total	20,934	100.0	26,612	100.0	78,189	100.0	77,771	100.0
Number of hauls	20		38		40		41	

Table 2.--Pollock biomass estimates determined from Shelikof Strait acoustic-midwater trawl surveys in 1980; 1981, 1983, and 1984.

Year	Survey number and period	Mean density ($kg/10^3m^2m$)	Total area (km^2)	Biomass ($t \times 10^6$)	95% confidence interval ($t \times 10^6$)	
1980	1 April 11-14	50.7	11,970	0.71	.57 to .82	(±15.5%)
1981	1 March 3-15	637.6	6,870	4.38	2.92 to 5.84	(±33.3%)
	2 March 24-27	363.6	8,674	3.15	2.07 to 4.23	(±34.3%)
	3 April 4-10	251.0	12,138	3.06	2.02 to 4.08	(±33.3%)
1983	1 March 6-15	144.9	17,587	2.46	1.54 to 3.40	(±37.7%)
	2 March 16-19	194.7	12,123	2.36	1.26 to 3.46	(±46.6%)
	3 April 6-13	41.2	19,733	0.82	0.57 to 1.07	(±30.5%)
1984	1 March 3- 9	133.6	16,567	2.03	1.43 to 2.64	(±29.9%)
	2 March 9-16	107.1	15,043	1.57	1.31 to 1.84	(±17.1%)
	3 March 16-18	139.3	14,383	1.90	1.06 to 2.75	(±44.2%)
	4 March 22-25	127.5	15,641	1.72	0.98 to 2.46	(±42.9%)
	5 April 1- 7	119.8	15,147	1.66	1.19 to 2.13	(±28.3%)

Annual estimates of maximum biomass

Year	Biomass ($t x 10^6$)	95% confidence interval ($t x 10^6$)	Source of estimates
1981	3.77	2.86 to 4.67	Mean of estimates for surveys 1 and 2
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 and 3

Table 3.--Percentage maturity compositions for age-3 and older female pollock sampled during Shelikof Strait acoustic-midwater trawl surveys in 1983 and 1984.

Year and survey period	Maturity stage				
	Immature	Developing	Mature	Spawning	Spent
1983					
March 6-15	0.0	17.4	82.1	0.5	0.0
March 16-19	0.0	15.2	81.2	2.8	0.8
April 6-12	0.0	17.9	5.8	17.8	63.5
1984					
March 1- 9	6.4	21.7	0.0	0.0	0.0
March 9-16	0.0	11.9	1.4	1.4	0.4
March 16-18[a]	--	--	--	--	--
March 22-25	0.6	14.2	48.5	33.0	3.6
April 1- 7	0.0	2.3	14.1	28.5	55.1

[a]Maturity by age data were not obtained for the March 16-18 survey.

significant densities) occur within and between years. One of the most noticeable changes, which (except for 1984) has been detected by the surveys each year, is the pronounced dispersion and, in some cases (1980 and 1983), apparent emigration of fish that occurs between late March and mid-April. This is reflected in the survey estimates of mean density, area and biomass (Table 2)[3/] and becomes apparent when, as shown for 1983 (Fig. 4), density distributions are compared between surveys within a year. Fig. 4 also provides an example of the fact that prior to spawning, pollock form the densest concentrations in the relatively deep (228-320 m) basin on the west side of the central portion of the Shelikof Strait. This behavior has been observed during all 4 years. In 1984, the early April dispersal and decrease inaverage density was not observed and it appears that the spawning period may have been extended.

The annual estimates of biomass from the survey indicate that a significant reduction in the size of the Shelikof pollock stock occurred between 1981 and 1984 (Table 2)[4/]. During this period the stock consisted primarily of the 1975-79 year classes (Table 4 and Fig. 5)[5/], all of

---

[3/]Echo sounder and trawl sampling data collected in the Shelikof area throughout March and early April, 1980 provide evidence that the average density of pollock in the area had decreased significantly by the time (11-14 April) of the echo integrator survey.

[4/]It is suspected that the biomass estimate for survey 1 in 1981 could be biased high as a result of the long time that was required to complete this survey (the survey was conducted during a period of extremely poor weather). However, the 1981-1984 decline in abundance is still apparent.

[5/]It should be noted that 1 and 2-year-old pollock are not representatively sampled by the survey. The relative availability of 3-year-old fish is not well known but, as discussed by Alton and Rose [1985 (in this report)], survey abundance estimates for this age group may provide a useful measure of year class strength.

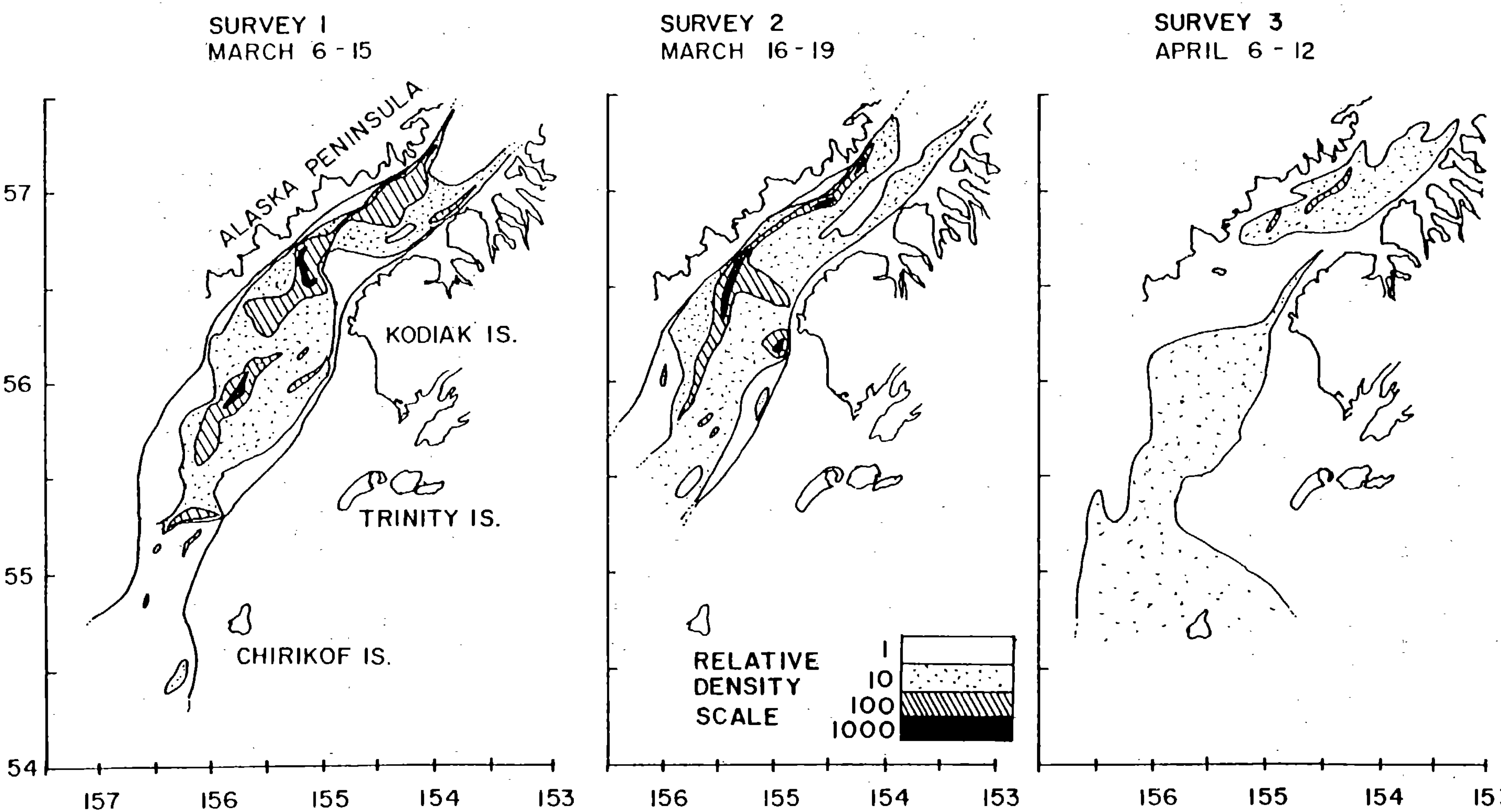


Figure 4.--Relative density distribution of midwater (off-bottom) pollock in Shelikof Strait during each of the three surveys conducted in 1983.

Table 4.--Estimates of age specific biomass (thousands of metric tons [t]) and numbers (millions) of pollock in Shelikof Strait determined from acoustic-midwater trawl surveys in 1980, 1981, 1983 and 1984.

Biomass

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	Total
1980[a]	1.8	49.1	16.4	370.2	158.0	43.8	38.7	20.3	10.1	0.6	0.0	0.0	709.0
1981[b]	0.9	350.6	375.0	339.4	1509.0	756.1	177.3	115.8	111.0	27.9	3.2	0.0	3766.1
1983[b]	0.0	58.9	103.9	570.7	700.8	497.2	360.6	105.1	17.3	12.1	4.8	1.6	2433.0
1984[b]	0.0	8.0	64.1	105.5	405.8	710.5	333.8	169.8	34.8	4.9	0.0	0.9	1838.1

Numbers

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	Total
1980[a]	105.4	394.6	57.3	1127.4	367.8	68.5	51.5	2.7	7.3	0.8	0.0	0.0	2183.3
1981[b]	39.4	3704.6	1590.7	888.5	3480.1	1464.1	258.6	151.2	115.7	31.4	3.5	0.0	11627.8
1983[b]	1.8	757.8	325.7	1410.0	1270.3	761.7	648.4	145.2	19.5	11.9	4.1	1.9	5358.3
1984[b]	1.5	74.2	258.9	231.1	700.9	1045.0	464.8	239.8	3.7	3.7	0.0	0.9	3062.9

[a]The 1980 estimates were obtained from a single survey late (11-14 April) in spawning period.

[b]The 1981, 1983 and 1984 age distribution are for stock size estimates determined by averaging estimates from selected surveys (see bottom portion of Table 2).

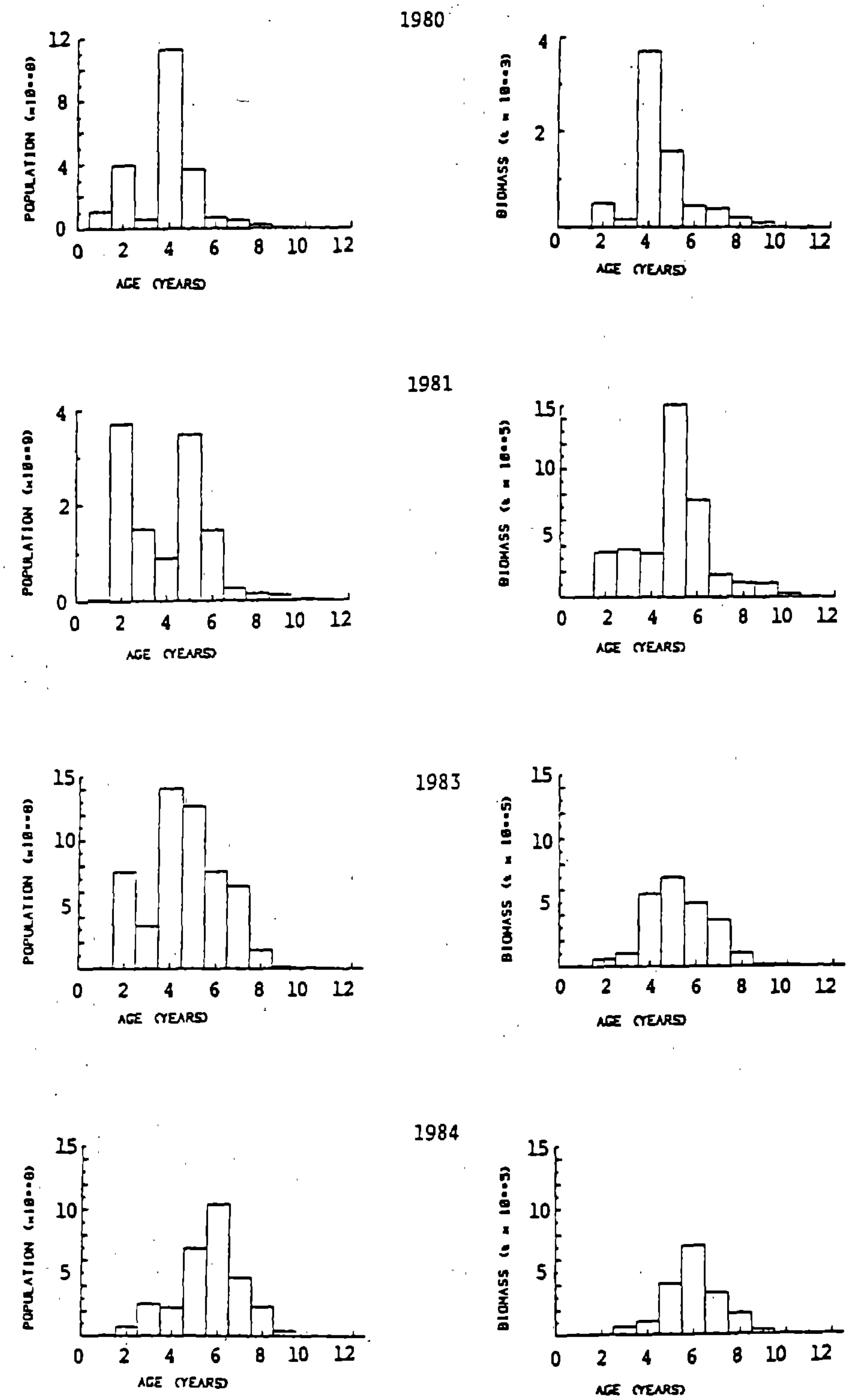


Figure 5.--Age distributions of Shelikof Strait pollock determined from 1980, 1981, 1983, and 1984 acoustic-midwater trawl surveys. The 1981, 1983, and 1984 age distributions are for stock size estimates determined by averaging estimates from selected surveys (see bottom portion of Table 2).

which, as indicated by the fishery data [Alton and Rose 1985 (in this report) and Alton 1985 (in this report)], appear to have been relatively strong. The decline in stock size is apparently due to the effect of mortality of these year classes coupled with the occurrence of a weak 1980 year class. The small size of this year class is indicated by its low abundance in 1983 as 3-year-olds and in 1984 as 4-year-olds in both the joint venture fishery data [Alton 1985 (in this report)] and the survey data (Table 4). Prior to 1984 4-year-olds were usually an important component of the Shelikof stocks[6/]. The weakness of the 1980 year class is also shown by the survey estimate of its abundance at age 3 relative to that of the strong 1978 year class (Table 4). The 1984 survey estimate of age-3 pollock is even lower than the 1983 estimate for this age group. Consequently, it appears that the 1981 year class is also weak.

The decline in abundance and increase in average age of pollock is reflected in significant increases in the survey estimates of mean length (Table 5 and Fig. 6). Very similar changes are also evident in the joint venture fishery length composition data [Alton 1985 (in this report)].

Substantial differences in age and length composition occurred from survey to survey during the series which were conducted in 1981, 1983 and 1984 (Figs. 6-12). More detailed analysis of these differences is needed to determine the extent to which they represent real variation, as opposed to possible artifacts due to inadequate sampling. The observed variability emphasizes the need for appropriate timing of the surveys and proper geographical distribution of the trawl sampling effort, and suggests the need for more comprehensive biological sampling. Roth survey and fishery data suggest that the stock of pollock age 4 and older can be reliably estimated

[6/]The relatively low survey estimate for age-4 pollock in 1981 is inconsistent with fishery data on the abundance of this age group, as well as with the survey estimates for 6 and 7-year-old fish in 1983 and 1984, respectively.

Table 5.--Mean lengths of pollock in midwater trawl samples collected in Shelikof Strait during March-April acoustic surveys in 1980, 1981, 1983, and 1984.

	Mean length (cm)		
Year	Males	Females	Combined
1980	31.6	32.9	32.2
1981	33.1	34.9	34.0
1983	38.1	39.4	39.1
1984	42.3	44.8	43.6

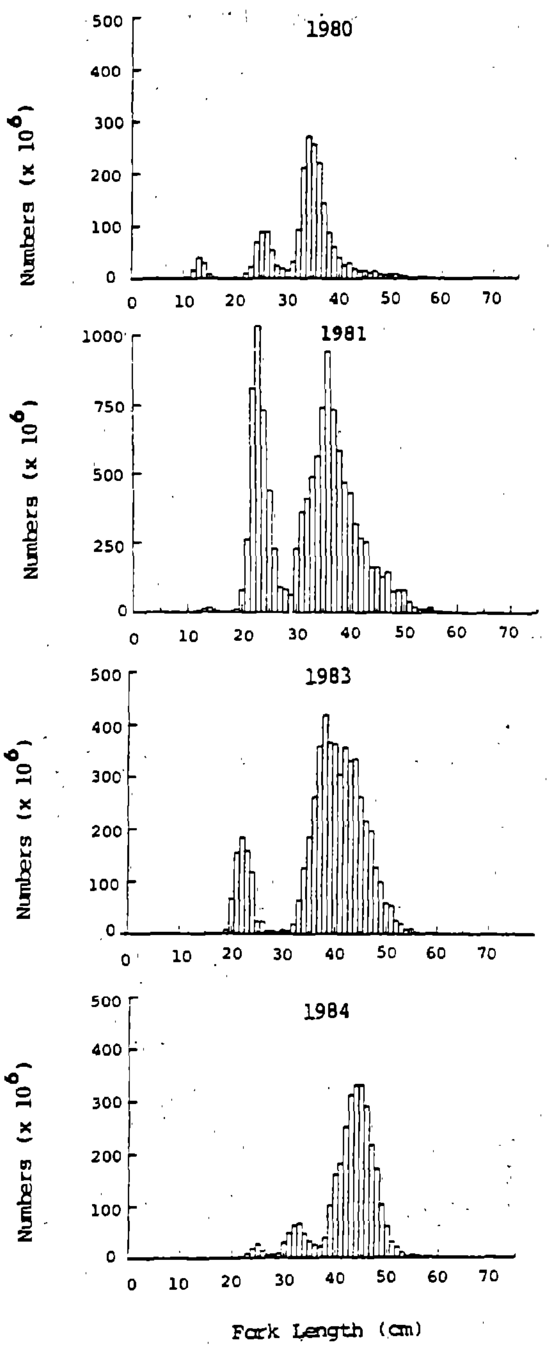


Figure 6. --Length distributions of Shelikof Strait pollock determined from 1980, 1981, 1983, and 1984 acoustic-midwater trawl surveys. The 1981, 1983, and 1984 length distributions are for stock size estimates determined by averaging estimates from selected surveys (see bottom portion of Table 2).

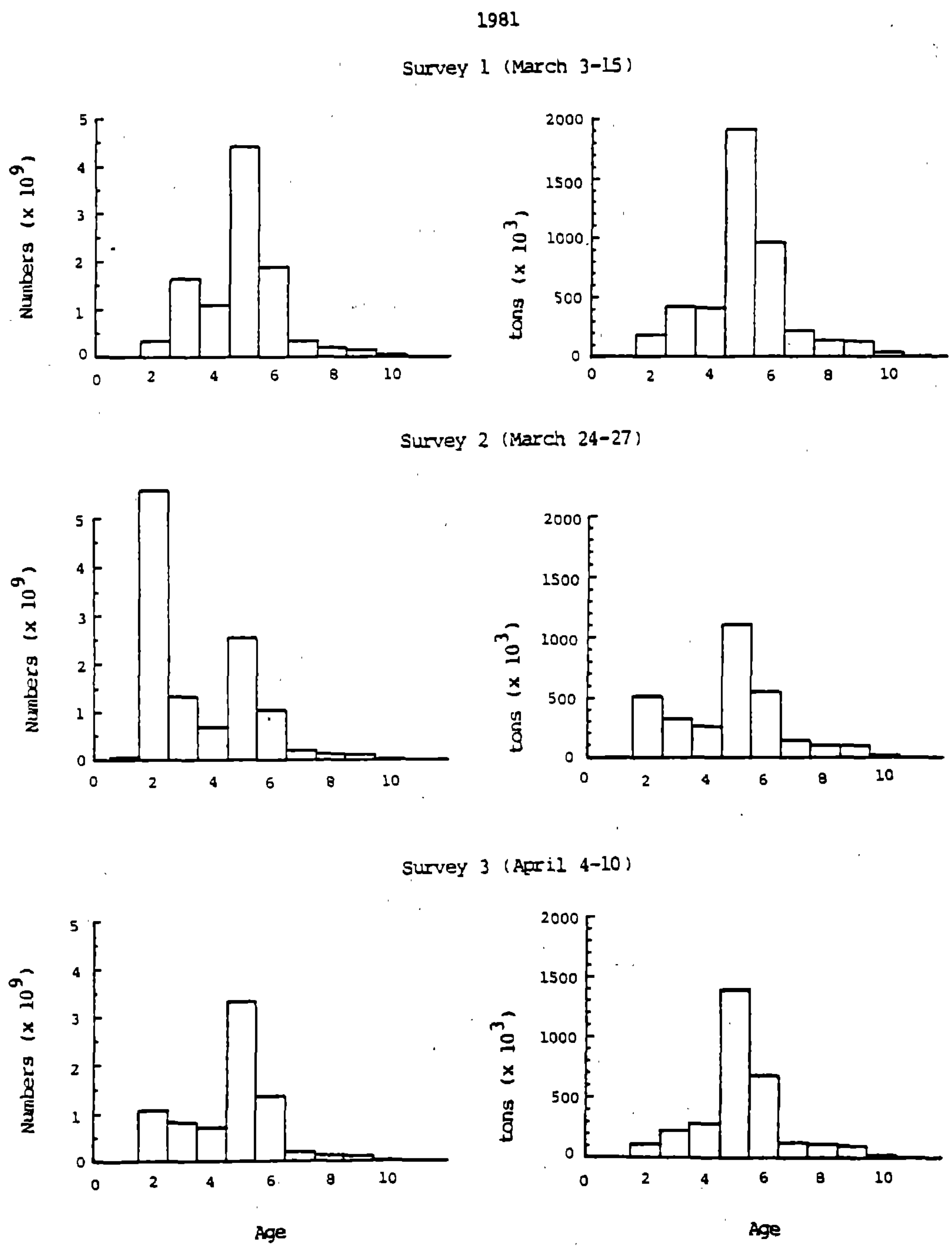


Figure 7.--Age distributions of Shelikof Strait pollock determined from each acoustic-midwater trawl survey in 1981.

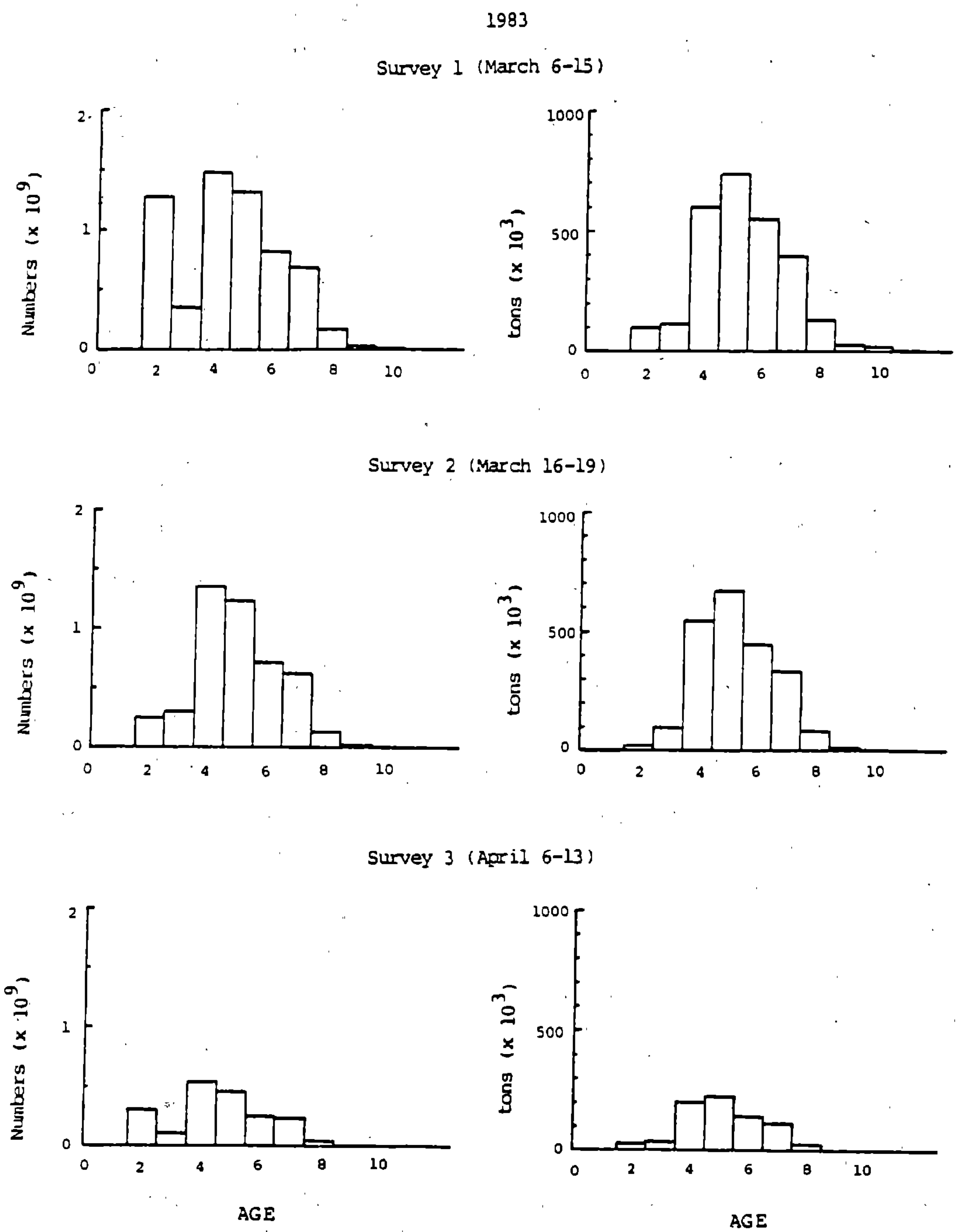


Figure 8.--Age distributions of Shelikof Strait pollock determined from each acoustic-midwater trawl survey in 1983.

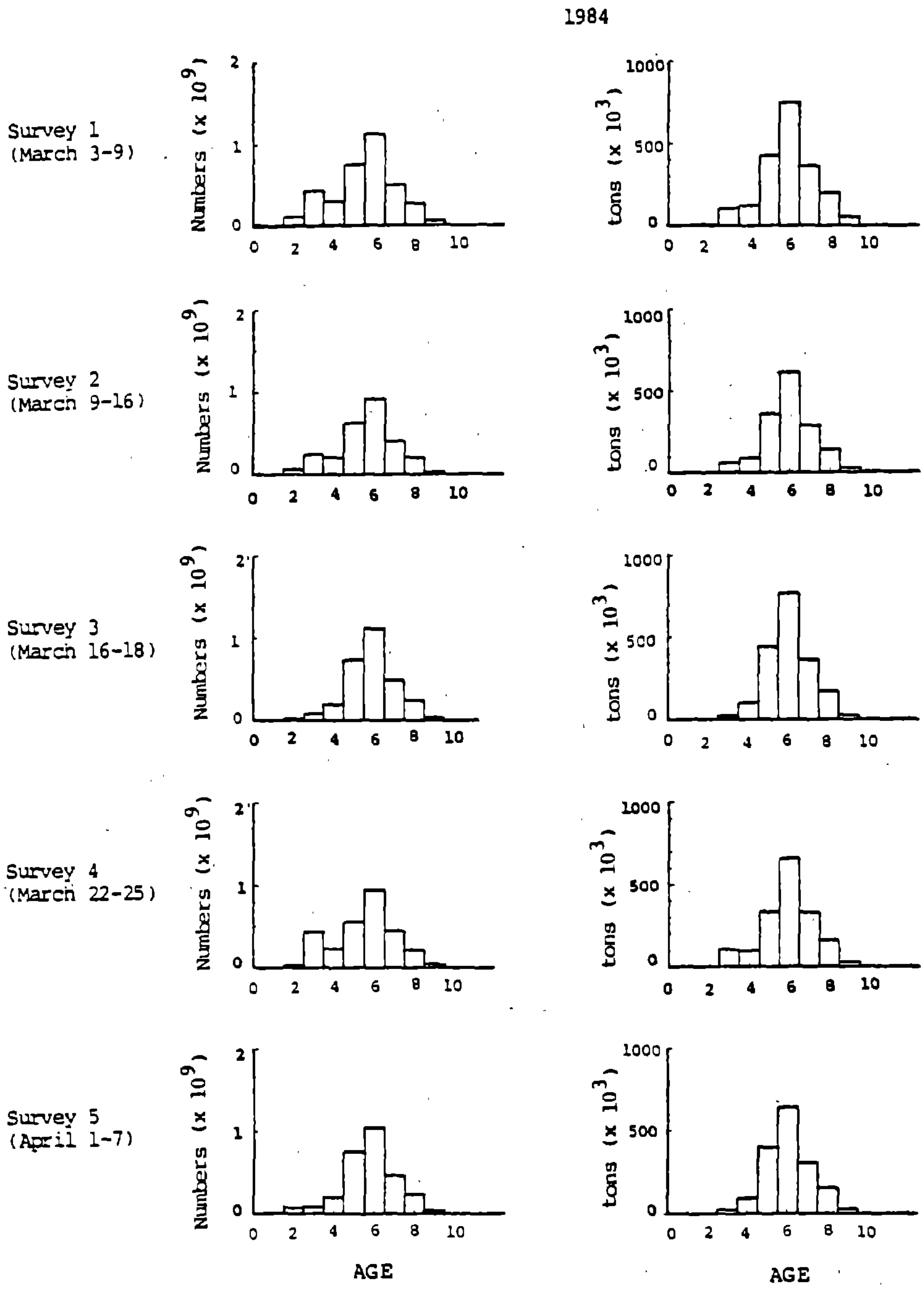


Figure 9.--Age distributions of Shelikof Strait pollock determined from each acoustic-midwater trawl survey in 1984.

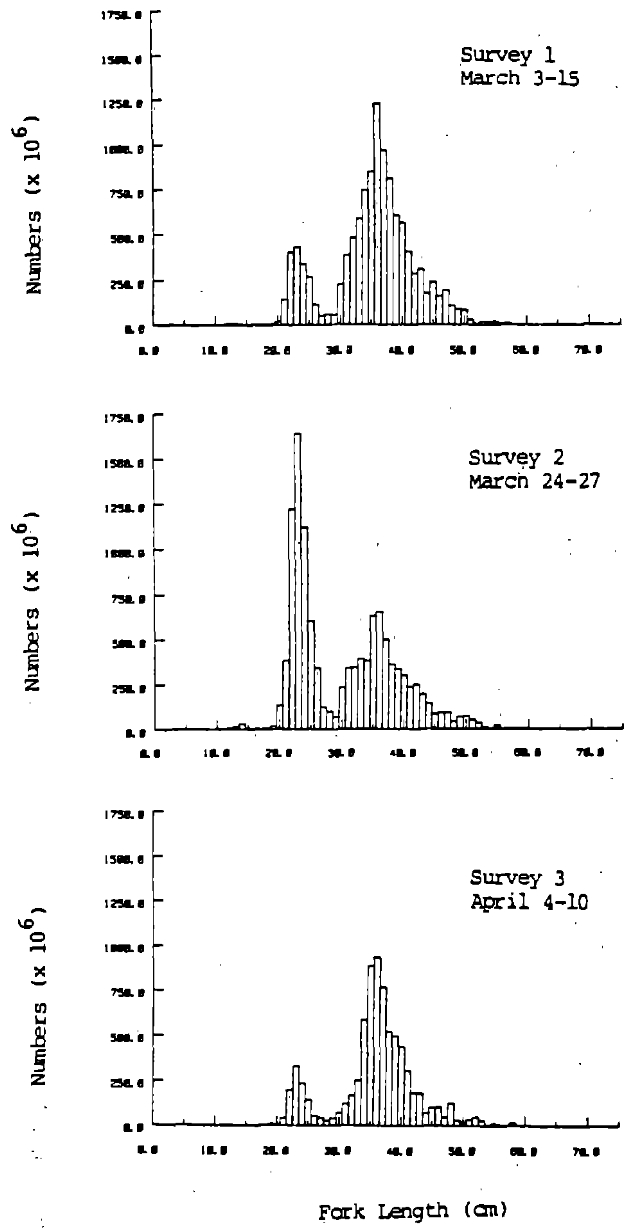


Figure 10.--Length distributions of Shelikof Strait pollock determined from each acoustic-midwater trawl survey in 1981.

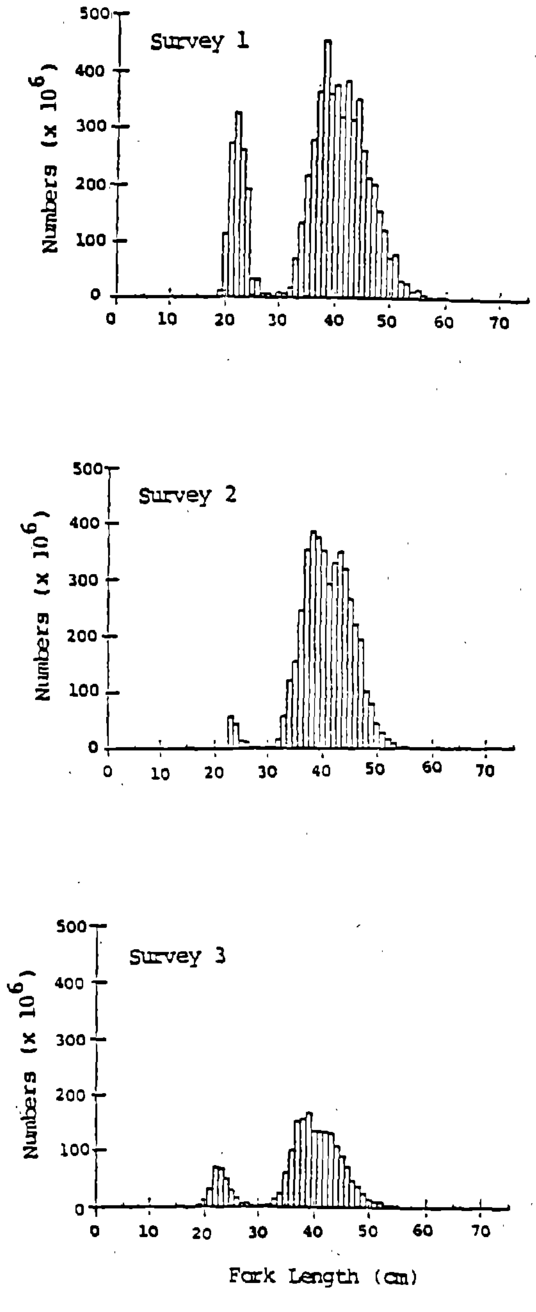


Figure 11 .--Length distributions of Shelikof Strait pollock determined from each acoustic-midwater trawl survey in 1983.

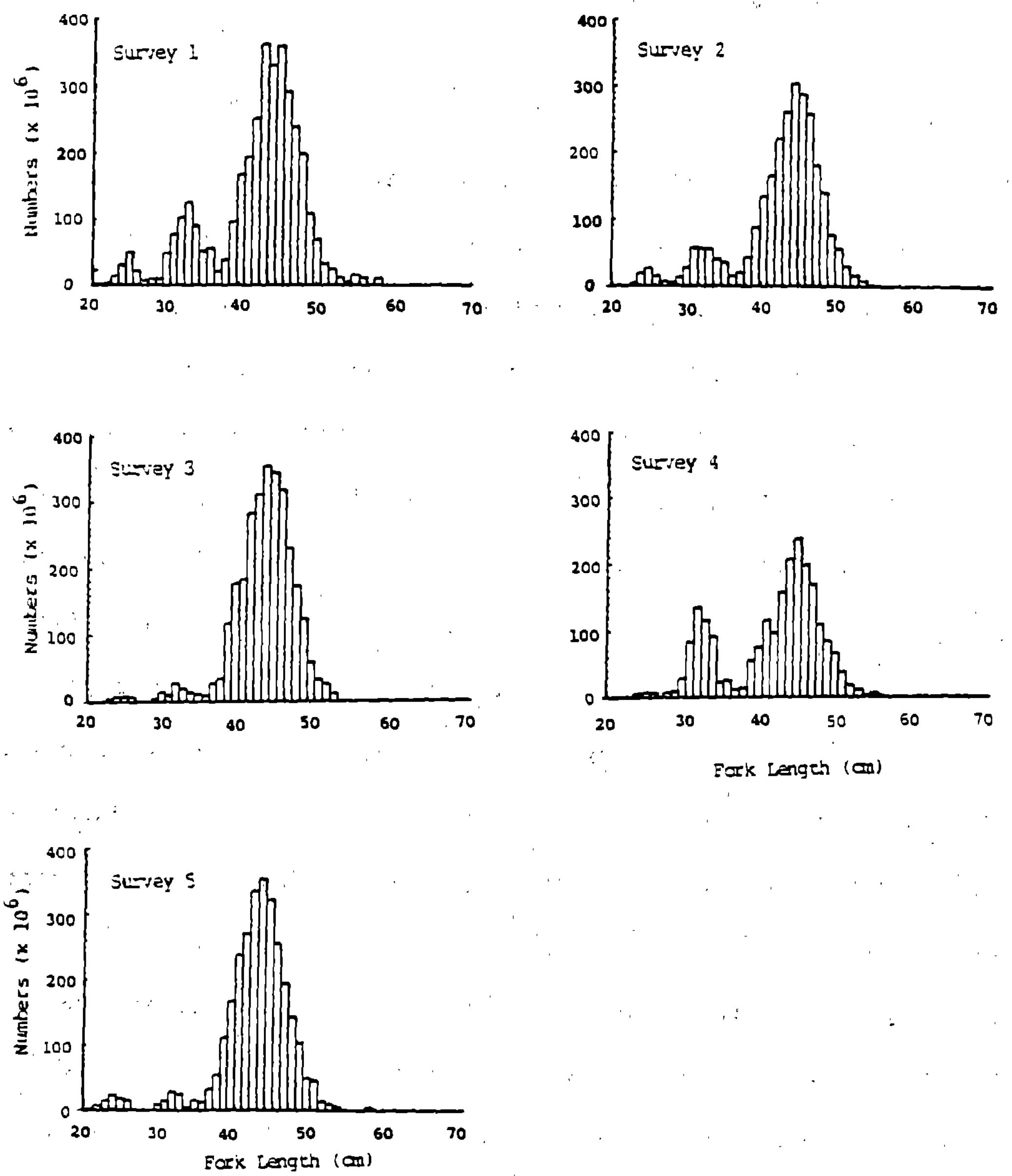


Figure 12.--Length distributions of Shelikof Strait pollock determined from each acoustic-midwater trawl survey in 1984.

by March surveys. However, the abundance of 3-year-old fish may be underestimated unless surveys are conducted earlier.

DISCUSSION

The 1980-84 acoustic-midwater trawl surveys have produced valuable information on the magnitude and behavior and biology of the Shelikof pollock resource. Although the time series of data is very limited, the results suggest that, when properly timed, the surveys can provide a reliable measure of temporal changes in the relative size of the total biomass of the adult spawning stock (fish > age 3). Also, for the adult stock, the actual biomass and the age specific population estimates determined from the surveys appear to correspond reasonably well with the results of fishery data analysis [Alton and Deriso 1983; Alton 1985 (in this report)]. However, a variety of information should be obtained in order to provide a much firmer basis for evaluating and improving the quality of the survey data. This is especially important because of problems with the fishery data base and the use of catch-at-age models [Alton and Rose 1985 (in this report)]. In particular, there is a need to 1) obtain behavior-specific estimates of the target strength of Shelikof pollock and 2) further examine the timing of the surveys and improve the survey trawl sampling/biological data base, primarily as they relate to the estimation of age composition and the availability of 3-year-old fish. As mentioned earlier, recent analysis suggests that survey estimates of the abundance of age-3 pollock may provide a valuable index to year-class strength [Alton and Rose 1985 (in this report)].

Knowledge of the target strength of pollock is critical to determining the accuracy of the acoustic survey estimates of absolute abundance. Target strength measurements have not yet been obtained for the Shelikof pollock stock. The target strength estimate (-31.3 dB/kg) which has been used to scale all of the echo integrator data from the Shelikof surveys is based on results obtained for nonspawning Bering Sea pollock at relatively shallow depths (50-85 m), and is an average value of day and night measurements for fish with a mean length of 47 cm (Traynor and Williamson 1983). Target strength measurements of Shelikof pollock should be obtained for different size groups, and-especially, for different environmental (day vs. night, depth) and physiological (prespawning, spawning, postspawning) conditions. It is currently planned to begin the collection of target strength data during the next survey (1985).

Further analysis of the biological data base for pollock available from the surveys is needed to better identify variation and sources of bias in age/length and other biological data and provide information needed to refine future sampling procedures. Length, sex ratio, and maturity appear to very substantially with time, depth, and area and suggest the need for a more comprehensive trawl sampling effort using a second research vessel and a midwater trawl capable of discrete depth sampling. However, until it is economically feasible to develop and implement such a sampling effort, it may be possible to improve results by developing a more efficient or optimal single vessel survey. This will involve a more rigorous analysis of the survey's acoustic and biological data sampling requirements and, subsequently, further evaluation of possible trade-offs between the acoustic (echo integrator) and trawl data collection efforts. Such an analysis and evaluation will include a more detailed investigation of the statistical precision of the present abundance estimates and of alternative survey designs and variance estimation procedures. Also, there is a real need to better integrate biological information from the U.S. Foreign Fishery Observer Program and more clearly define how this information can be used to supplement, or possibly substitute for, biological data obtained from the survey.

Significant expansion of the pollock acoustic surveys to other regions of the Gulf of Alaska is not planned for the near future. This is principally because of the need to continue monitoring the Shelikof stock, and to accelerate associated research efforts. Also, other sources of information, including an extensive set of ichthyoplankton surveys (Dunn et al. 1984), indicate that spawning in the central and western Gulf is heavily concentrated in the Shelikof region. During 25-31 March 1984, moderate size aggregations of spawning pollock were found in the Prince William Sound region and in a small area near Resurrection Bay, but no echo sign indicative of pollock was located in the Amatuli Trench-Middleton Island area. However, several reports by fishermen indicate that spawning pollock may occur in significant quantities in the latter area in April.

Additional surveys of the on-bottom component of the Shelikof spawning pollock stock are not planned. The biomass of this component was estimated at 184,000 metric tons,(t) from a 3-19 March 1983 bottom trawl survey (Brown 1983). The estimate was derived assuming a trawl efficiency of 100% (percentage of fish in path of trawl and below headrope that are captured). If it is assumed that the 1983 acoustic survey estimate (2.43 million t) of the off-bottom component is valid (and, as appears reasonable, that the acoustic and bottom trawl estimates are independent of each other), the near-bottom component represented approximately 7% of the total biomass.

REFERENCES

Alton, M. S. 1985. Walleye pollock fisheries of the Gulf of Alaska, 1983-84. In R. L. Major (editor), Condition of groundfish resources of the Gulf of Alaska region as assessed in 1984, p. 11. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWFC-80.

Alton, M. S., and R. B. Deriso. 1983. Condition of Gulf of Alaska pollock resource. In G. Stauffer (editor), Condition of groundfish resources of the Gulf of Alaska region as assessed in 1983, p. l-l to 1-19. NWAFC Processed Rep. 84-02. Northwest and Alaska Fish. Cent., Natl. Mar,. Fish: Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Alton, M. S., and C. S. Rose. 1985. Condition of the walleye pollock resources of the Gulf of Alaska as estimated in 1984, p. 1. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWFC-80.

Brown, E. 1983. Preliminary information on walleye pollock from results of the spring 1983 bottom trawl survey of Shelikof Strait. In G. Stauffer (editor), Condition of groundfish resources of the Gulf of Alaska region as assessed in 1983, p. 8-1 to 8-21. NWAFC Processed Rep. 84-02. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Dunn, J. R., A. W. Kendall, Jr., and R. D. Bates. 1984. Distribution and abundance patterns of eggs and larvae of walleye pollock (Theragra chalcogramma) in the western Gulf of Alaska. NWAFC Processed Rep. 84-10, 66 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, 2725 Montlake Blvd. E., Seattle, WA 98112.

Traynor, J. J. 1984. Dual beam measurement of fish target strength and results of an echo integration survey of the eastern Bering Sea walleye pollock (*Theragra chalcogramma*). Ph.D. Thesis, Univ. Washington, Seattle, 153 p.

Traynor, J. J. and N. J. Williamson. 1983. Target strength measurements of walleye pollock (*Theragra chalcogramma*) and a simulation study of the dual beam method. In O. Nakken and S. C. Venema (editors), Symposium on fisheries acoustics, Bergen, Norway; 21-24 June 1982, p. 112-124. Food Agric. Organ. U.N., Rome, FAO Fish Rep. 300.

Williamson, N. J. 1982. Cluster sampling estimation of the variance of abundance estimates derived from quantitative echo sounder surveys. Can J. Fish. Aquat. Sci. 39:229-231.

1984 U.S. RESEARCH SURVEYS AND RESEARCH PLANS FOR 1985 IN THE NORTHEASTERN PACIFIC OCEAN

by

Lael L. Ronholt

FIELD RESEARCH CONDUCTED IN 1984

Gulf of Alaska

Pacific Cod Survey

A survey to measure the abundance and magnitude of the spawning Pacific cod, *Gadus macrocephalus*, aggregation in the western Gulf of Alaska was conducted from Kodiak Island to the Shumagin Islands with the National Oceanic and Atmospheric Administration (NOAA) ship *Miller Freeman* during February.

Groundfish Study Areas

A bottom trawl survey was conducted to monitor changes in the distribution, abundance, and biological characteristics of the groundfish stocks in selected study areas of the Gulf of Alaska. A cooperative U.S.-U.S.S.R. survey was carried out with the Soviet vessel *Shantar* during May-July in the Fox Island, Shumagin, Kodiak, and Middleton study areas.

Triennial Survey

A cooperative U.S.-Japan comprehensive groundfish resource assessment survey of the Gulf of Alaska was undertaken during June-October. One small Japanese stern trawler, *Daikichi* Maru No. 38, two chartered U.S. stern trawlers, *Morning Star* and *Ocean Spray*, and the NOAA ship *Miller Freeman* participated in the survey. This work was closely coordinated with the cooperative U.S.-Japan longline survey for sablefish. *Anoplopoma Fimbria*, and Pacific cod which was conducted with the Japanese longliner *Ryusho* Maru No. 15.

Sablefish Index Sites

The four established sablefish indexing sites off southeastern Alaska were successfully sampled during June-August using the NOAA ship John N. Cobb. Additional data was obtained with which to examine the reliability of the abundance indices.

Sablefish Tagging

During the last half of October, a sablefish tagging program was conducted in the Dixon Entrance area of southeastern Alaska using the NOAA ship Miller Freeman. Conductivity, temperature, and depth observations were made along predetermined tracklines to measure oceanographic conditions.

Rockfish Studies

A maturity and time of larval release study of Pacific ocean perch, *Sebastes alutus*, was conducted in the Cape Ommaney area of southeastern Alaska aboard the NOAA ship Chapman during April-May. Plankton samples were taken during the cruise, and salinity, temperature, and depth observations recorded.

Sablefish Spawning

During November, an ichthyoplankton survey to determine the spawning period of sablefish has conducted in the Cape Ommaney area aboard the NOAA ship Murre II.

Ichthyoplankton

Ichthyoplankton surveys were conducted in March and April with the NOAA ship Chapman and the Soviet research vessel Shantar. Research focused on the early life history of walleye pollock, *Theragra chalcogramma*, in order to (a) estimate the size of the spawning stock in Shelikof Strait from egg surveys, (b) estimate egg mortality using field samples, and (c) investigate the amount of spawning in the Amatuli Trough and Chirikof Island areas.

Shelikof Strait Pollock

An acoustic-midwater trawl survey of the off-bottom component of the Shelikof Strait spawning pollock stock was conducted with the NOAA ship *Miller Freeman*, during March-April.

West Coast

Sablefish Index

The nine sablefish trap index sites from Cape Sebastian, Oregon to San Diego, California were successfully sampled during September-November using the charter vessel U.S. *Dominator*. In addition to measuring sablefish abundance and collecting biological data, tests were conducted to measure the relative efficiency of two different types of trap.

Upper Slope Groundfish

A survey was conducted during September-October using the charter vessel Half Moon Bay to (a) assess the feasibility of using the area-swept technique to assess deep-water groundfish species in areas with steep, rough substrata, (b) collect catch per unit effort and biological data, and (c) tag juvenile sablefish.

Ichthyoplankton

A U.S.--U.S.S.R. ichthyoplankton survey was conducted off the Washington, Oregon, and northern California coasts during March-April with the Soviet research vessel *Poseidon*.

FIELD RESEARCH PLANS FOR 1985

Gulf of Alaska

Groundfish Study Areas

Cooperative U.S.-U.S.S.R. and U.S.-Republic of Korea bottom trawl surveys to monitor changes in the distribution, abundance, and biological parameters of the groundfish stocks are anticipated in selected study areas.

Juvenile Surveys

A juvenile survey of the groundfish species in the central and western Gulf of Alaska is tentatively planned.

Sablefish Spawning

An ichthyoplankton survey to determine the spawning period for sablefish will be conducted in the Cape Ommaney area during January using the NOAA ship Murre II.

Sablefish Index Site

The annual survey of the four established sablefish index sites off southeastern Alaska is scheduled.

Groundfish Hydroacoustics

A tentative study is planned to test the feasibility of using acoustic signals to estimate the abundance of near-bottom groundfish species.

Shelikof Strait Pollock

An acoustic-midwater trawl survey of the Shelikof Strait spawning pollock stock is scheduled to determine age-specific estimates of stock size at maximum spawning and to collect in situ measurements of pollock target strength.

Fisheries-Oceanography

A multidiscipline, multiagency, fisheries-oceanography experiment (FOX) is planned to examine the environment in which pollock spawn and the young develop in Shelikof Strait. The Recruitment Processes Group will study the vertical distribution of eggs and larvae and the feeding and growth of larvae at various levels of density.

West Coast

Sablefish Index

A survey is scheduled to sample the sablefish indexing stations off Oregon and Washington.

Pacific Ocean Perch

A survey is scheduled to determine the distribution and abundance of Pacific ocean perch off Washington and Oregon.