INTERNATIONAL PACIFIC HALIBUT COMMISSION

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The Pacific Halibut Resource and Fishery in Regulatory Area 2

I. Management and Biology

by

Stephen H. Hoag, Richard J. Myhre, Gilbert St-Pierre,
and Donald A. McCaughran

II. Estimates of Biomass, Surplus Production, and Reproductive Value

by

Richard B. Deriso and Terrance J. Quinn II

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INTERNATIONAL PACIFIC HALIBUT COMMISSION
P.O. BOX 95009, UNIVERSITY STATION
SEATTLE, WASHINGTON 98105, U.S.A.

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FOREWORD

The Halibut Convention between Canada and the United States provides authority for the International Pacific Halibut Commission to manage the halibut fishery. The 1979 amendment to this Convention called for a two-year phase-out of reciprocal fishing privileges between the two countries, and required that 60% of the catch in Regulatory Area 2 be taken in Canadian waters and 40% in U.S. waters. The Commission staff was asked by the governments to review the biology and management of halibut in Area 2 and to specifically examine the scientific basis for the 60%/40% division of the catch. This report is in response to their request.

I. Management and Biology

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Stephen H. Hoag, Richard J. Myhre, Gilbert St-Pierre,
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ABSTRACT

This report reviews the biology and management of the Pacific halibut resource and fishery in Regulatory Area 2 and examines the scientific basis of the required 60%/40% division of catch between Canadian and U.S. waters. Information on the distribution, reproduction, and migration of halibut among regulatory subareas is provided along with data on the size, age, and sex composition of the catch. Estimates of bottom area, catch, biomass, and surplus production were used to determine the productivity of each subarea. The results indicate that a 60%/40% catch division is reasonably justified as a long-term management objective. However, productivity among subareas varies annually, and a more flexible method of dividing catches among subareas could result in more uniform exploitation rates and might increase total production from Area 2.

I. Management and Biology

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INTRODUCTION

The authority for managing Pacific halibut *(Hippoglossus stenolepis)* and the formation of the International Pacific Halibut Commission (IPHC) is incorporated in the Halibut Convention, a treaty between Canada and the United States, and in the Enabling Acts passed by the two countries to carry out the terms of the Convention. The first Convention was signed in 1923 and has been revised several times to give IPHC broader authority and flexibility to institute needed conservation measures (Bell 1969, Skud 1977b). The 1930 Convention provided authority for dividing convention waters into regulatory areas and four such areas were defined in 1932. Since then, several changes have occurred in the number of areas and subdivisions used by IPHC to manage the fishery. Presently, six regulatory areas or subareas are in effect (Figure 1). Subareas 2A, 2B, and 2C comprise Area 2 and subareas 3A and 3B comprise Area 3. The original Area 1 is encompassed within Area 2A, and Area 4 is managed as a single unit.

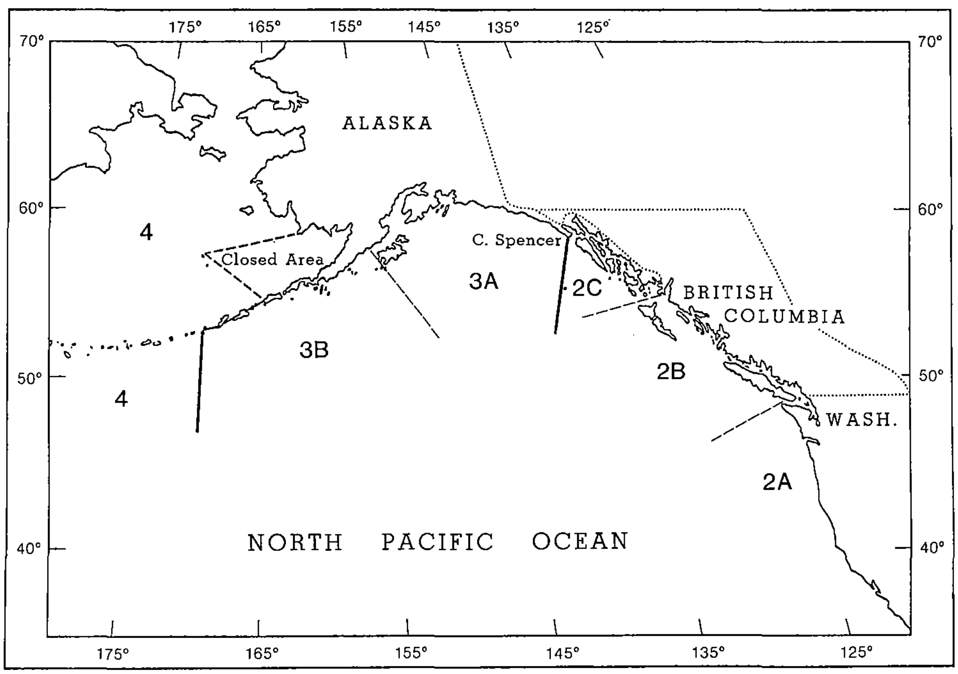

Figure 1. IPHC regulatory subareas in 1981.

The United States Fisheries Conservation and Management Act of 1976 required renegotiation of all international fisheries treaties. As a result, Canada and the United States amended the 1953 Halibut Convention on March 29, 1979. The amendment, termed a protocol, called for a phase-out of reciprocal fishing privileges between the two countries, and required that 60% of the catch in Area 2 be taken in Canadian waters (subarea 2B), and 40% in U.S. waters (subareas 2A and 2C). Accordingly, IPHC has managed the Area 2 halibut fishery since 1979 by apportioning the Area 2 catch limit between Canadian and U.S. waters.

The required 60%/40% division of the Area 2 catch created a number of management problems (IPHC 1979). Foremost is the migratory behavior of halibut (Skud 1977a). Eggs and larvae from halibut spawning in British Columbia drift north and west into Alaskan waters, possibly as far as the eastern Bering Sea. Countering this drift, juvenile halibut migrate east and south, some moving from Alaskan waters into British Columbia, Washington, and Oregon. Halibut also cross national boundaries seasonally for feeding and spawning. Because of these "transboundary" movements fishing in one national zone affects the yield from the other zone. A further complication arises because the annual rates of migration may not be consistent and possibly vary with environmental conditions. Also, incidental catches of halibut in fisheries for other species present a potential interception problem because the incidental mortality in one nation's waters is inflicted on highly mobile juvenile halibut that may be destined to cross international boundaries and contribute to the other nation's fishery (Hoag 1976).

At the February 1981 Annual Meeting of IPHC, the IPHC staff was asked to review the biology and management of halibut in Area 2 and to specifically examine the scientific basis for the 60%/40% split. The request was initiated by several fishermen's organizations which questioned the appropriateness of the catch division because of a disparity in the catch-per-unit-effort (CPUE) among subareas. CPUE has been substantially higher in southeast Alaska (subarea 2C) than in British Columbia (subarea 2B) since 1979. The Area 2 study was completed and an unpublished report was submitted to the two governments in December 1981.

This paper presents the results of the study regarding the management and biology of halibut in Area 2. An evaluation of the basis for the 60%/40% catch division is included. Estimates of abundance and surplus production which were used in evaluating the catch division are provided in the accompanying report (Deriso and Quinn, Section II of this report).

THE RESOURCE

Distribution

Halibut occur throughout Area 2, as far south as Santa Barbara, California. They are demersal and found from the shore to depths of about 150 fathoms (274 m), although some have been found as deep as 600 fathoms (1097 m) during the winter when spawning occurs (IPHC 1978). Halibut move from deep water along the edge of the continental shelf to shallower banks and coastal waters during the summer and most return to deeper water in the winter. Areas that halibut inhabit, as well as documented fishing grounds, are depicted in Appendix Figures 1a-1c. These figures are based on a compilation of information collected by IPHC from commercial and sport fishermen and from research cruises since 1930. Some of the fishing grounds shown in the figures have become less productive in recent years, and halibut are now relatively scarce at some locations, particularly those off Washington, Oregon, and California.

The bottom area from the shore to 150 fathoms (274 m) approximates the total habitat occupied by halibut and may indicate the relative productivity in each subarea if other factors such as fish density are similar among subareas. However, fish density is not uniform among subareas and tends to be less in subarea 2A than in either 2B or 2C. The bottom area of the fishing grounds may be a better indicator of potential productivity than total habitat because fish density is probably more uniform among the various grounds. Using a compensating polar planimeter, the bottom area (in square nautical miles) of the habitat and the fishing grounds was estimated for each subarea as follows:

Subarea	Habitat	Fishing Grounds
2A	11,656 mi sq (20.1%)	921 mi sq (3.7%)
2B	31,599 mi sq (54.6%)	14,338 mi sq (57.5%)
2C	14,617 mi sq (25.3%)	9,661 mi sq (38.8%)
Total	57,872 mi sq (100.0%)	24,920 mi sq (100.0%)

Note that 3.7% of the total fishing grounds are in subarea 2A compared to 20.1% of the total habitat. This suggests that subarea 2A is considerably less productive for halibut than subareas 2B or 2C.

Reproduction and Development

Halibut in Area 2 may reach 40 years of age and over 200 cm in length. Females tend to grow faster and live longer than males, which seldom are more than 20 years old or 150 cm long. Southward (1967) showed that the growth rate of halibut increased from the 1930's to the 1960's, perhaps in response to reduced halibut numbers, although environmental factors may also have played a role.

Maturity varies with sex, age, and size of fish (Schmitt and Skud 1978). Most males are mature when they are 8 years old or 80 cm long. About 50% of the females are mature when they are 12 years old or about 120 cm. The number of eggs produced by a female halibut is related to its size. For example, a 125 cm female produces about 500,000 eggs, whereas a female over 200 cm may produce 4 million eggs. However, younger age classes produce more total eggs than older age classes. For example, 12-year-olds generally produce about 25 percent of the total egg production, 13-year-olds about 20 percent, and 14-year-olds about 16 percent. This trend reflects the decline in numbers of females with age, which offsets the increased production of eggs with size.

Known spawning grounds in Area 2 are in deep waters (over 200 meters) along the edge of the continental shelf (St-Pierre, unpublished[1]). Early fishing records indicate that some spawning may occur in shoal waters, but at the present time there is no firm evidence of this. Spawning has been reported off Destruction Island, off the Washington coast, and off Sidney Inlet, Vancouver Island. Major spawning locations

[1] St-Pierre, Gilbert. Ms. Observations and data on Pacific halibut with reference to time and locations of spawning. International Pacific Halibut Commission, Seattle, Washington.

in British Columbia waters are the Whaleback and Frederick Island grounds, which lie west of the north end of Graham Island, and the Cape St. James grounds, which lie off the southern tip of Moresby Island (IPHC 1978). To the north, spawning takes place all along the edge of the continental shelf off the coast of southeastern Alaska. The best known spawning grounds off southeastern Alaska are those between Cape Bartolome and Cape Ommaney and the region south of Cape Cross. Other locations include Forrester Island, Whale Bay, and Biorka Island.

The peak spawning period is from December to March, with the maximum spawning intensity occurring in mid-January (St-Pierre, unpublished[1]). The actual peak of spawning may fluctuate from year to year, depending upon environmental conditions. Hatching time varies with water temperature. Forrester and Alderdice (1973) reported that development from fertilization to hatching required about 20 days at 5 degrees C. Eggs and larvae are heavier than the surface sea water and drift passively in deep ocean currents (IPHC 1978). As the larvae grow, their specific gravity decreases and they gradually move toward the surface and drift to shallower waters on the continental shelf (Thompson and Van Cleve 1936). Halibut eggs and larvae are transported many hundreds of miles by the ocean currents before they settle near shore. Most eggs spawned in Area 2 probably drift into Area 3 before they settle to the bottom as young halibut.

Migration

Tagging experiments have been an important source of information on halibut migrations since the Commission was formed (Thompson and Herrington 1930). Although the early tagging work was directed toward adult halibut, the importance of the movements of juveniles and the drift of eggs and larvae was recognized (Thompson and Van Cleve 1936). However, the early work seemed to indicate a clear separation of the halibut stocks in Areas 2 and 3. Recent investigations suggest a close relationship among stocks in Regulatory Areas 2 and 3. Skud (1977a) reexamined data on the distribution of eggs and early stages of larvae and reaffirmed the conclusion that there is little or no drift of these stages from Area 3 to Area 2, but presented evidence that eggs and larvae from British Columbia drift northward and could be carried as far as the eastern Bering Sea.

Tagging of juvenile halibut taken in bottom trawls showed extensive movements from Area 3 to Area 2, and 30% of all recoveries from juveniles released in the western Gulf of Alaska were taken in British Columbia (Skud 1977a). The abundance of fish from 2 to 4 years of age was highest in the northern and western areas of the Gulf of Alaska. In southeastern Alaska and British Columbia, the modal age of juveniles was generally higher than it was in Area 3 (5-6 years versus 3-4 years), indicating extensive movement of juvenile halibut from Area 3 to Area 2.

The major conclusions from Skud's study are (1) that the stocks from Area 2 and Area 3 intermingle at all stages of their life history, (2) that juvenile halibut account for most of the compensatory movement to counterbalance the drift of eggs and larvae, and (3) tagging data show that the extent of movement depends on the season of release and recovery as well as the size of fish. The movement of adult halibut tagged in the summer and recovered in the winter or, vice versa, generally is more extensive than that from summer to summer, and the predominant direction of movement changed seasonally. These adult movements were thought to be related to spawning and feeding activities.

[1] St-Pierre, Gilbert. Ms. Observations and data on Pacific halibut with reference to time and locations of spawning. International Pacific Halibut Commission, Seattle, Washington.

More recent studies also indicate that most halibut in Area 2 were located in Area 3 or Area 4 at an earlier time in their lives. Estimates of annual halibut migration have recently been updated (Deriso, unpublished) and are based on analysis of tagging experiments conducted during 1950 through 1979 (Table 1). The results show that about 3-4% of the halibut over 65 cm annually move from Area 3 to Area 2. Within Area 2, about 3% annually move from subarea 2C to subarea 2B; less than 1% move from 2B to 2A. Reverse migrations from 2B to 2C and from Area 2 to Area 3 were relatively minor (less than 0.8% annually).

The rate of migration is highest for small halibut and generally decreases with increasing size (Figure 2). For example, over 10% of the fish averaging 40 cm migrated from subarea 3A to Area 2 annually, compared to less than 5% of fish averaging 148 cm.

Preliminary results from recent tagging studies on spawning grounds off southeastern Alaska (subarea 2C) indicate substantial migrations within Area 2 (IPHC 1981). In January and February 1979, 1,002 halibut were tagged off Cape Bartolome and Cape Addington. Summer recoveries of these fish indicated a movement from winter spawning grounds to summer feeding grounds. There were 51 recoveries with location information from these releases during the 1979 and 1980 seasons (Figure 3). Of these, 40 were taken in subarea 2B. Some were taken on the outer coast, but most had moved to shallower, inside grounds. The recoveries were widely distributed over the British Columbia coast from Dixon Entrance to as far south as Cape Cook, off the northwest coast of Vancouver Island. At least 30% of the releases must have moved to the British Columbia coast to have produced the number of tagged fish reported.

A second study involved tagging 1,511 halibut in outside waters of southeastern Alaska between Cape Ommaney and Cape Spencer in January and February 1980, futher north than the study in the previous year. Of 27 recoveries, four (15%) were taken in subarea 2B waters. This indicates that the halibut spawning off the northern portion of southeastern Alaska are less likely to summer in British Columbia waters than those spawning off the southern portion of southeastern Alaska.

STOCK COMPOSITION

Juveniles

Skud (1977a) examined results from IPHC surveys of juvenile halibut with trawls and compared the age composition of juveniles for various survey locations. The catch of juveniles in Area 2 was small compared to catches in Area 3 (IPHC 1958) and most of

Table 1. Estimated percentage of halibut over 65 cm that move from one area to another each year (Deriso, unpublished). Values updated from those in IPHC (1981).

	Destination Subarea				
Subarea of Origin	2A	2B	2C	3A	3B
2A*	100.0	0.0	0.0	0.0	0.0
2B	0.1	98.8	0.8	0.3	0.0
2C	0.0	2.8	96.8	0.5	0.0
3A	0.1	1.3	1.5	95.3	1.8
3B	0.0	1.4	3.3	11.4	83.8

*Assumed values because of insufficient data.

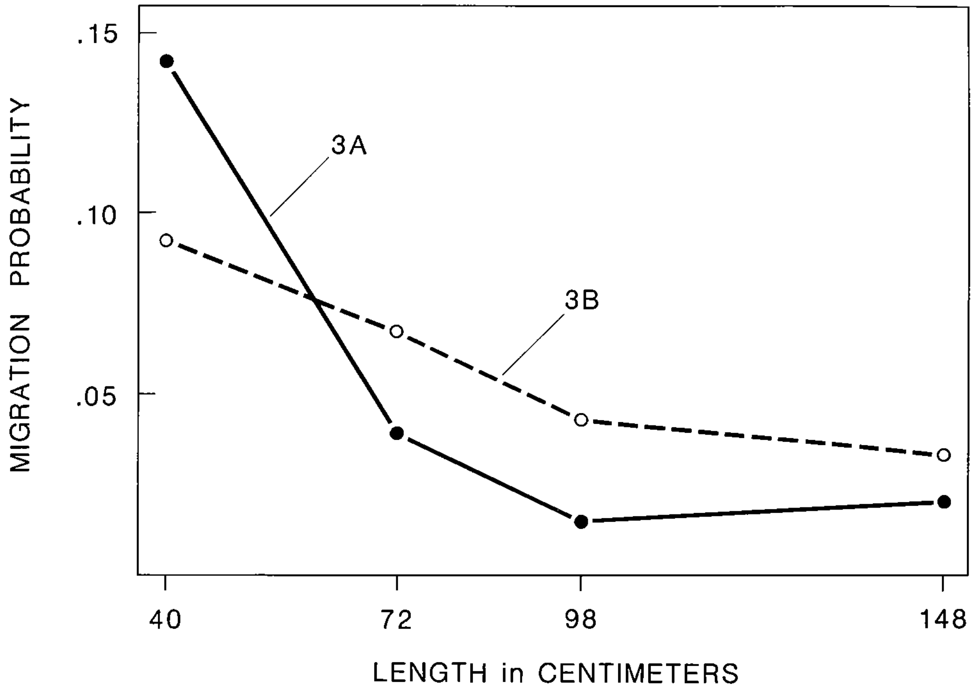

Figure 2. Relationship between size and annual migration of halibut from Area 3 to Area 2. Lengths indicated are mid-points of release size groups: less than 65 cm, 65-79 cm, 80-119 cm, and 120+ cm; results from IPHC (1981) were updated by Deriso (unpublished).

the Area 2 locations are no longer surveyed. Table 2 provides an example of the CPUE and age composition of the catch at each survey location. The results are presented separately for inshore and offshore stations. Samples from inshore stations were taken with a trawl of 1-1/4 inch (3.18 cm) mesh during 15-minute tows while a 3-1/2 inch (8.89 cm) net was used on offshore stations and tows were 1 hour long. The offshore data from Hecate Strait are not entirely comparable because the results are from commercial trawlers, although the mesh sizes were similar to those used by the research trawler.

The inshore data indicate that relatively few juvenile halibut less than 3 years of age inhabit Area 2. Except for Shelikof Bay, the modal age for juveniles in Area 2 was 4 or 5 years, compared to 1 year in Area 3. The results from the offshore stations show similar trends, although the peak abundance occurs at a later age than at inshore stations, suggesting that juvenile halibut tend to move offshore with age. The larger mesh size used at the offshore stations only partly accounts for the older ages.

IPHC has annually surveyed Shelikof Bay (subarea 2C) since 1957 to monitor trends in the relative abundance of juvenile halibut in Area 2. Table 3 shows the CPUE (number per 15-minute haul) by age with the 1-1/4 inch mesh net. Prior to 1968, the area was surveyed at least twice a year, and the results vary considerably within each year. Fish of the year (0-year-olds) become more available later in the summer and only a few were caught during the early summer. Modal ages ranged from 0 to 4 years. Although highly variable, CPUE in Shelikof Bay has generally declined since the late 1960's, suggesting reduced abundance: CPUE averaged 33.8 fish per haul before 1969

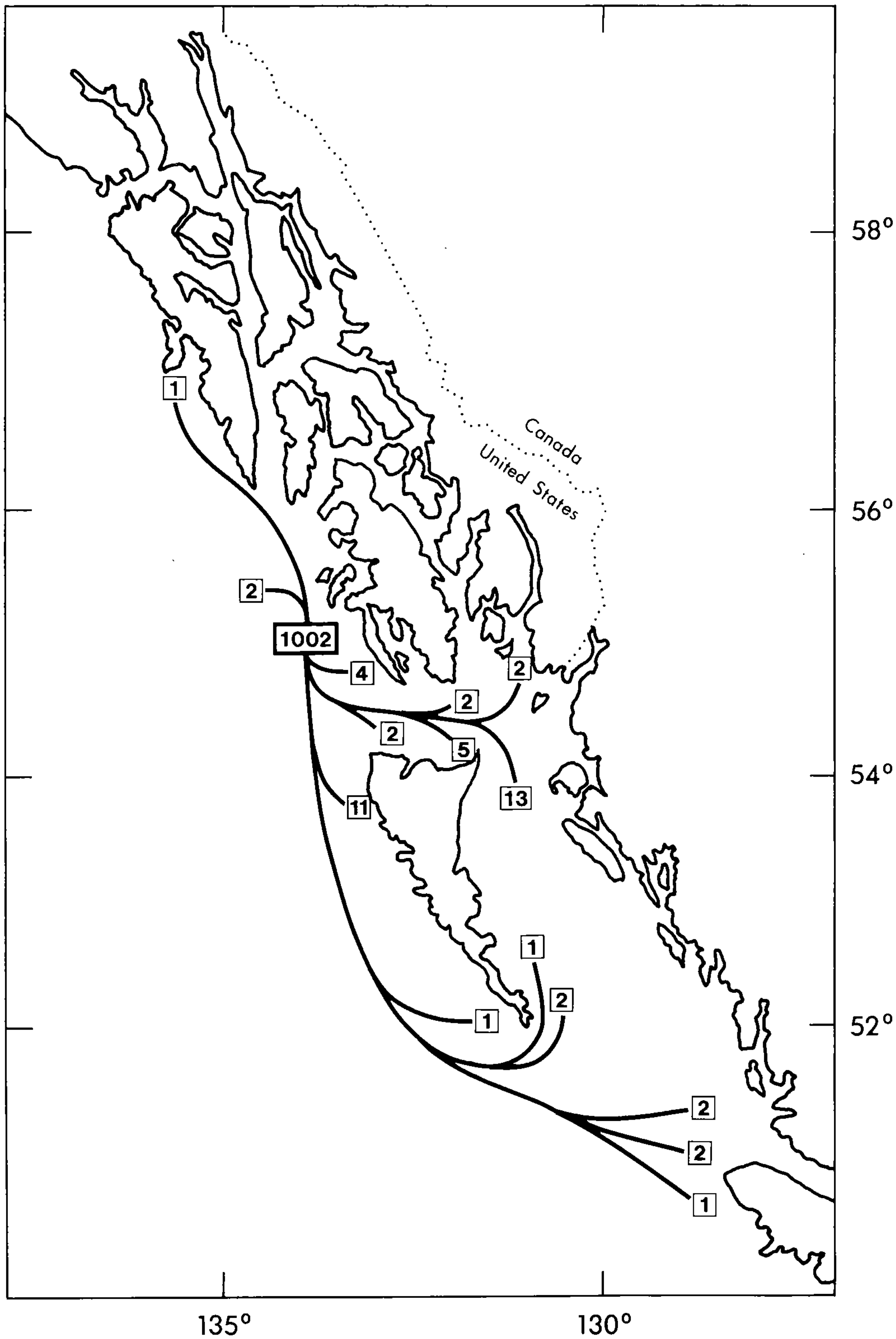

Figure 3. Distribution of 51 summer recoveries in 1979 and 1980 from 1,002 releases off Cape Bartolome and Cape Addington in January-February 1979.

Table 2. Number of halibut less than 65 cm long per trawl haul by age and locality in 1965; modal ages underlined (from Skud 1977a).

Area	Age 0	1	2	3	4	5	6+	Total	Mean Age
				Inshore Stations (10-40 meters)					
Subarea 3A									
Kodiak Island	—	49.21	22.79	5.21	1.79	0.43	0.00	79.43	1.5
Cape St. Elias	—	32.17	25.75	11.67	9.75	1.17	1.67	82.17	2.1
Subarea 2C									
Icy Strait	—	—	0.91	1.45	7.55	3.00	0.45	13.36	4.0
Shelikof Bay	0.04	14.50	3.17	2.50	7.25	2.13	0.58	30.17	2.4
Subarea 2B									
Dixon Entrance	—	3.14	1.43	1.86	7.14	8.00	7.14	28.71	4.3
				Offshore Stations (30-200 meters)					
Subarea 3B									
Chirikof Island	—	0.95	6.59	27.18	14.00	6.27	3.85	58.86	3.5
Trinity Islands	—	—	5.50	13.50	18.00	2.50	1.00	40.50	3.5
Subarea 3A									
Kodiak Island	—	—	1.07	9.21	24.04	10.93	2.50	47.75	4.1
Cape St. Elias	—	—	—	0.25	2.50	2.50	1.25	6.50	4.7
Subarea 2B									
Hecate Strait	—	—	—	—	0.42	1.53	2.05	4.00	5.4

compared to 9.7 since then. Tagging experiments indicate that most of the young fish in Shelikof Bay move south into subarea 2B (IPHC 1973). Hence, the reduced CPUE may indicate reduced recruitment of young halibut into subarea 2B.

Juvenile halibut in Area 2 tend to be larger for a given age than those in other areas. For example, Table 4 provides a comparison of the length of female halibut in Shelikof Bay with those at Kayak Island, Alitak Bay, and Unimak Island for the combined years of 1966, 1967, and 1968. All sampling occurred between mid-July and September. Halibut at age 1 year at Shelikof Bay averaged about 20% longer than at Kayak Island and were twice as large as those further west at Alitak Bay and Unimak Island. The differences in size are greater at younger ages and decrease as the fish become older, perhaps as a result of the migration of fish from Areas 3A and 3B to Area 2. Larger, faster growing fish may tend to migrate at a younger age than smaller, slower growing fish. The slightly earlier sampling time at the locations in subareas 3A and 3B may have contributed to the smaller size of fish in these areas, but does not explain all of the observed difference. Although juvenile halibut less than 3 years of age are not commonly found in subarea 2B, limited information suggests that juveniles in subarea 2B are even larger than those in subarea 2C. For example, 1-year-old female halibut (53 fish) were captured in upper Hecate Strait (Tow Hill and Archibald Island) during late August-early September 1955 and their average length was 28.1 cm.

Table 3. CPUE (number per 15-minute haul) of halibut at Shelikof Bay (subarea 2C), 1957-1981; modal ages underlined.

		Age (Years)									
Year	Month	0	1	2	3	4	5	6	7	8	Total
1957	July	1.0	2.6	0.9	3.9	2.6	1.1	0.3	—	—	12.4
	September	2.9	2.0	2.1	8.6	5.3	2.8	1.3	—	—	25.0
1958	August	3.7	11.2	1.0	0.3	0.1	—	—	—	—	16.2
	September	43.5	4.8	0.2	0.0	0.2	—	—	—	—	48.7
1959	July	10.9	24.0	1.4	1.6	1.4	1.6	0.6	—	—	41.5
	September	24.4	28.1	1.4	0.7	0.8	1.0	0.1	—	—	56.6
1960	July	0.1	24.3	5.5	2.9	1.1	0.5	0.2	—	—	34.6
	August	10.9	12.9	5.0	4.1	1.8	1.2	0.4	—	—	36.3
	September	17.0	16.2	0.4	1.2	0.4	1.2	0.2	—	—	36.6
1961	July	2.0	4.0	0.2	0.1	—	—	—	—	—	6.3
	August	134.2	4.7	0.0	0.1	0.2	—	—	—	—	139.2
1962	August	0.0	9.7	0.9	1.5	0.9	1.5	0.1	—	—	14.6
	September	3.2	31.6	0.1	0.1	—	—	—	—	—	35.0
1963	July	0.0	1.6	15.6	2.2	0.0	0.1	0.1	—	—	19.6
	September	6.1	7.7	2.8	0.9	0.3	—	—	—	—	17.8
1964	July	0.0	10.7	1.2	12.5	10.9	2.2	0.9	0.1	—	38.5
	September	9.3	14.1	0.5	5.3	3.0	0.5	0.3	—	—	33.0
1965	July	0.0	5.8	2.3	2.5	7.1	2.0	0.4	0.2	0.1	20.4
	August	0.1	24.1	3.3	1.4	4.4	1.5	—	—	0.2	35.0
1966	July	0.0	1.2	5.6	1.0	2.3	3.7	0.4	—	—	14.2
	September	1.2	5.0	2.9	1.8	1.3	1.3	—	—	—	13.5
1967	June	0.0	5.3	0.4	3.2	5.8	3.1	2.1	0.4	0.2	20.5
	August	14.5	5.3	3.8	3.4	8.8	5.5	2.4	0.1	—	43.8
1968	June	0.0	7.8	5.0	5.7	25.6	15.1	2.0	2.9	0.2	64.3
	August	1.9	2.3	6.1	1.1	3.9	3.5	1.0	0.7	—	20.5
1969	September	1.2	3.0	1.1	0.5	0.5	1.0	0.1	—	—	7.4
1970	September	0.8	1.7	0.6	0.8	1.1	0.2	0.1	0.1	—	5.4
1971	August	8.0	0.3	0.3	3.4	3.1	1.7	0.2	—	—	17.0
1972	September	0.3	1.9	0.4	0.3	1.8	0.8	0.2	—	—	5.7
1973	August	0.0	1.1	0.3	0.8	0.7	1.6	0.9	0.1	—	5.5
1974	August	0.0	8.6	0.8	0.2	0.6	0.7	—	—	—	10.9
1975	August	0.0	0.9	0.8	0.2	1.0	2.4	0.5	0.4	—	6.3
1976	August	0.0	2.6	1.2	1.3	1.4	0.4	0.8	0.5	—	8.2
1977	August	15.4	0.6	0.0	0.4	0.0	0.2	0.8	—	—	17.4
1978	August	3.6	25.7	—	—	—	—	—	—	—	29.3
1979	August	0.0	1.1	2.5	0.3	0.1	0.1	0.1	—	—	4.2
1980	August	0.0	0.1	0.4	0.8	0.3	0.1	—	—	—	1.7
1981	August	2.4	0.8	0.6	0.2	1.0	0.0	0.4	0.2	—	5.6

Table 4. Mean length (cm) of female halibut by age and sampling location, 1966-1968.

Location	Months	Age of female halibut (years) 1	2	3	4
Subarea 2C:					
Shelikof Bay	Late August/September				
Mean length		22.4	31.4	41.4	45.1
No. sampled		47	39	20	27
Subarea 3A:					
Kayak Island	August				
Mean length		17.7	28.2	34.0	47.8
No. sampled		49	67	104	31
Subarea 3B:					
Alitak Bay	Mid-July/early August				
Mean length		12.7	23.0	32.7	45.2
No. sampled		30	85	53	38
Unimak Island	Mid-July				
Mean length		11.6	22.8	32.4	44.2
No. sampled		10	23	50	10

Adults

Information on the age and size composition of adult halibut is available from the sampling of commercial landings (IPHC, unpublished data). Average age and weight have generally increased since the 1930's in most regions of Area 2, although there is considerable variability among regions and time periods (Table 5). In the 1930's, the average age was between 8.0 and 9.9 years, and the average weight was between 8.9 and 14.9 pounds. By the 1960's, average age increased slightly to between 8.6 and 11.5 years, and average weight ranged from 19.3 to 29.3 pounds. These changes probably are a result of several factors. The abundance of young halibut appears to have declined since the 1930's (Hoag and McNaughton 1978), and the fishery may have become more selective for large and old fish (Myhre 1969; Hamley and Skud 1978). An additional increase in average age and size occurred in 1973 due to raising the minimum size limit from 65 cm in length (about 5 pounds) to 81 cm (about 10 pounds).

Halibut caught on the outside grounds of the Charlotte and Southeast regions are larger and older than those in the inside grounds. The reason for this difference is not known, although the greater intensity of the commercial fishery on the inside grounds may be a contributory factor. The age and size composition of landings from outside grounds in Area 2 are similar to those from Area 3 (IPHC 1978).

Table 5. **Average age and weight of halibut in the commercial landings by region and time period. Data were not available for Subarea 2A.**

	Average Age (years)					
Region	1931-40	1941-50	1951-60	1961-72		1973-78*
Subarea 2B					minimum size increased	
Vancouver	9.9	8.6	10.8	11.5		13.0
Charlotte-Outside	None	11.3	10.8	10.2		11.8
Charlotte-Inside	8.0	8.4	9.2	8.6		10.3
Subarea 2C						
Southeast-Outside	8.1	11.2	11.8	11.1		12.3
Southeast-Inside	None	None	10.5	10.4		11.4
	Average Weight in Pounds (heads off-eviscerated)					
	1931-40	1941-50	1951-60	1961-72		1973-78*
Subarea 2B					minimum size increased	
Vancouver	14.9	11.8	17.7	24.4		33.4
Charlotte-Outside	None	16.7	24.0	23.1		37.1
Charlotte-Inside	10.6	11.5	16.1	19.3		30.2
Subarea 2C						
Southeast-Outside	8.9	16.1	23.1	29.3		42.6
Southeast-Inside	None	None	23.6	22.5		34.6

*Not comparable with other years because minimum size limit was raised in 1973.

Sex composition information is not available from commercial landings because halibut are dressed at sea, and external sex characteristics have not been identified. Research operations provide data on sex composition, but sampling effort is meager in many regions and time-periods. Hoag et al. (1979) summarized data on size, age, and sex composition of halibut caught during research cruises. They documented that females are larger than males at a given age, and that sex composition tends to vary geographically and seasonally. For research cruises during 1960-1977, catches in Charlotte (Inside) and Southeast (Outside) had a higher proportion of males than catches in Charlotte (Outside) (Table 6). Catches throughout Area 2 tend to have a higher proportion of males than those in Area 3.

THE FISHERY

The halibut fishery is composed of the commercial and sport fishery. In addition, halibut are caught incidentally in other fisheries such as those for groundfish and crab. The characteristics and history of each of these fisheries is distinctive, and each is described in detail below. All weights referred to herein are head-off eviscerated weights, sometimes referred to as net weight.

Table 6. Summary of size, age, and sex data collected on research cruises, 1960-1977 (Hoag et al. 1979). Wgt. is average weight, heads-off, eviscerated.

	Charlotte (Inside)				Charlotte (Outside)				Southeast (Outside)			
	Male		Female		Male		Female		Male		Female	
Age	No.	Wgt.	No.	Wgt.	No.	Wgt.	No.	Wgt.	No.	Wgt.	No.	Wgt.
2	1	—	1	—	—	—	—	—	—	—	—	—
3	40	3.6	75	4.9	8	3.9	1	3.9	—	—	—	—
4	322	6.5	508	7.2	10	4.8	17	5.1	12	1.8	1	1.5
5	1370	8.2	994	9.6	45	4.3	50	6.4	47	3.3	44	5.6
6	3024	8.9	2816	12.5	212	6.9	100	10.8	291	5.5	119	6.8
7	3976	9.9	3314	14.1	289	7.8	229	12.7	613	6.6	385	11.1
8	4887	10.8	3360	17.7	479	11.7	392	19.4	1264	9.8	518	16.7
9	5139	11.9	2979	21.7	395	12.4	423	25.9	1986	11.5	1063	21.9
10	2784	15.1	1686	30.0	253	17.1	362	33.8	1802	15.9	783	31.8
11	1787	17.5	988	38.2	137	25.3	198	45.4	768	25.0	593	39.5
12	867	21.1	590	49.1	209	27.9	303	47.7	708	27.9	532	51.7
13	523	24.3	447	55.9	74	37.5	118	67.8	356	32.8	335	60.6
14	373	26.1	336	65.6	99	30.3	117	69.6	364	31.4	330	67.7
15	308	29.2	291	75.3	94	41.0	130	89.6	248	32.8	322	72.6
16	196	31.7	175	87.1	109	49.2	150	90.1	377	31.6	271	72.7
17	160	34.5	159	86.5	79	40.5	112	87.2	139	43.5	218	75.3
18	98	50.5	111	87.6	85	41.2	27	110.9	260	37.8	229	77.0
19	41	38.9	93	86.8	27	36.5	32	103.0	117	41.4	103	91.0
20	30	54.2	81	105.6	20	44.6	21	126.5	120	45.0	126	81.3
21	13	40.3	95	92.6	—	—	8	108.3	99	51.8	71	96.8
22	18	47.6	41	86.8	13	57.4	26	107.7	82	50.7	46	91.5
23	3	96.5	42	104.9	2	67.2	14	133.0	22	56.2	31	90.3
24	1	67.2	26	123.1	—	—	1	154.1	—	—	22	110.4
25+	6	55.9	32	123.8	5	75.5	4	168.0	6	45.0	16	142.1
TOTAL	25967		19240		2644		2835		9681		6158	

The Commercial Fishery

Fishery Statistics

The commercial fishery is recognized to have started in 1888 (IPHC 1978), but accurate statistics for the fishery are only available since 1929 (Myhre et al. 1977). Statistics are compiled from two basic sources: records of landings from fish buyers and records from logbooks of fishing vessels. Myhre et al. (1977) described the procedure for calculating and reporting statistics.

A summary of the statistics for the Area 2 halibut fishery is presented in Appendix Table I. In this table, catch statistics are shown by subareas based on national divisions of Area 2 insofar as possible (Figure 1). Because the exact locations of the boundary

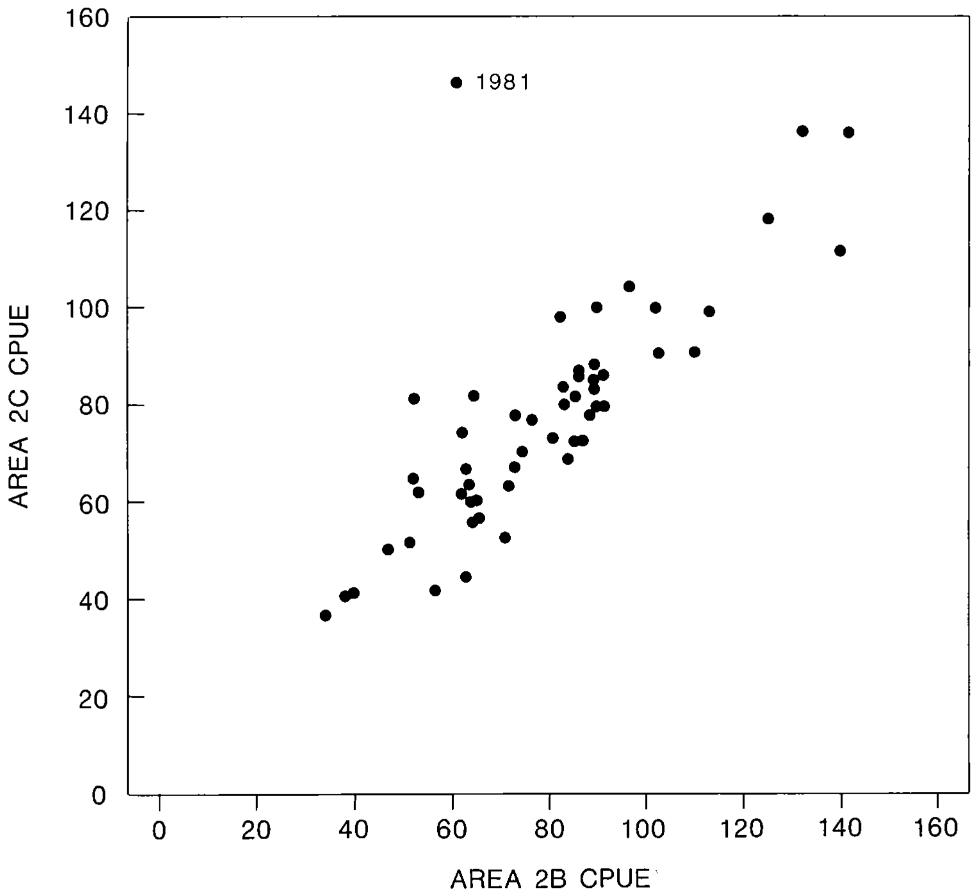

Figure 4. Comparison of CPUE in Areas 2B and 2C, 1929-1981.

lines are yet to be determined, the catch by vessels that fished in contested waters was assigned to the nationality of the vessel. Consequently, the catch statistics for some areas vary slightly from those reported by Myhre et al. (1977).

Table 7 shows the North American setline catch for subareas 2A, 2B, and 2C from 1929-1981. The percentage of the catch in each subarea is also provided. These data show that the catch in subareas 2A, 2B, and 2C has averaged 0.7, 14.0, and 8.4 million pounds respectively. This subarea catch distribution represents 3.0, 60.5, and 36.4% of the total Area 2 catch.

Figure 4 compares the CPUE of halibut in subareas 2B and 2C since 1929. From 1929 to 1980 CPUE's for the two subareas are well correlated (r = 0.9). The CPUE in subarea 2C has been higher than in subarea 2B since 1979, and the 1981 value deviates considerably from the long-term relationship.

Table 7. **Halibut catch by the North American setline fishery in subareas 2A, 2B, and 2C, 1929-1981. Percentage in each subarea is also provided.**

	Catch (millions of pounds)				Percentage		
Year	2A	2B	2C	Total	2A	2B	2C
1929	1.6	14.5	9.7	25.7	6.2	56.4	37.7
1930	1.2	12.6	8.4	22.2	5.4	56.8	37.8
1931	1.3	14.0	7.3	22.5	5.8	62.2	32.4
1932	1.3	14.0	7.6	22.9	5.7	61.1	33.2
1933	1.1	14.1	8.1	23.3	4.7	60.5	34.8
1934	2.0	14.4	7.6	24.0	8.3	60.0	31.7
1935	1.8	14.3	7.5	23.6	7.6	60.6	31.8
1936	0.9	13.7	8.7	23.3	3.9	58.8	37.3
1937	0.9	15.3	7.8	24.1	3.7	63.5	32.4
1938	1.0	16.0	7.1	24.1	4.1	66.4	29.5
1939	1.4	17.7	6.5	25.6	5.5	69.1	25.4
1940	1.0	17.9	7.6	26.4	3.8	67.8	28.8
1941	0.5	16.5	7.2	24.3	2.1	67.9	29.6
1942	0.7	14.4	8.3	23.4	3.0	61.5	35.5
1943	1.2	16.0	8.1	25.4	4.7	63.0	31.9
1944	0.9	15.1	10.3	26.3	3.4	57.4	39.2
1945	0.7	14.6	8.4	23.8	2.9	61.3	35.3
1946	0.9	18.4	9.9	29.2	3.1	63.0	33.9
1947	0.6	17.7	9.5	27.7	2.2	63.9	34.3
1948	0.4	17.7	9.8	27.8	1.4	63.7	35.3
1949	0.6	16.3	9.4	26.4	2.3	61.7	35.6
1950	0.7	17.5	8.8	27.0	2.6	64.8	32.6
1951	0.6	20.1	9.9	30.6	2.0	65.7	32.4
1952	0.6	20.7	9.5	30.8	1.9	67.2	30.8
1953	0.5	23.8	8.4	32.7	1.5	72.8	25.7
1954	0.9	25.0	11.0	36.8	2.4	67.9	29.9
1955	0.6	18.7	8.5	27.8	2.2	67.3	30.6
1956	0.5	20.1	14.4	39.1	1.4	57.3	41.0
1957	0.6	17.7	12.2	30.5	2.0	58.0	40.0
1958	0.5	18.5	11.2	30.2	1.7	61.3	37.1
1959	0.7	17.0	12.9	30.5	2.3	55.7	42.3
1960	0.9	18.2	12.7	31.8	2.8	57.2	39.9
1961	0.5	16.1	12.3	28.9	1.7	55.7	42.6
1962	0.4	15.2	13.1	28.7	1.4	53.0	45.6
1963	0.4	15.9	9.9	26.2	1.5	60.7	37.8
1964	0.3	12.1	7.2	19.6	1.5	61.7	36.7
1965	0.2	12.4	11.7	24.3	0.8	51.0	48.1
1966	0.2	11.4	11.7	23.3	0.9	48.9	50.2
1967	0.2	10.4	9.2	19.7	1.0	52.8	46.7
1968	0.1	10.6	5.7	16.4	0.6	64.6	34.8
1969	0.2	13.2	9.0	22.4	0.9	58.9	40.2
1970	0.2	10.6	9.1	19.9	1.0	53.3	45.7
1971	0.3	10.0	6.4	16.8	1.8	59.5	38.1
1972	0.4	10.3	5.6	16.3	2.5	63.2	34.4
1973	0.2	7.0	5.7	12.9	1.6	54.3	44.2
1974	0.5	4.6	5.6	10.7	4.7	43.0	52.3
1975	0.5	7.1	6.2	13.8	3.6	51.4	44.9
1976	0.2	7.3	5.5	13.0	1.5	56.2	42.3
1977	0.2	5.4	3.2	8.8	2.3	61.4	36.4
1978	0.1	4.6	4.3	9.0	1.1	51.1	47.8
1979	0.05	4.8	4.5	9.4	0.5	51.1	47.9
1980	0.02	5.7	3.2	8.9	0.2	64.0	36.0
1981	0.20	5.7	4.0	9.9	2.0	57.6	40.4
Average	0.7	14.0	8.4	23.2	3.0	60.5	36.4

The Fleet

The composition of the halibut fleet was relatively stable until 1970 (IPHC 1978). Since then, there has been an influx of setline vessels stimulated in part by a marked increase in the price of halibut. Also, many fishermen entered the halibut fishery because they were not eligible to fish for salmon under the present limited entry program. The number of Canadian and United States vessels that fished for halibut in Area 2 in the years 1976 through 1981 is shown in Table 8. Vessels that are less than 5 net tons or do not use setline gear do not require an IPHC license. In 1981, about 75% of the total Area 2 vessels were unlicensed. Although numerous, unlicensed vessels caught only 30% of the catch in 1981.

Table 8. Number of Canadian and U.S. vessels that fished for halibut in Area 2, 1976-1981.

Vessel	CANADA							U.S.					
Category	1976	1977	1978		1979*	1980*	1981*	1976	1977	1978	1979	1980	1981
Area 2													
Unlicensed**													
Trollers	1114	735	489	LIMITED ENTRY	5	5	12	1297	933	981	828	339	465
Setliners	256	144	97		22	7	9	517	364	350	649	564	633
Licensed													
5-19	269	618	557		292	294	275	135	158	175	215	271	296
20-39	34	38	37		32	33	36	35	45	35	47	60	58
40-59	2	2	3		8	5	9	3	4	6	8	5	1
60+	—	3	1		3	1	4	1	2	1	1	—	—
TOTAL	1675	1540	1184		362	348	345	1988	1506	1548	1748	1239	1453

*Not comparable with years before 1979 because of limited entry.

**Vessels less than 5 net tons or using gear other than setlines.

Beginning in 1979, the Canadian government established a limited entry fishery for halibut, resulting in a marked decrease in the number of small vessels in the Canadian halibut fishery (Table 8). At present the United States fleet does not have a limited entry program.

The Sport Fishery

Before 1973, sport fishing for halibut was legal only during the commercial halibut season. Sport catches were small, and seasons were sufficiently long to accommodate most sport fishing activities (Skud 1975). The sport fishery began expanding, and when commercial seasons became shorter during the 1960's and 1970's as a result of reduced catch limits, the opportunity for sport fishing was curtailed. The sport catch was still not significant relative to the commercial catch, and IPHC decided in 1973 to set a separate season for sport fishing along with a limit on the number of fish per day each fisherman could retain. Regulations in 1982 specify a season from March 1 to October 31 with a daily limit of two fish per person.

IPHC relies on state or provincial agencies for estimates of the sport catch of halibut. These estimates are often made in conjunction with a creel census for salmon, and, as such, may not be precise. Skud (1975) examined available information and concluded that the annual sport catch for all areas was about 20,000 fish or 250,000 pounds. The estimates were not separated by regulatory area, although half of the catch was attributed to Alaska waters.

The sport fishery continued to expand in most areas through the 1970's. The coastwide catch by sport fishermen in 1981 is estimated at 1.1 million pounds (75,000 fish), of which about 40% occurred in Area 2. A summary of the estimated sport catch in Area 2 since 1977 is presented in Table 9.

Table 9. Estimated annual sport catch in pounds of halibut by subareas, 1977-1981.

Subarea	1977	1978	1979	1980	1981
2A*	16,786	9,756	19,155	22,463	26,320
2B	17,237	8,505	17,863	10,808	12,403
2C	109,624	115,244	246,278	467,331	410,630
Total	143,647	133,505	283,296	500,602	449,353

*Washington state only

The Area 2 sport catch increased substantially in 1979 and 1980, reaching a peak of about 0.5 million pounds. Subarea 2C accounted for most of the catch. The sport catch is about 5% of the commercial catch in Area 2 and is still not of major significance in the management of the resource. The average weight of sport-caught halibut in Area 2 is between 15 and 20 pounds.

Incidental Catches in Other Fisheries

Incidental catches of halibut are taken inadvertently by fishermen seeking other species. Although regulations require that incidentally caught halibut be returned to the sea, many of the released fish die from injuries received during their capture (Hoag 1975). Most of the Area 2 incidental catch occurs in the Canadian trawl fishery off British Columbia (IPHC 1981), and is made up of fish smaller than 81 cm, the minimum size limit in the commercial fishery (Hoag 1971). A small but unestimated catch also occurs in the longline and pot fisheries off British Columbia.

Hoag (1971) and Hoag and French (1976) estimated the incidental catch of halibut in the foreign and domestic trawl fisheries for groundfish. The estimates have since been updated and preliminary estimates are available for other fisheries such as the shrimp and crab fisheries (Table 10). Some of the estimates are based on meager data and may change as additional information becomes available. However, they do indicate the relative magnitude of losses to the different fisheries. Acceptable estimates of the annual incidental catch are not available for the years prior to 1962, but catches during the 1950's were probably near 2 million pounds per year, and were taken primarily in groundfish trawls off British Columbia. From 1966 to 1976, about 4 million pounds were caught annually in Area 2: 3 million pounds by the domestic trawl fishery and 1 million pounds by the foreign trawl fishery. All of the catch by domestic trawlers was taken off British Columbia, and the catch by foreign trawlers was split about equally between British Columbia and southeast Alaskan waters. The catch

Table 10. **Estimated incidental catches of halibut by subarea[1] and fishery in Regulatory Area 2, 1962[2]-1981 (thousands of pounds, net weight).**

	2B			2C					
Year	Foreign Fish Trawls	Can./US Fish Trawls	Total	Foreign Fish Trawls	U.S. Fish Trawls	U.S. Shrimp Trawls	U.S. Crab Pots[3]	Total	Area 2 Total
1962	0	2351	2351	0	0	7	113	120	2471
1963	0	2153	2153	0	0	6	97	103	2256
1964	0	2210	2210	0	0	5	72	77	2887
1965	0	2870	2870	0	0	5	29	34	2904
1966	159	3014	3173	7	0	6	5	18	3191
1967	340	2623	2963	235	0	4	155	394	3357
1968	416	3094	3510	312	0	3	119	434	3944
1969	360	3646	4006	265	0	3	137	405	4411
1970	36	2867	2903	360	0	2	51	413	3376
1971	45	3399	3444	338	0	1	42	381	3825
1972	288	2924	3212	555	0	1	74	630	3842
1973	313	2392	2705	547	0	1	146	694	3399
1974	491	2475	2966	230	0	2	199	431	3397
1975	365	3088	3453	337	0	2	168	507	3960
1976	325	3478	3803	407	0	1	219	627	4430
1977	0	3461	3461	279[4]	0	1	195	475	3936
1978	0	2941	2941	75	0	2	191	268	3209
1979	0	3703	3703	519	Trace	2	216	737	4440
1980	0	2744	2744	217	Trace	3	301	521	3265
1981	0	2375	2375	196	17	2	207	422	2797

[1] Annual estimates for subarea 2A are not available but catches are minor.

[2] From 1954-1961, about 2 million pounds of halibut were caught annually in domestic fish trawls in subarea 2B. Also, from 1953-1961, less than 10,000 pounds of halibut were taken each year in shrimp trawls in subarea 2C.

[3] King and Tanner crab pots only.

[4] NMFS estimate is 216 thousand pounds.

by the southeast Alaska crab fishery was approximately 100,000 pounds in the mid-1960's, and 200,000 pounds in the mid-1970's.

The total incidental catch by regulatory area is given in Table 11. Although the incidental catch from Area 2 has an immediate bearing on the halibut resource in Area 2, the larger incidental catch in Areas 3 and 4 has had an impact because some halibut from those areas migrate into Area 2. Hence, halibut in Area 2 benefit from any reductions in the incidental catch of halibut from Areas 3 and 4 as well as Area 2.

Table 11. Estimated incidental catch of halibut by regulatory area and year, 1962-1981 (thousands of pounds, net weight).

Year	Area 2	Area 3	Area 4	Total
1962	2471	5420	5820	13711
1963	2256	8338	10791	21385
1964	2287	13194	7704	23185
1965	2904	18942	5711	27557
1966	3191	14294	4295	21780
1967	3357	10750	7522	21629
1968	3944	7686	8971	20601
1969	4411	5293	9035	18739
1970	3316	6333	9252	18901
1971	3825	4977	14760	23562
1972	3842	8056	11457	23355
1973	3399	8418	8687	20504
1974	3397	9861	7555	20813
1975	3960	6124	3374	13458
1976	4430	6289	4372	15091
1977	3936	6537	3104	13577
1978	3209	4919	5515	13643
1979	4440	6931	5595	16966
1980	3265	8619	8812	20696
1981	2797	6875	6310	15982

MANAGEMENT OF THE RESOURCE

General Review

The Halibut Convention and the Enabling Acts passed by Canada and the United States provide authority for the IPHC to regulate the halibut fishery (IPHC 1978). The IPHC management goal is to maintain the stocks of halibut at levels which will produce the optimum sustained yield. The management methods for accomplishing this objective include the setting of fishing areas, fishing seasons, catch quotas, definition of suitable gear for catching halibut, and licensing of vessels for statistical purposes. IPHC sets regulations annually after receiving advice and proposals from its scientific staff and from the halibut industry. IPHC regulations become effective upon adoption by Canada and the United States. IPHC does not have authority to enforce the regulations; instead, this function is performed by federal fishery officers in both countries. State fishery officers in the U.S. enforce the halibut regulations if those regulations are incorporated into their state code.

The first halibut fishery regulation was a three-month winter closure established by the 1923 Halibut Convention to protect spawning concentrations of halibut. The first regulations enacted by the Halibut Commission went into effect in 1932. At that time, Commission research indicated that the halibut stocks were depleted by excessive fishing in earlier years, and the regulations were designed to reduce the intensity of fishing and to allow the stocks to rebuild (Babcock, Found, Freeman, and O'Malley 1930). During the next 30 years, the halibut stock conditions improved as indicated by increasing abundance, larger average size, and older average age. As the stocks improved, the regulations permitted larger catch limits. By 1960, the Commission believed that the halibut stocks had reached their maximum sustained yield level. However, at about the same time, domestic and foreign trawl fisheries expanded on the halibut grounds, and large numbers of halibut were taken as incidental catch by these fisheries. Most of the halibut taken by these trawlers were smaller and younger than those taken by the commercial halibut fishery. Information on the magnitude of the incidental catch was unavailable so IPHC was not able to account for the full impact of the incidental catch on the halibut resource. By the late 1960's, the halibut stocks showed clear signs of declining abundance and more restrictive regulations were adopted for the halibut fishery. Furthermore, alarm over the magnitude of the incidental halibut catch prompted the Commission to urge the governments of Canada and the United States to reduce the foreign incidental catch because the Commission lacked authority to impose regulations on the other fisheries. The first regulation imposed to reduce the incidental catch was a time-area closure during January-March 1974 in the southeastern Bering Sea. In subsequent years this closure was expanded in time and space and additional closures were adopted in the Gulf of Alaska. At the same time, estimates of the source and magnitude of the incidental catch were improving. In the United States, passage of the Fisheries Conservation Management Act of 1976 established the Fishery Management Councils for the purpose of regulating fisheries other than halibut and established the U.S. conservation zone. At the same time, Canada extended its conservation zone and assumed authority for management of fisheries other than halibut therein. Ongoing research has indicated that, while foreign trawlers are still the major source of the incidental catch of halibut, the domestic trawl, crab, and shrimp fisheries are also significant contributors. The Commission has repeatedly advised the governments and other fishery management agencies of the importance of the incidental halibut catch and requested support in attempting to reduce this waste of the valuable halibut resource.

During the late 1960's and the 1970's, the Commission adopted regulations that severely limited the catch of halibut by the commercial fishery. The Commission's objective was to set annual catch limits below the estimated surplus production to allow stocks to rebuild. The minimum size limit was also increased in 1973 to reduce the mortality of young fish and make better use of their high growth potential. In recent years, the stocks have responded to these regulations, and stock abundance is increasing in Area 2 as a whole. While some further improvement in stock condition can be expected to result from strict regulation of the halibut fishery, more effective regulation of the incidental catch of halibut is required if the full productive capacity of the resource is to be realized.

Summary of Regulations

Detailed information on regulations adopted for Regulatory Area 2 is available in the regulation pamphlets for each year. These regulations were summarized by Skud (1977b), and by Bell and Best (1968). The waters south of Willapa Bay, Washington, were designated Area 1 until 1967, when the boundary line at Willapa Bay was dropped and all of the waters south of Cape Spencer, Alaska, were designated Area 2. The original northern boundary of Area 2 was near Lituya Bay but was moved to Cape Spencer in 1933. A brief summary of past regulations in the current Area 2 is given below.

Two nursery areas were established in Area 2 in 1932. One was located at the north shore of Graham Island in Dixon Entrance, known as the Masset nursery area, and the other was located north and west of Noyes Island in southeastern Alaska, known as the Timbered Islet nursery area. These nursery areas were abandoned in 1961 because large numbers of juvenile halibut were no longer found in these areas. In 1951, Area 2 was subdivided to increase the exploitation of halibut on some underfished grounds. At that time, the Commission could open and close an area only once during the year. The 1953 treaty provided authority for the Commission to open and close an area more than once a year, whereupon the subdivisions of Area 2 were eliminated. Area 2 was divided at the national boundary lines in 1981 to facilitate management of the fishery under the 1979 Protocol to the Halibut Convention. U.S. waters south of Canada became Area 2A, Canadian waters became Area 2B, and U.S. waters north of Canada to the Cape Spencer line became Area 2C.

Table 12 shows the quotas set and the catch taken in Areas 1 and 2, separately and combined, from 1932 to 1980.

Table 12. Quota and catch (thousands of pounds) in Areas 1 and 2, 1932-1981.

	Area 1		Area 2		Total
Year	Quota	Catch	Quota	Catch	Catch
1932		869	22,500	21,986	22,855
1933		741	21,700	22,530	23,271
1934	1,400	1,614	21,700	22,363	23,977
1935		1,492	21,700	22,067	23,559
1936		714	21,700	22,605	23,319
1937		714	21,700	23,359	24,073
1938		718	22,700	23,391	24,109
1939		1,091	22,700	24,499	25,590
1940		825	22,700	25,578	26,403
1941		349	22,700	23,941	24,290
1942		290	22,700	23,144	23,434
1943		428	23,000	24,933	25,361
1944		326	23,500	26,023	26,349
1945		443	24,500	23,353	23,796
1946		574	24,500	28,594	29,168
1947		409	24,500	27,330	27,739
1948		259	25,500	27,568	27,827
1949		385	25,500	26,027	26,412
1950		377	25,500	26,620	26,997
1951		289	25,500	30,309	30,598
1952		320	25,500	30,488	30,808
1953		210	25,500	32,501	32,711
1954		551	26,500	36,240	36,791
1955		377	26,500	27,429	27,806
1956		325	26,500	34,772	35,097
1957		296	26,500	30,238	30,534
1958		212	26,500	29,998	30,210
1959		129	26,500	30,401	30.530
1960		238	26,500	31,520	31,758
1961		223	28,000	28,637	28,860
1962		275	28,000	28,443	28,718
1963		169	28,000	26,001	26,170
1964		104	25,000	19,465	19,569
1965		98	23,000	24,154	24,252
1966		81	23,000	23,178	23,259
1967*			23,000	19,719	19,719
1968			23,000	16,394	16,394
1969			21,000	22,377	22,377
1970			20,000	19,885	19,885
1971			20,000	16,773	16,773
1972			15,000	16,283	16,283
1973			13,000	12,929	12,929
1974			13,000	10,744	10,744
1975			13,000	13,830	13.830
1976			13,000	13,048	13,048
1977			11,000	8,820	8,820
1978			9,000	9,020	9,020
1979			9,000**	9,433	9,433
1980			9,300	8,910	8,910
1981			9,000	9,866	9,866

*Beginning in 1967, Area 1 was merged with Area 2.
**During the 1979 fishing season, the Commission increased the quota to 9.6 million pounds to increase the Canadian share of the Area 2 catch.

Table 13 shows the opening and closing dates and the length of the halibut fishing season in Area 2 from 1932 to 1981. In 1935, 1944, and 1956 the fleet did not begin fishing on the stated opening date due to labor disputes. Those days on which fishing did not occur are excluded from the length of the season. From 1951 to 1960 the number of fishing days includes special seasons of 7 to 10 days. From 1977 to 1980 the fishing season consisted of a sequence of open and closed periods. The length of season shown for those years is the number of fishing days.

Table 13. **Opening and closing dates and length of season in Area 2, 1932-1981.**

Year	Opening Date	Closing Date	Length of Season*	Year	Opening Date	Closing Date	Length of Season*
				1961	5-10	9-07	120
1932	2-16	10-22	250	1962	5-09	9-08	122
1933	2-01	8-25	206	1963	5-09	11-30	205
1934	3-01	8-19	172	1964	5-01	9-15	137
1935	3-01	9-06	159	1965	5-01	9-15	137
1936	3-16	8-10	148	1966	5-09	8-25	108
1937	3-16	7-28	135	1967	5-09	10-15	159
1938	4-01	7-29	120	1968	5-04	10-15	164
1939	4-01	7-29	120	1969	5-07	9-21	137
1940	4-01	7-13	104	1970	4-25	9-21	149
1941	4-01	6-30	91	1971	5-07	11-01	178
1942	4-16	6-29	75	1972	5-01	8-10	101
1943	4-16	6-20	66	1973	5-10	8-13	95
1944	4-16	7-09	51	1974	5-17	9-15	121
1945	5-01	6-15	46	1975	5-01	9-06	128
1946	5-01	6-11	42	1976	5-08	9-08	123
1947	5-01	6-08	39	1977	5-10	9-10	73
1948	5-01	6-01	32	1978	5-15	9-08	62
1949	5-01	6-03	34	1979 (C)	5-25	8-05	40
1950	5-01	6-01	32	(US)	5-25	7-03	23
1951	5-01	5-28	38	1980 (C)	5-20	11-05	65
1952	5-14	6-08	36	(US)	5-20	5-30	10
1953	5-17	6-09	34	1981 (C)	5-7	8-19	58
1954	5-16	6-05	29				
1955	5-12	6-05	31	(US-WA)	6-7	9-19	56
1956	5-12	6-27	45				
1957	5-01	6-17	54	(US-AK)	6-7	6-14	7
1958	5-04	7-02	66				
1959	5-01	7-08	75				
1960	5-01	7-13	98				

* In 1935, 1944, and 1956, the fleet did not begin fishing on the opening date because of externalities such as price disputes. These non-fishing periods are excluded from the length of the season. From 1951 to 1960, the number of fishing days includes special seasons of 7 to 10 days. From 1977 to 1981 the fishing season consisted of a sequence of open and closed periods. The length of season shown for those years is the number of fishing days.

Gear restrictions were adopted by the Commission to prohibit use of gear having undesirable selection properties. The first gear restriction applied to the halibut fishery was in 1935 when dory gear was prohibited because it tended to take a greater proportion of small fish than longline gear (Bell 1956). In 1938 a regulation was adopted which prohibited the use of set nets for catching halibut. In 1944 this prohibition was extended to include nets of any kind, and in 1972 it was further extended to include pots.

The first size limit was set in 1940 when a minimum legal size of five pounds was established (Myhre 1974). In 1944 a corresponding length limit of 26 inches was added to the weight limit. In 1973 the weight limit was rescinded and the length limit was raised to 32 inches with the head on, or 24 inches with the head off.

BASIS OF THE 60%/40% CATCH DIVISION

Estimates of the average productivity of each subarea were needed to evaluate the basis of a division of the catch. Previous investigations were concerned primarily with estimating the maximum sustained yield (MSY) or the annual surplus production (ASP) of the Area 2 resource as a whole rather than by subareas. Chapman et al. (1962) concluded that MSY in Area 2 was about 32 million pounds annually. Setline catches in Area 2 approached the estimated MSY during most of the 1950's and exceeded MSY during two years, reaching a high of 37 million pounds in 1954. CPUE and estimates of biomass declined steadily from the 1950's to the mid-1970's (Hoag and McNaughton 1978), suggesting that catches exceeded the ASP. By 1980 the ASP, also called equilibrium yield, had dropped to about 10 million pounds (IPHC 1981). Part of the decline in abundance and productivity during the 1960's and 1970's was a result of incidental catches which, combined with setline catches, apparently caused total catch to exceed the ASP (Quinn et al., in press).

In judging the biological basis for the 60%/40% catch division between Canadian and U.S. waters, we examined estimates of bottom area, historical catch, biomass, and ASP. These parameters provide a measure of the productivity of the halibut resource among subareas. Estimates of bottom area and historical catch were provided in earlier sections of this report and estimates of biomass and ASP were obtained from Deriso and Quinn, (Section II of this report). Estimates of biomass and ASP after 1970 were excluded because the estimation techniques rely on catches over the life of each year-class and information on most year-classes in the fishery since 1970 is still incomplete. Also, stock conditions since 1970 have been generally poor and may not be typical of the long-term productivity of the resource. The results were as follows:

	Percentage in each subarea		
Estimates	2A	2B	2C
Bottom Area*	3.7	57.5	38.8
Catch (1929-1981)	3.0	60.5	36.4
Biomass**	3.3	54.3	42.3
ASP**	2.5	62.6	34.9

*Fishing grounds
**Average of two methods for 1935-1970 (Deriso and Quinn, Section II of this report)

Estimates of bottom area and biomass would suggest that about 56% of the catch should come from Area 2B. However, estimates of ASP indicate that subarea 2B is more productive and could produce nearly 63% of the catch. Historically, the catch in 2B has averaged about 60.5% of the total.

These results suggest that the 60%/40% division of the catch is reasonably justified as a long-term management objective. However, we note that it may be difficult to manage the stock on a fixed division because conditions vary over time. For example, the ASP of subarea 2B ranged from less than 50% to over 70% of the total during 1935-1970 (Deriso and Quinn, Section II of this report). Consequently, there were years when a 50%/50% division or a 70%/30% division might have been more appropriate. Fixing the division of the catch will result in unequal exploitation rates among subareas. Whether annual deviations in ASP and biomass are sufficiently large to cause detrimental effects on the resource under a fixed catch division is not known. A more flexible division of the catch would allow for changes in productivity among subareas and might increase the total production from the Area 2 resource.

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LITERATURE CITED

Babcock, John Pease, William A. Found, Miller Freeman, and Henry O'Malley. 1930. Investigations of the International Fisheries Commission to December, 1930, and their bearing on regulations of the Pacific halibut fishery. International Fisheries Commission, Report No. 7: 29 p.

Bell, F. Heward. 1956. The incidental capture of halibut by various types of fishing gear. International Pacific Halibut Commission, Report No. 23: 48 p.

__________. 1969. Agreements, conventions and treaties between Canada and the United States of America with respect to the Pacific halibut fishery. International Pacific Halibut Commission, Report No. 50: 102 p.

Bell, F. Heward and E.A. Best. 1968. The halibut fishery south of Willapa Bay, Washington. International Pacific Halibut Commission, Report No. 51: 35 p.

Chapman, Douglas G., Richard J. Myhre, and G. Morris Southward. 1962. Utilization of Pacific halibut stocks: Estimation of maximum sustainable yield, 1960. International Pacific Halibut Commission, Report No. 31: 35 p.

Forrester, C. R., and D. F. Alderdice. 1973. Laboratory observations on early development of the Pacific halibut. International Pacific Halibut Commission, Technical Report No. 9: 13 p.

Hamley, John M., and Bernard E. Skud. 1978. Factors affecting longline catch and effort: II. Hook spacing. International Pacific Halibut Commission, Scientific Report No. 64: 16-24.

Hoag, Stephen H. 1971. Effects of domestic trawling on the halibut stocks of British Columbia. International Pacific Halibut Commission, Scientific Report No. 53: 18 p.

__________. 1975. Survival of halibut released after capture by trawls. International Pacific Halibut Commission, Scientific Report No. 57: 18 p.

Hoag, Stephen H., and Robert R. French. 1976. The incidental catch of halibut by foreign trawlers. International Pacific Halibut Commission, Scientific Report No. 60: 24 p.

Hoag, Stephen H., and Ronald J. McNaughton. 1978. Abundance and fishing mortality of Pacific halibut, cohort analysis, 1935-1976. International Pacific Halibut Commission, Scientific Report No. 65: 45 p.

Hoag, Stephen H., Cyreis C. Schmitt, and William H. Hardman. 1979. Size, age, and frequency of male and female halibut: Setline research catches, 1925-1977. International Pacific Halibut Commission, Technical Report No. 17: 112 p.

International Pacific Halibut Commission. 1958. Regulations and investigations of the Pacific halibut fishery in 1957. International Pacific Halibut Commission, Report No. 26: 16 p.

__________. 1966. Regulations and investigations of the Pacific halibut fishery in 1965. International Pacific Halibut Commission, Report No. 40: 23 p.

__________. 1973. Annual Report, 1972. International Pacific Halibut Commission, 36 p.

———. 1978. The Pacific halibut: Biology, fishery, and management. International Pacific Halibut Commission, Technical Report No. 16: 56 p.

———. 1979. Annual Report, 1978. International Pacific Halibut Commission, 40 p.

———. 1981. Annual Report, 1980. International Pacific Halibut Commission, 49 p.

Myhre, Richard J. 1969. Gear selection and Pacific halibut. International Pacific Halibut Commission, Report No. 51: 35 p.

———. 1974. Minimum size and optimum age of entry for Pacific halibut. International Pacific Halibut Commission, Scientific Report No. 55: 15 p.

Myhre, Richard J., Gordon J. Peltonen, Gilbert St-Pierre, Bernard E. Skud, and Raymond E. Walden. 1977. The Pacific halibut fishery: catch, effort, and CPUE, 1929-1975. International Pacific Halibut Commission, Technical Report No. 14: 94 p.

Quinn, Terrance J., II, Richard B. Deriso, Stephen H. Hoag, and Richard J. Myhre. In press. A summary of methods of estimating annual surplus production for the Pacific halibut fishery. International North Pacific Fisheries Commission, Special Scientific Sessions, October 28-30, 1981.

Schmitt, Cyreis C., and Bernard E. Skud. 1978. Relation of fecundity to long-term changes in growth, abundance, and recruitment. International Pacific Halibut Commission, Scientific Report No. 66: 31 p.

Skud, Bernard Einar. 1975. The sport fishery for halibut: development, recognition, and regulation. International Pacific Halibut Commission, Technical Report No. 13: 19 p.

———. 1977a. Drift, migration, and intermingling of Pacific halibut stocks. International Pacific Halibut Commission, Scientific Report No. 63: 42 p.

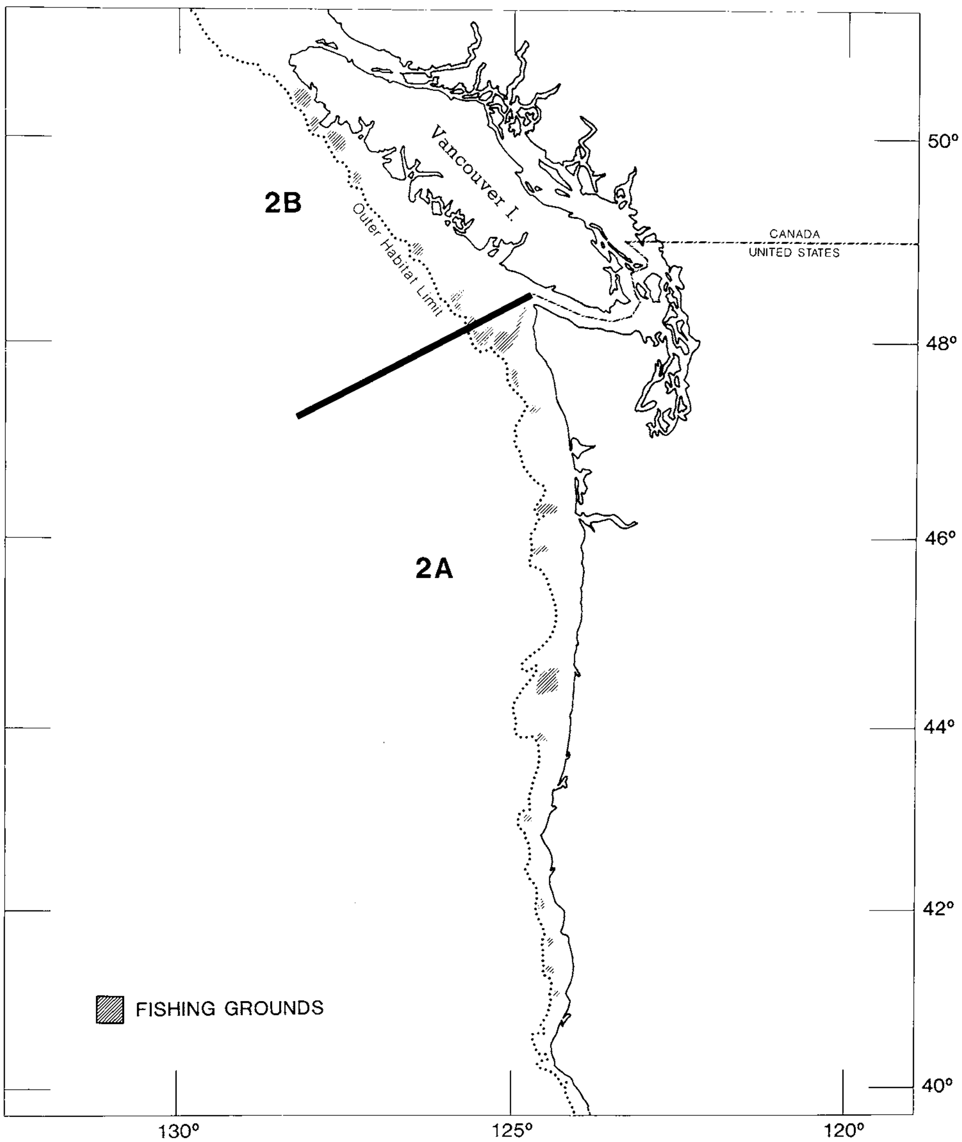
———. 1977b. Regulations of the Pacific halibut fishery, 1924-1976. International Pacific Halibut Commission, Technical Report No. 15: 47 p.

Southward, G. Morris. 1967. Growth of Pacific Halibut. International Pacific Halibut Commission, Report No. 43: 40 p.

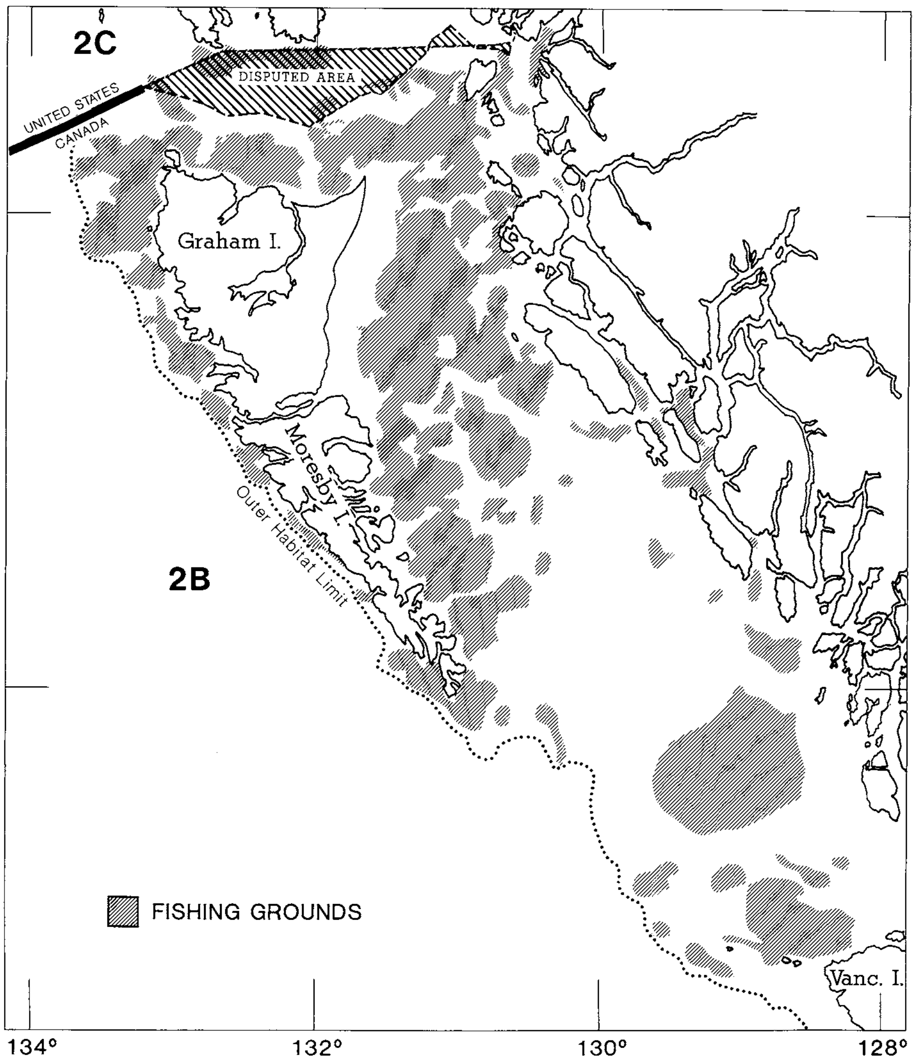
Thompson, William F., and Richard Van Cleve. 1936. Life history of the Pacific halibut. (2) Distribution and early life history. International Fisheries Commission Report No. 9: 184 p.

Thompson, William F., and William H. Herrington. 1930. Life history of the Pacific halibut. (1) Marking experiments. International Fisheries Commission Report No. 2: 137 p.

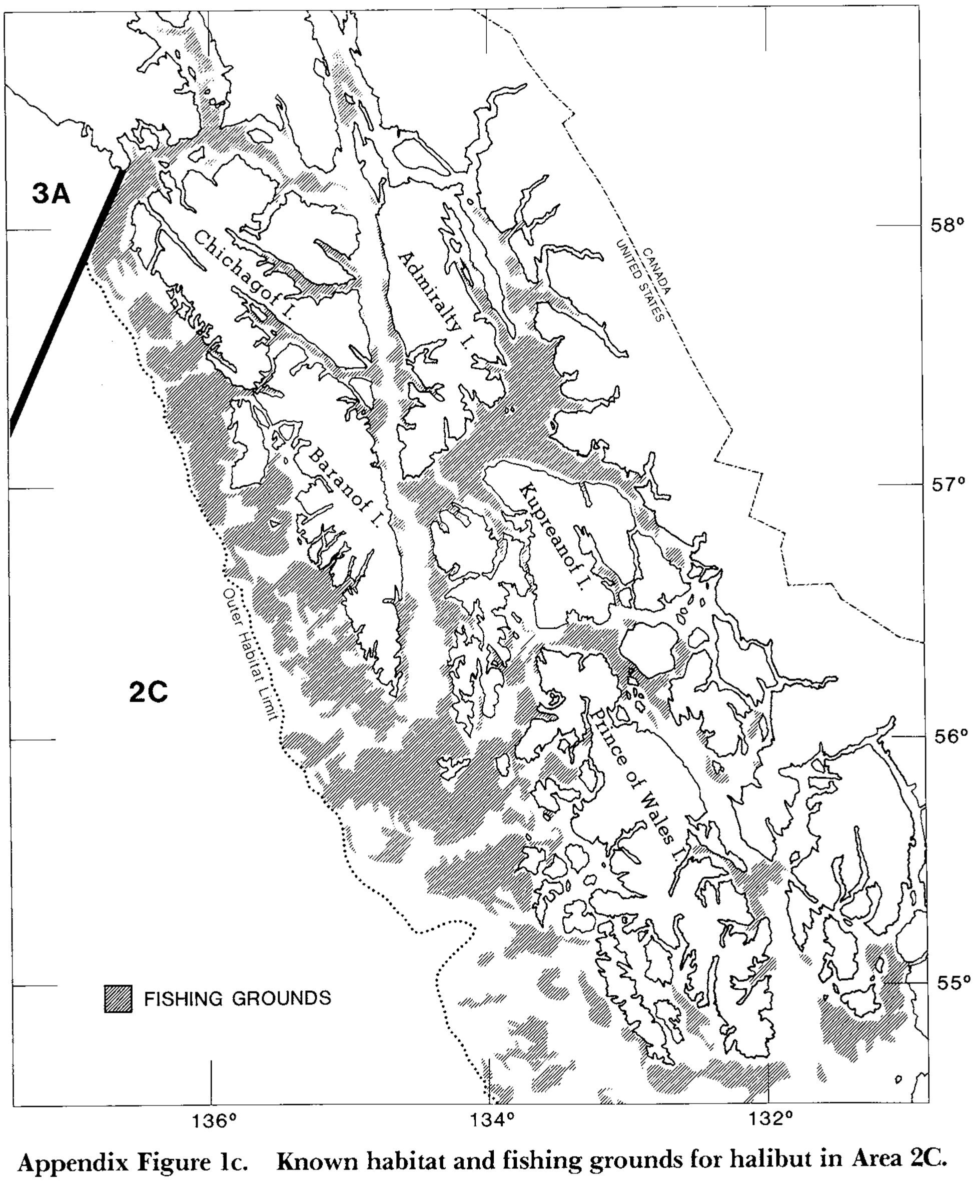
APPENDIX



Appendix Figure 1a. Known habitat and fishing grounds for halibut in Area 2A.



Appendix Figure 1b. Known habitat and fishing grounds for halibut in Area 2B.



Appendix Figure 1c. Known habitat and fishing grounds for halibut in Area 2C.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1929	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	52	66.2*	785	0.0	1512	33.5	45173	9.1	1564	34.0	45958
Vancouver I.	480	66.2*	7246	0.0	1086	28.5	38171	29.7	1566	34.5	45417
Charlotte-O	1471	66.2	22207	31.4	726	44.0	16491	24.4	2197	56.8	38698
Charlotte-I	6163	40.0	154152	43.0	4532	36.0	125790	24.0	10695	38.2	279942
SE Alaska-O	218	32.1	6801	25.3	4841	42.9	112733	36.1	5059	42.3	119534
SE Alaska-I	0	0.0	0	0.0	4628	40.3	114739	13.0	4628	40.3	114739
Total 2A	52	66.2	785	0.0	1512	33.5	45173	9.1	1564	34.0	45958
Total 2B	8114	44.2	183605	38.3	6344	35.2	180452	25.0	14458	39.7	364057
Total 2C	218	32.1	6801	25.3	9469	41.6	227472	24.8	9687	41.3	234273
Total Area 2	8384	43.9	191191	37.7	17325	38.2	453097	23.5	25709	39.9	644288

1930	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0.0	0	0.0	1167	29.7	39299	21.8	1167	29.7	39299
Vancouver I.	366	17.6	20750	3.2	766	23.5	32558	54.9	1132	21.2	53308
Charlotte-O	1398	52.9	26412	57.1	467	46.5	10053	63.0	1865	51.1	36465
Charlotte-I	4980	34.1	145956	58.0	4649	34.1	136210	54.9	9629	34.1	282166
SE Alaska-O	265	32.5	8145	38.0	4038	38.3	105547	55.0	4303	37.8	113692
SE Alaska-I	0	0.0	0	0.0	4117	35.5	115923	20.3	4117	35.5	115923
Total 2A	0	0.0	0	0.0	1167	29.7	39299	21.8	1167	29.7	39299
Total 2B	6744	34.9	193118	54.9	5882	32.9	178821	55.5	12626	33.9	371939
Total 2C	265	32.5	8145	38.0	8155	36.8	221470	37.5	8420	36.7	229615
Total Area 2	7009	34.8	201263	54.2	15204	34.6	439590	43.3	22213	34.7	640853

1931	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0.0	0	0.0	1279	35.0	36532	18.8	1279	35.0	36532
Vancouver I.	443	27.6	16076	8.8	610	29.4	20766	68.7	1053	28.6	36842
Charlotte-O	1327	51.6	25709	48.4	284	37.0	7673	73.2	1611	48.3	33382
Charlotte-I	5143	36.4	141235	44.0	6191	39.5	156807	53.3	11334	38.0	298042
SE Alaska-O	106	49.8	2128	60.2	3793	43.8	86535	65.3	3899	44.0	88663
SE Alaska-I	0	0.0	0	0.0	3357	37.1	90551	30.9	3357	37.1	90551
Total 2A	0	0.0	0	0.0	1279	35.0	36532	18.8	1279	35.0	36532
Total 2B	6913	37.8	183020	42.6	7085	38.2	185246	55.4	13998	38.0	368266
Total 2C	106	49.8	2128	60.2	7150	40.4	177086	49.2	7256	40.5	179214
Total Area 2	7019	37.9	185148	42.9	15514	38.9	398864	49.5	22533	38.6	584012

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1932	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0.0	0	0.0	1254	43.2	29047	24.4	1254	43.2	29047
Vancouver I.	417	34.9	11946	5.5	1199	37.7	31795	63.5	1616	36.9	43741
Charlotte-O	1175	53.6	21927	51.3	443	51.6	8594	65.7	1618	53.0	30521
Charlotte-I	4244	46.5	91248	60.1	6483	48.4	134078	58.7	10727	47.6	225326
SE Alaska-O	124	46.0	2693	66.0	3725	53.4	69730	76.0	3849	53.1	72423
SE Alaska-I	0	0.0	0	0.0	3791	47.8	79368	47.2	3791	47.8	79368
Total 2A	0	0.0	0	0.0	1254	43.2	29047	24.4	1254	43.2	29047
Total 2B	5836	46.6	125121	54.4	8125	46.6	174467	59.8	13961	46.6	299588
Total 2C	124	46.0	2693	66.0	7516	50.4	149098	61.5	7640	50.3	151791
Total Area 2	5960	46.6	127814	54.6	16895	47.9	352612	57.9	22855	47.6	480426

1933	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0.0	0	0.0	1116	36.3	30748	23.4	1116	36.3	30748
Vancouver I.	568	36.3	15662	25.1	1066	34.7	30680	63.4	1634	35.3	46342
Charlotte-O	1610	67.7	23765	76.7	463	53.8	8614	54.6	2073	64.0	32379
Charlotte-I	5283	53.9	98078	73.1	5107	50.9	100275	70.4	10390	52.4	198353
SE Alaska-O	189	58.5	3233	100.0	3627	52.4	69283	69.5	3816	52.6	72516
SE Alaska-I	0	0.0	0	0.0	4242	50.9	83338	37.9	4242	50.9	83338
Total 2A	0	0.0	0	0.0	1116	36.3	30748	23.4	1116	36.3	30748
Total 2B	7461	54.3	137505	70.3	6636	47.5	139569	68.2	14097	50.9	277074
Total 2C	189	58.5	3233	100.0	7869	51.6	152621	52.5	8058	51.7	155854
Total Area 2	7650	54.4	140738	71.0	15621	48.4	322938	57.1	23271	50.2	463676

1934	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0.0	0	0.0	1984	36.2	54854	14.5	1984	36.2	54854
Vancouver I.	543	36.5	14864	16.8	761	36.8	20697	60.3	1304	36.7	35561
Charlotte-O	1956	71.8	27240	67.1	285	55.7	5115	89.9	2241	69.3	32355
Charlotte-I	6182	52.3	118315	68.6	4706	54.3	86636	83.2	10888	53.1	204951
SE Alaska-O	276	62.1	4443	90.5	3412	66.9	51014	67.2	3688	66.5	55457
SE Alaska-I	10	83.3	120	65.0	3862	58.4	66121	43.4	3872	58.5	66241
Total 2A	0	0.0	0	0.0	1984	36.2	54854	14.5	1984	36.2	54854
Total 2B	8681	54.1	160419	65.0	5752	51.2	112448	80.5	14433	52.9	272867
Total 2C	286	62.7	4563	89.6	7274	62.1	117135	54.6	7560	62.1	121698
Total Area 2	8967	54.4	164982	65.8	15010	52.8	284437	59.2	23977	53.4	449419

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1935	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	1770	49. 2	35975	20. 4	1770	49. 2	35975
Vancouver I.	877	58. 0	15109	36. 7	923	45. 6	20248	59. 1	1800	50. 9	35357
Charlotte-O	1491	76. 3	19533	75. 2	90	83. 2	1082	46. 7	1581	76. 7	20615
Charlotte-I	6308	63. 6	99212	70. 3	4596	62. 7	73324	82. 3	10904	63. 2	172536
SE Alaska-O	280	65. 8	4259	86. 3	3376	74. 7	45203	70. 0	3656	73. 9	49462
SE Alaska-I	0	0. 0	0	0. 0	3848	61. 2	62902	43. 8	3848	61. 2	62902
Total 2A	0	0. 0	0	0. 0	1770	49. 2	35975	20. 4	1770	49. 2	35975
Total 2B	8676	64. 8	133854	67. 7	5609	59. 3	94654	78. 0	14285	62. 5	228508
Total 2C	280	65. 7	4259	86. 3	7224	66. 8	108105	56. 0	7504	66. 8	112364
Total Area 2	8956	64. 8	138113	68. 3	14603	61. 2	238734	60. 1	23559	62. 5	376847

1936	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	901	36. 5	24694	22. 6	901	36. 5	24694
Vancouver I.	921	44. 1	20907	39. 0	777	32. 6	23799	48. 7	1698	38. 0	44706
Charlotte-O	1565	70. 7	22151	76. 2	34	47. 7	713	97. 1	1599	69. 9	22864
Charlotte-I	5951	54. 5	109209	64. 2	4451	51. 2	87000	80. 2	10402	53. 0	196209
SE Alaska-O	267	58. 4	4575	71. 5	3548	64. 6	54948	57. 4	3815	64. 1	59523
SE Alaska-I	0	0. 0	0	0. 0	4904	65. 5	74827	44. 7	4904	65. 5	74827
Total 2A	0	0. 0	0	0. 0	901	36. 5	24694	22. 6	901	36. 5	24694
Total 2B	8437	55. 4	152267	63. 7	5262	47. 2	111512	75. 7	13699	51. 9	263779
Total 2C	267	58. 4	4575	71. 5	8452	65. 1	129775	50. 0	8719	64. 9	134350
Total Area 2	8704	55. 5	156842	63. 9	14615	54. 9	265981	57. 6	23319	55. 2	422823

1937	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	917	67. 7	13546	16. 5	917	67. 7	13546
Vancouver I.	1080	56. 6	19079	42. 7	788	47. 8	16486	48. 2	1868	52. 5	35565
Charlotte-O	1212	74. 4	16282	70. 6	15	59. 3	253	100. 0	1227	74. 2	16535
Charlotte-I	7336	58. 8	124728	56. 3	4882	67. 9	71874	83. 6	12218	62. 1	196602
SE Alaska-O	226	61. 2	3691	54. 3	2799	60. 9	45977	41. 1	3025	60. 9	49668
SE Alaska-I	0	0. 0	0	0. 0	4818	61. 9	77786	38. 8	4818	61. 9	77786
Total 2A	0	0. 0	0	0. 0	917	67. 7	13546	16. 5	917	67. 7	13546
Total 2B	9628	60. 1	160089	56. 6	5685	64. 2	88613	78. 8	15313	61. 6	248702
Total 2C	226	61. 2	3691	54. 3	7617	61. 5	123763	39. 6	7843	61. 5	127454
Total Area 2	9854	60. 2	163780	56. 5	14219	62. 9	225922	53. 8	24073	61. 8	389702

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1938	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	951	47. 7	19924	17. 5	951	47. 7	19924
Vancouver I.	1361	65. 8	20670	48. 6	1052	63. 3	16630	53. 6	2413	64. 7	37300
Charlotte-O	1117	89. 0	12548	77. 0	0	0. 0	0	0. 0	1117	89. 0	12548
Charlotte-I	6965	64. 7	107733	65. 1	5533	87. 0	63576	84. 2	12498	73. 0	171309
SE Alaska-O	134	88. 7	1511	91. 3	2599	71. 5	36348	40. 0	2733	72. 2	37859
SE Alaska-I	0	0. 0	0	0. 0	4397	64. 1	68545	42. 3	4397	64. 1	68545
Total 2A	0	0. 0	0	0. 0	951	47. 7	19924	17. 5	951	47. 7	19924
Total 2B	9443	67. 0	140951	64. 1	6585	82. 1	80206	79. 3	16028	72. 5	221157
Total 2C	134	88. 7	1511	91. 3	6996	66. 7	104893	41. 4	7130	67. 0	106404
Total Area 2	9577	67. 2	142462	64. 5	14532	70. 9	205023	57. 0	24109	69. 4	347485

1939	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	1363	43. 8	31138	10. 5	1363	43. 8	31138
Vancouver I.	812	50. 3	16144	62. 7	525	42. 7	12289	38. 2	1337	47. 0	28433
Charlotte-O	1082	87. 1	12429	66. 9	0	0. 0	0	0. 0	1082	87. 1	12429
Charlotte-I	8841	63. 8	138607	65. 6	6431	66. 1	97364	83. 6	15272	64. 7	235971
SE Alaska-O	201	91. 3	2203	76. 3	2433	63. 6	38272	42. 8	2634	65. 1	40475
SE Alaska-I	0	0. 0	0	0. 0	3902	56. 9	68543	35. 7	3902	56. 9	68543
Total 2A	0	0. 0	0	0. 0	1363	43. 8	31138	10. 5	1363	43. 8	31138
Total 2B	10735	64. 2	167180	65. 5	6956	63. 4	109653	80. 2	17691	63. 9	276833
Total 2C	201	91. 2	2203	76. 3	6335	59. 3	106815	38. 4	6536	60. 0	109018
Total Area 2	10936	64. 6	169383	65. 7	14654	59. 2	247606	55. 7	25590	61. 4	416989

1940	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	981	41. 2	23832	7. 4	981	41. 2	23832
Vancouver I.	994	54. 8	18123	26. 2	734	49. 2	14910	33. 4	1728	52. 3	33033
Charlotte-O	814	109. 2	7457	83. 2	7	87. 0	81	57. 1	821	108. 9	7538
Charlotte-I	9170	63. 6	144154	52. 5	6113	67. 4	90720	85. 4	15283	65. 1	234874
SE Alaska-O	141	112. 5	1253	95. 7	2752	69. 3	39702	46. 1	2893	70. 6	40955
SE Alaska-I	0	0. 0	0	0. 0	4697	55. 5	84689	39. 9	4697	55. 5	84689
Total 2A	0	0. 0	0	0. 0	981	41. 2	23832	7. 4	981	41. 2	23832
Total 2B	10978	64. 7	169734	52. 4	6854	64. 8	105711	79. 8	17832	64. 7	275445
Total 2C	141	112. 5	1253	95. 7	7449	59. 9	124391	42. 2	7590	60. 4	125644
Total Area 2	11119	65. 0	170987	53. 0	15284	60. 2	253934	56. 8	26403	62. 1	424921

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1941	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0.0	0	0.0	509	43.3	11759	17.0	509	43.3	11759
Vancouver I.	1397	71.8	19460	50.5	888	54.4	16313	17.2	2285	63.9	35773
Charlotte-O	838	92.1	9101	71.8	0	0.0	0	0.0	838	92.1	9101
Charlotte-I	8276	59.4	139239	55.2	5144	65.8	78142	76.4	13420	61.7	217381
SE Alaska-O	97	75.1	1292	65.3	2410	71.6	33663	50.5	2507	71.7	34955
SE Alaska-I	0	0.0	0	0.0	4731	60.2	78618	34.4	4731	60.2	78618
Total 2A	0	0.0	0	0.0	509	43.3	11759	17.0	509	43.3	11759
Total 2B	10511	62.6	167800	55.9	6032	63.9	94455	67.8	16543	63.1	262255
Total 2C	97	75.1	1292	65.3	7141	63.6	112281	39.8	7238	63.7	113573
Total Area 2	10608	62.7	169092	56.0	13682	62.6	218495	51.3	24290	62.7	387587

1942	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0.0	0	0.0	718	68.5	10489	21.7	718	68.5	10489
Vancouver I.	892	52.8	16900	42.5	1100	54.6	20146	33.1	1992	53.8	37046
Charlotte-O	928	82.4	11265	79.1	42	38.1	1102	16.4	970	78.4	12367
Charlotte-I	6989	60.8	114906	50.7	4440	64.8	68531	76.8	11429	62.3	183437
SE Alaska-O	309	72.9	4236	73.8	3325	76.1	43716	53.2	3634	75.8	47952
SE Alaska-I	0	0.0	0	0.0	4691	73.0	64239	36.4	4691	73.0	64239
Total 2A	0	0.0	0	0.0	718	68.5	10489	21.7	718	68.5	10489
Total 2B	8809	61.6	143071	52.9	5582	62.2	89779	67.7	14391	61.8	232850
Total 2C	309	72.9	4236	73.8	8016	74.3	107955	43.4	8325	74.2	112191
Total Area 2	9118	61.9	147307	53.6	14316	68.8	208223	51.8	23434	65.9	355530

1943	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0.0	0	0.0	1237	67.7	18282	25.3	1237	67.7	18282
Vancouver I.	1008	55.1	18283	42.9	1142	64.4	17723	30.9	2150	59.7	36006
Charlotte-O	1199	98.6	12159	75.2	20	76.6	261	80.0	1219	98.1	12420
Charlotte-I	8705	73.4	118556	57.0	3913	74.0	52879	70.1	12618	73.6	171435
SE Alaska-O	212	72.9	2908	40.3	2538	81.2	31253	47.0	2750	80.5	34161
SE Alaska-I	0	0.0	0	0.0	5387	76.7	70231	42.8	5387	76.7	70231
Total 2A	0	0.0	0	0.0	1237	67.7	18282	25.3	1237	67.7	18282
Total 2B	10912	73.2	148998	57.7	5075	71.6	70863	61.3	15987	72.7	219861
Total 2C	212	72.9	2908	40.3	7925	78.1	101484	44.2	8137	77.9	104392
Total Area 2	11124	73.2	151906	57.4	14237	74.7	190629	48.6	25361	74.0	342535

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1944	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	0	0.0	0	0.0	897	69.0	12999	15.6	897	69.0	12999
Vancouver I.	626	61.1	10247	40.7	547	64.7	8460	43.7	1173	62.7	18707
Charlotte-O	1213	122.7	9883	73.9	13	98.8*	132	0.0	1226	122.4	10015
Charlotte-I	9060	87.4	103617	54.0	3669	98.8	37125	73.4	12729	90.4	140742
SE Alaska-O	207	82.0	2523	48.6	4271	104.9	40707	30.5	4478	103.6	43230
SE Alaska-I	0	0.0	0	0.0	5846	79.2	73810	43.5	5846	79.2	73810
Total 2A	0	0.0	0	0.0	897	69.0	12999	15.6	897	69.0	12999
Total 2B	10899	88.1	123747	55.5	4229	92.5	45717	69.3	15128	89.3	169464
Total 2C	207	82.0	2523	48.6	10117	88.3	114517	38.0	10324	88.2	117040
Total Area 2	11106	88.0	126270	55.4	15243	88.0	173233	45.4	26349	88.0	299503

1945	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	13	65.3*	199	0.0	716	93.5	7657	15.5	729	92.8	7856
Vancouver I.	280	65.3	4289	34.1	341	60.5	5634	41.8	621	62.6	9923
Charlotte-O	1120	109.1	10263	61.3	55	85.4	644	67.8	1175	107.7	10907
Charlotte-I	9687	87.4	110812	53.0	3105	77.9	39836	75.8	12792	84.9	150648
SE Alaska-O	139	67.5	2058	16.8	2804	83.2	33702	43.4	2943	82.3	35760
SE Alaska-I	0	0.0	0	0.0	5536	68.3	81035	40.4	5536	68.3	81035
Total 2A	13	65.3	199	0.0	716	93.5	7657	15.5	729	92.8	7856
Total 2B	11087	88.4	125364	53.4	3501	75.9	46114	72.3	14588	85.1	171478
Total 2C	139	67.5	2058	16.8	8340	72.7	114737	41.4	8479	72.6	116795
Total Area 2	11239	88.1	127621	52.8	12557	74.5	168508	48.5	23796	80.4	296129

1946	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	5	66.8*	75	0.0	895	88.4	10125	10.8	900	88.2	10200
Vancouver I.	310	66.8	4642	38.6	507	57.5	8810	23.2	817	60.7	13452
Charlotte-O	1474	89.5	16462	34.8	57	152.1	375	57.4	1531	90.9	16837
Charlotte-I	12449	88.4	140779	44.9	3591	95.0	37801	78.9	16040	89.8	178580
SE Alaska-O	184	63.0	2919	5.7	3853	89.8	42914	43.0	4037	88.1	45833
SE Alaska-I	0	0.0	0	0.0	5843	71.8	81390	41.8	5843	71.8	81390
Total 2A	5	66.7	75	0.0	895	88.4	10125	10.8	900	88.2	10200
Total 2B	14233	87.9	161883	43.7	4155	88.4	46986	71.8	18388	88.0	208869
Total 2C	184	63.0	2919	5.7	9696	78.0	124304	42.2	9880	77.7	127223
Total Area 2	14422	87.5	164877	43.2	14746	81.3	181415	48.7	29168	84.2	346292

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1947	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	4	108. 0*	37	0. 0	568	87. 2	6516	7. 1	572	87. 3	6553
Vancouver I.	569	108. 0	5270	30. 2	343	102. 2	3355	10. 7	912	105. 7	8625
Charlotte-O	1220	102. 2	11933	51. 2	0	0. 0	0	0. 0	1220	102. 2	11933
Charlotte-I	14975	89. 3	167647	53. 9	592	93. 6	6324	42. 3	15567	89. 5	173971
SE Alaska-O	275	158. 2	1738	62. 1	3425	89. 8	38146	44. 3	3700	92. 8	39884
SE Alaska-I	0	0. 0	0	0. 0	5768	73. 1	78949	47. 5	5768	73. 1	78949
Total 2A	4	108. 1	37	0. 0	568	87. 2	6516	7. 1	572	87. 3	6553
Total 2B	16764	90. 7	184850	52. 9	935	96. 6	9679	30. 7	17699	91. 0	194529
Total 2C	275	158. 2	1738	62. 1	9193	78. 5	117095	46. 3	9468	79. 7	118833
Total Area 2	17043	91. 3	186625	53. 0	10696	80. 2	133290	42. 8	27739	86. 7	319915

1948	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	407	100. 3	4059	18. 4	407	100. 3	4059
Vancouver I.	1129	102. 5	11017	23. 9	690	109. 3	6316	43. 1	1819	104. 9	17333
Charlotte-O	936	120. 4	7775	63. 6	0	0. 0	0	0. 0	936	120. 4	7775
Charlotte-I	11721	83. 8	139927	58. 5	3191	108. 7	29344	77. 7	14912	88. 1	169271
SE Alaska-O	418	140. 1	2984	56. 7	3350	104. 7	32003	37. 4	3768	107. 7	34987
SE Alaska-I	0	0. 0	0	0. 0	5985	76. 6	78119	41. 6	5985	76. 6	78119
Total 2A	0	0. 0	0	0. 0	407	100. 3	4059	18. 4	407	100. 3	4059
Total 2B	13786	86. 9	158719	56. 0	3881	108. 8	35660	71. 5	17667	90. 9	194379
Total 2C	418	140. 1	2984	56. 7	9335	84. 8	110122	40. 1	9753	86. 2	113106
Total Area 2	14204	87. 8	161703	56. 0	13623	90. 9	149841	48. 4	27827	89. 3	311544

1949	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	1	71. 8*	14	0. 0	617	95. 8	6439	24. 9	618	95. 8	6453
Vancouver I.	1166	71. 8	16250	11. 7	570	70. 5	8085	29. 1	1736	71. 3	24335
Charlotte-O	875	117. 8	7427	59. 9	0	0. 0	0	0. 0	875	117. 8	7427
Charlotte-I	11006	85. 9	128073	59. 2	2726	90. 5	30114	76. 9	13732	86. 8	158187
SE Alaska-O	532	160. 0	3325	57. 0	3603	102. 7	35094	48. 3	4135	107. 6	38419
SE Alaska-I	0	0. 0	0	0. 0	5316	74. 4	71434	35. 1	5316	74. 4	71434
Total 2A	1	71. 4	14	0. 0	617	95. 8	6439	24. 9	618	95. 8	6453
Total 2B	13047	86. 0	151750	55. 0	3296	86. 3	38199	68. 7	16343	86. 0	189949
Total 2C	532	160. 0	3325	57. 0	8919	83. 7	106528	40. 4	9451	86. 0	109853
Total Area 2	13580	87. 6	155089	55. 1	12832	84. 9	151166	46. 9	26412	86. 2	306255

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1950	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0.0	0	0.0	703	101.4	6936	14.8	703	101.4	6936
Vancouver I.	973	66.5	14629	5.9	572	86.1	6644	29.7	1545	72.6	21273
Charlotte-O	823	108.2	7604	49.1	46	120.6	381	59.8	869	108.8	7985
Charlotte-I	12192	87.5	139354	56.1	2879	102.9	27970	76.1	15071	90.1	167324
SE Alaska-O	136	104.8	1298	80.4	3070	90.7	33843	41.4	3206	91.2	35141
SE Alaska-I	0	0.0	0	0.0	5603	81.5	68742	40.2	5603	81.5	68742
Total 2A	0	0.0	0	0.0	703	101.4	6936	14.8	703	101.4	6936
Total 2B	13988	86.6	161587	52.2	3497	99.9	34995	68.3	17485	88.9	196582
Total 2C	136	104.8	1298	80.4	8673	84.5	102585	40.7	8809	84.8	103883
Total Area 2	14124	86.7	162885	52.4	12873	89.1	144516	46.7	26997	87.8	307401

1951	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0.0	0	0.0	585	110.8	5279	19.8	585	110.8	5279
Vancouver I.	788	32.1	24516	0.3	478	73.6	6495	57.6	1266	40.8	31011
Charlotte-O	1032	119.1	8667	60.6	1	61.2	16	100.0	1033	119.0	8683
Charlotte-I	13830	85.6	161585	55.5	3960	91.4	43310	78.5	17790	86.8	204895
SE Alaska-O	531	135.4	3922	63.2	3290	98.2	33509	38.1	3821	102.1	37431
SE Alaska-I	0	0.0	0	0.0	6103	95.6	63842	40.2	6103	95.6	63842
Total 2A	0	0.0	0	0.0	585	110.8	5279	19.8	585	110.8	5279
Total 2B	15650	80.4	194768	53.1	4439	89.1	49821	76.4	20089	82.1	244589
Total 2C	531	135.4	3922	63.2	9393	96.5	97351	39.5	9924	98.0	101273
Total Area 2	16181	81.4	198690	53.4	14417	94.6	152451	50.0	30598	87.1	351141

1952	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0.0	0	0.0	617	97.0	6361	20.4	617	97.0	6361
Vancouver I.	663	12.5	53040	0.0	336	73.7	4561	32.4	999	17.3	57601
Charlotte-O	1117	158.5	7046	62.3	35	118.0	297	56.3	1152	156.9	7343
Charlotte-I	14768	110.4	133782	57.0	3748	116.2	32249	80.2	18516	111.5	166031
SE Alaska-O	585	105.1	5565	77.3	2888	88.5	32640	56.4	3473	90.9	38205
SE Alaska-I	0	0.0	0	0.0	6051	105.9	57136	44.9	6051	105.9	57136
Total 2A	0	0.0	0	0.0	617	97.0	6361	20.4	617	97.0	6361
Total 2B	16548	85.4	193868	55.1	4119	111.0	37107	76.1	20667	89.5	230975
Total 2C	585	105.1	5565	77.3	8939	99.6	89776	48.7	9524	99.9	95341
Total Area 2	17133	85.9	199433	55.8	13675	102.6	133244	55.7	30808	92.6	332677

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1953	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	0	0.0	0	0.0	502	135.7	3698	23.2	502	135.7	3698
Vancouver I.	816	149.3*	5466	0.0	368	93.7	3925	42.4	1184	126.1	9391
Charlotte-O	1151	149.3	7710	49.5	22	173.8*	127	0.0	1173	149.7	7837
Charlotte-I	15821	130.7	121081	61.8	5626	173.8	32378	82.9	21447	139.8	153459
SE Alaska-O	273	103.8	2631	61.4	2423	102.0	23766	54.8	2696	102.1	26397
SE Alaska-I	0	0.0	0	0.0	5709	116.8	48896	52.3	5709	116.8	48896
Total 2A	0	0.0	0	0.0	502	135.7	3698	23.2	502	135.7	3698
Total 2B	17788	132.5	134257	58.1	6016	165.1	36430	80.1	23804	139.5	170687
Total 2C	273	103.8	2631	61.4	8132	111.9	72662	53.0	8405	111.6	75293
Total Area 2	18061	131.9	136888	58.2	14650	129.9	112790	63.1	32711	131.0	249678

1954	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	0	0.0	0	0.0	853	170.6	5001	18.1	853	170.6	5001
Vancouver I.	1293	138.9	9310	4.6	700	117.8	5942	28.9	1993	130.7	15252
Charlotte-O	1408	157.9	8915	56.2	5	158.5	32	100.0	1413	157.9	8947
Charlotte-I	14561	130.3	111772	58.6	7018	171.6	40896	82.2	21579	141.3	152668
SE Alaska-O	223	136.4	1635	46.4	2778	140.5	19774	51.6	3001	140.2	21409
SE Alaska-I	0	0.0	0	0.0	7952	134.4	59156	49.2	7952	134.4	59156
Total 2A	0	0.0	0	0.0	853	170.6	5001	18.1	853	170.6	5001
Total 2B	17262	132.8	129997	54.4	7723	164.8	46870	77.5	24985	141.3	176867
Total 2C	223	136.4	1635	46.4	10730	135.9	78930	49.8	10953	136.0	80565
Total Area 2	17485	132.8	131632	54.3	19306	147.6	130801	59.5	36791	140.2	262433

1955	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	0	0.0	0	0.0	612	123.3	4965	28.3	612	123.3	4965
Vancouver I.	693	121.2	5717	13.6	655	127.3	5144	39.8	1348	124.1	10861
Charlotte-O	952	150.1	6344	88.0	0	0.0	0	0.0	952	150.1	6344
Charlotte-I	10893	122.6	88872	66.1	5458	126.4	43192	78.9	16351	123.8	132064
SE Alaska-O	260	121.9	2133	59.0	2112	132.5	15938	62.8	2372	131.3	18071
SE Alaska-I	0	0.0	0	0.0	6171	114.0	54141	66.0	6171	114.0	54141
Total 2A	0	0.0	0	0.0	612	123.3	4965	28.3	612	123.3	4965
Total 2B	12538	124.2	100933	64.9	6113	126.5	48336	74.7	18651	124.9	149269
Total 2C	260	121.9	2133	59.0	8283	118.2	70079	65.2	8543	118.3	72212
Total Area 2	12798	124.2	103066	64.8	15008	121.6	123380	67.6	27806	122.8	226446

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1956	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	529	116. 8	4530	26. 3	529	116. 8	4530
Vancouver I.	736	89. 5	8227	13. 5	661	92. 6	7137	62. 7	1397	90. 9	15364
Charlotte-O	1548	172. 6	8969	80. 4	0	0. 0	0	0. 0	1548	172. 6	8969
Charlotte-I	12473	133. 9	93185	66. 8	4752	133. 3	35651	90. 7	17225	133. 7	128836
SE Alaska-O	230	135. 0	1704	85. 0	3743	152. 4	24555	60. 1	3973	151. 3	26259
SE Alaska-I	0	0. 0	0	0. 0	10425	131. 2	79484	63. 9	10425	131. 2	79484
Total 2A	0	0. 0	0	0. 0	529	116. 8	4530	26. 3	529	116. 8	4530
Total 2B	14757	133. 7	110381	65. 6	5413	126. 5	42788	87. 2	20170	131. 7	153169
Total 2C	230	135. 0	1704	85. 0	14168	136. 2	104039	62. 9	14398	136. 2	105743
Total Area 2	14987	133. 7	112085	65. 9	20110	132. 9	151357	68. 5	35097	133. 2	263442

1957	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	596	124. 3	4795	32. 9	596	124. 3	4795
Vancouver I.	608	94. 5	6436	16. 3	541	66. 7	8111	45. 9	1149	79. 0	14547
Charlotte-O	1505	132. 6	11352	85. 7	17	119. 9	142	100. 0	1522	132. 4	11494
Charlotte-I	11833	103. 3	114604	59. 5	3183	95. 9	33186	79. 2	15016	101. 6	147790
SE Alaska-O	364	133. 0	2737	71. 3	4000	112. 3	35623	63. 2	4364	113. 8	38360
SE Alaska-I	0	0. 0	0	0. 0	7887	93. 6	84233	58. 9	7887	93. 6	84233
Total 2A	0	0. 0	0	0. 0	596	124. 3	4795	32. 9	596	124. 3	4795
Total 2B	13946	105. 3	132392	60. 4	3741	90. 3	41439	74. 6	17687	101. 7	173831
Total 2C	364	133. 0	2737	71. 3	11887	99. 2	119856	60. 4	12251	99. 9	122593
Total Area 2	14310	105. 9	135129	60. 7	16224	97. 7	166090	62. 6	30534	101. 4	301219

1958	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	523	144. 5	3619	37. 7	523	144. 5	3619
Vancouver I.	871	85. 7	10162	1. 4	425	98. 9	4299	53. 4	1296	89. 6	14461
Charlotte-O	965	104. 5	9238	85. 5	50	142. 6	351	83. 0	1015	105. 9	9589
Charlotte-I	12802	110. 9	115433	58. 0	3418	116. 5	29335	87. 1	16220	112. 0	144768
SE Alaska-O	324	132. 8	2440	98. 0	4040	100. 9	40051	59. 9	4364	102. 7	42491
SE Alaska-I	0	0. 0	0	0. 0	6792	84. 4	80433	62. 5	6792	84. 4	80433
Total 2A	0	0. 0	0	0. 0	523	144. 5	3619	37. 7	523	144. 5	3619
Total 2B	14638	108. 6	134833	56. 4	3893	114. 6	33985	83. 4	18531	109. 8	168818
Total 2C	324	132. 8	2440	98. 0	10832	89. 9	120484	61. 6	11156	90. 8	122924
Total Area 2	14962	109. 0	137273	57. 3	15248	96. 5	158088	66. 3	30210	102. 3	295361

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1959	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	0	0.0	0	0.0	669	113.0	5920	39.5	669	113.0	5920
Vancouver I.	914	89.3	10238	13.4	732	108.4	6752	52.7	1646	96.9	16990
Charlotte-O	1183	108.4	10911	73.8	78	281.5	277	48.7	1261	112.7	11188
Charlotte-I	11204	93.2	120259	53.4	2884	102.0	28267	82.9	14088	94.9	148526
SE Alaska-O	856	143.8	5952	93.8	4620	109.1	42362	57.8	5476	113.3	48314
SE Alaska-I	0	0.0	0	0.0	7390	98.3	75143	62.0	7390	98.3	75143
Total 2A	0	0.0	0	0.0	669	113.0	5920	39.5	669	113.0	5920
Total 2B	13301	94.1	141408	52.4	3694	104.7	35296	76.2	16995	96.2	176704
Total 2C	856	143.8	5952	93.8	12010	102.2	117505	60.4	12866	104.2	123457
Total Area 2	14157	96.1	147360	54.9	16373	103.2	158721	63.1	30530	99.7	306081

1960	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	0	0.0	0	0.0	885	133.7	6618	34.0	885	133.7	6618
Vancouver I.	863	78.1	11046	4.1	584	108.4	5386	42.7	1447	88.1	16432
Charlotte-O	788	130.5	6036	75.0	48	119.9	401	66.7	836	129.9	6437
Charlotte-I	12593	112.4	112072	53.6	3306	126.1	26218	83.0	15899	115.0	138290
SE Alaska-O	774	111.1	6964	66.8	4675	109.1	42832	54.4	5449	109.4	49796
SE Alaska-I	0	0.0	0	0.0	7242	92.5	78331	68.9	7242	92.5	78331
Total 2A	0	0.0	0	0.0	885	133.7	6618	34.0	885	133.7	6618
Total 2B	14244	110.3	129154	51.8	3938	123.0	32005	76.9	18182	112.8	161159
Total 2C	774	111.1	6964	66.8	11917	98.4	121163	63.2	12691	99.1	128127
Total Area 2	15018	110.3	136118	52.6	16740	104.8	159786	64.9	31758	107.3	295904

1961	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	0	0.0	0	0.0	497	91.2	5449	25.1	497	91.2	5449
Vancouver I.	752	61.6	12198	7.0	501	95.7	5233	40.0	1253	71.9	17431
Charlotte-O	665	128.2	5187	62.2	0	0.0	0	0.0	665	128.2	5187
Charlotte-I	10991	104.9	104762	58.6	3183	106.7	29835	82.1	14174	105.3	134597
SE Alaska-O	628	104.0	6040	99.4	4272	103.6	41236	48.9	4900	103.6	47276
SE Alaska-I	0	0.0	0	0.0	7371	83.3	88490	60.2	7371	83.3	88490
Total 2A	0	0.0	0	0.0	497	91.2	5449	25.1	497	91.2	5449
Total 2B	12408	101.6	122147	55.7	3684	105.1	35068	76.3	16092	102.4	157215
Total 2C	628	104.0	6040	99.4	11643	89.8	129726	56.1	12271	90.4	135766
Total Area 2	13036	101.7	128187	57.8	15824	92.9	170243	59.8	28860	96.7	298430

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1962	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	449	98. 0	4579	16. 8	449	98. 1	4579
Vancouver I.	727	87. 3	8329	2. 7	446	76. 2	5857	47. 5	1173	82. 7	14186
Charlotte-O	976	114. 5	8525	62. 7	0	0. 0	0	0. 0	976	114. 5	8525
Charlotte-I	11319	88. 6	127702	47. 9	1710	90. 4	18924	79. 4	13029	88. 9	146626
SE Alaska-O	1111	101. 9	10899	79. 8	4907	89. 2	55036	48. 1	6018	91. 3	65935
SE Alaska-I	0	0. 0	0	0. 0	7073	71. 8	98528	50. 9	7073	71. 8	98528
Total 2A	0	0. 0	0	0. 0	449	98. 1	4579	16. 8	449	98. 1	4579
Total 2B	13022	90. 1	144556	46. 4	2156	87. 0	24781	73. 1	15178	89. 6	169337
Total 2C	1111	101. 9	10899	79. 8	11980	78. 0	153564	49. 7	13091	79. 6	164463
Total Area 2	14133	90. 9	155455	49. 1	14585	79. 7	182924	52. 2	28718	84. 9	338379

1963	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	412	67. 3	6121	21. 3	412	67. 3	6121
Vancouver I.	865	63. 3	13661	5. 7	309	63. 1	4898	35. 3	1174	63. 3	18559
Charlotte-O	1463	89. 2	16405	43. 9	107	146. 1	732	100. 0	1570	91. 6	17137
Charlotte-I	11202	88. 3	126855	46. 3	1917	95. 7	20029	65. 2	13119	89. 3	146884
SE Alaska-O	897	81. 4	11024	68. 3	3440	81. 5	42201	44. 6	4337	81. 5	53225
SE Alaska-I	0	0. 0	0	0. 0	5558	66. 6	83491	56. 8	5558	66. 6	83491
Total 2A	0	0. 0	0	0. 0	412	67. 3	6121	21. 3	412	67. 3	6121
Total 2B	13530	86. 2	156921	43. 4	2333	90. 9	25659	63. 4	15863	86. 9	182580
Total 2C	897	81. 4	11024	68. 3	8998	71. 6	125692	52. 1	9895	72. 4	136716
Total Area 2	14427	85. 9	167945	45. 0	11743	74. 6	157472	53. 3	26170	80. 4	325417

1964	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	280	107. 5	2604	31. 1	280	107. 5	2604
Vancouver I.	552	36. 5	15143	2. 0	214	66. 4	3223	33. 5	766	41. 7	18366
Charlotte-O	1722	119. 6	14400	63. 2	39	78. 1	499	82. 3	1761	118. 2	14899
Charlotte-I	8247	80. 0	103094	37. 4	1351	94. 3	14325	92. 2	9598	81. 7	117419
SE Alaska-O	876	79. 3	11042	80. 5	2380	80. 1	29716	75. 0	3256	79. 9	40758
SE Alaska-I	0	0. 0	0	0. 0	3908	68. 2	57320	47. 1	3908	68. 2	57320
Total 2A	0	0. 0	0	0. 0	280	107. 5	2604	31. 1	280	107. 5	2604
Total 2B	10521	79. 3	132637	39. 8	1604	88. 9	18047	84. 1	12125	80. 5	150684
Total 2C	876	79. 3	11042	80. 5	6288	72. 2	87036	57. 6	7164	73. 0	98078
Total Area 2	11397	79. 3	143679	42. 9	8172	75. 9	107687	61. 9	19569	77. 9	251366

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1965	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	214	84. 4	2534	38. 8	214	84. 5	2534
Vancouver I.	610	68. 2	8942	3. 1	210	65. 1	3224	24. 2	820	67. 4	12166
Charlotte-O	1908	100. 4	18998	58. 5	130	112. 0	1160	78. 1	2038	101. 1	20158
Charlotte-I	7961	83. 4	95501	28. 7	1545	96. 8	15961	83. 9	9506	85. 3	111462
SE Alaska-O	1805	91. 9	19649	82. 2	3451	86. 4	39957	57. 0	5256	88. 2	59606
SE Alaska-I	0	0. 0	0	0. 0	6418	85. 3	75205	49. 9	6418	85. 3	75205
Total 2A	0	0. 0	0	0. 0	214	84. 5	2534	38. 8	214	84. 5	2534
Total 2B	10479	84. 9	123441	32. 7	1885	92. 7	20345	76. 9	12364	86. 0	143786
Total 2C	1805	91. 9	19649	82. 2	9869	85. 7	115162	52. 4	11674	86. 6	134811
Total Area 2	12284	85. 8	143090	39. 9	11968	86. 7	138041	56. 0	24252	86. 3	281131

1966	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	183	101. 5	1803	33. 0	183	101. 5	1803
Vancouver I.	833	60. 6	13745	5. 8	129	92. 0	1403	37. 3	962	63. 5	15148
Charlotte-O	1401	101. 2	13848	40. 9	86	144. 0	597	94. 8	1487	102. 9	14445
Charlotte-I	7561	83. 5	90588	22. 2	1373	101. 2	13563	91. 4	8934	85. 8	104151
SE Alaska-O	1655	83. 9	19722	60. 0	3622	83. 2	43527	48. 3	5277	83. 4	63249
SE Alaska-I	0	0. 0	0	0. 0	6416	80. 0	80177	40. 8	6416	80. 0	80177
Total 2A	0	0. 0	0	0. 0	183	101. 5	1803	33. 0	183	101. 5	1803
Total 2B	9795	82. 9	118181	23. 4	1588	102. 0	15563	87. 2	11383	85. 1	133744
Total 2C	1655	83. 9	19722	60. 0	10038	81. 1	123704	43. 5	11693	81. 5	143426
Total Area 2	11450	83. 0	137903	28. 7	11809	83. 7	141070	49. 2	23259	83. 4	278973

1967	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	199	72. 0	2763	45. 9	199	72. 0	2763
Vancouver I.	818	53. 7	15245	4. 0	160	92. 9	1722	70. 7	978	57. 6	16967
Charlotte-O	1132	99. 5	11382	74. 5	44	98. 9	445	100. 0	1176	99. 4	11827
Charlotte-I	7114	83. 5	85237	37. 9	1084	100. 4	10794	89. 4	8198	85. 4	96031
SE Alaska-O	742	71. 0	10457	97. 4	2194	82. 4	26630	54. 8	2936	79. 2	37087
SE Alaska-I	0	0. 0	0	0. 0	6232	80. 4	77496	49. 6	6232	80. 4	77496
Total 2A	0	0. 0	0	0. 0	199	72. 0	2763	45. 9	199	72. 0	2763
Total 2B	9064	81. 0	111864	39. 4	1288	99. 4	12961	88. 1	10352	82. 9	124825
Total 2C	742	71. 0	10457	97. 4	8426	80. 9	104126	50. 9	9168	80. 0	114583
Total Area 2	9806	80. 2	122321	43. 8	9913	82. 7	119850	55. 7	19719	81. 4	242171

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1968	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	138	60. 9	2267	59. 9	138	60. 9	2267
Vancouver I.	806	50. 2	16066	5. 6	172	123. 1	1397	85. 5	978	56. 0	17463
Charlotte-O	966	87. 2	11076	60. 6	92	181. 8	506	93. 5	1058	91. 3	11582
Charlotte-I	7828	93. 9	83396	45. 7	715	113. 0	6325	94. 3	8543	95. 2	89721
SE Alaska-O	1011	79. 8	12666	70. 5	1455	80. 4	18088	65. 2	2466	80. 2	30754
SE Alaska-I	0	0. 0	0	0. 0	3211	85. 8	37405	53. 6	3211	85. 8	37405
Total 2A	0	0. 0	0	0. 0	138	60. 9	2267	59. 9	138	60. 9	2267
Total 2B	9600	86. 8	110538	43. 8	979	119. 0	8228	92. 7	10579	89. 1	118766
Total 2C	1011	79. 8	12666	70. 5	4666	84. 1	55493	57. 2	5677	83. 3	68159
Total Area 2	10611	86. 1	123204	46. 4	5783	87. 6	65988	63. 3	16394	86. 7	189192

1969	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	60	32. 4*	1849	0. 0	170	74. 8	2271	28. 7	230	55. 8	4120
Vancouver I.	709	32. 4	21853	1. 0	81	76. 9	1053	13. 6	790	34. 5	22906
Charlotte-O	1491	100. 2	14885	63. 3	136	131. 0	1038	100. 0	1627	102. 2	15923
Charlotte-I	10095	88. 2	114478	35. 3	650	107. 6	6039	84. 6	10745	89. 2	120517
SE Alaska-O	904	82. 9	10901	61. 9	2145	82. 1	26127	50. 8	3049	82. 3	37028
SE Alaska-I	0	0. 0	0	0. 0	5936	84. 3	70406	46. 0	5936	84. 3	70406
Total 2A	60	32. 4	1849	0. 0	170	74. 9	2271	28. 7	230	55. 8	4120
Total 2B	12295	81. 3	151216	36. 8	867	106. 6	8130	81. 0	13162	82. 6	159346
Total 2C	904	82. 9	10901	61. 9	8081	83. 7	96533	47. 3	8985	83. 6	107434
Total Area 2	13259	80. 9	163966	38. 3	9118	85. 3	106934	50. 1	22377	82. 6	270900

1970	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	1	24. 3*	41	0. 0	158	146. 6	1078	44. 8	159	142. 1	1119
Vancouver I.	590	24. 3	24281	0. 4	134	99. 3	1350	20. 5	724	28. 2	25631
Charlotte-O	829	78. 3	10586	51. 4	111	182. 5	608	95. 0	940	84. 0	11194
Charlotte-I	8730	87. 4	99871	32. 9	245	95. 4	2568	86. 5	8975	87. 6	102439
SE Alaska-O	997	69. 9	14269	56. 2	2117	72. 9	29058	41. 6	3114	71. 9	43327
SE Alaska-I	0	0. 0	0	0. 0	5973	79. 7	74919	43. 4	5973	79. 7	74919
Total 2A	1	24. 4	41	0. 0	158	146. 6	1078	44. 8	159	142. 1	1119
Total 2B	10149	75. 3	134738	32. 5	490	108. 3	4526	70. 4	10639	76. 4	139264
Total 2C	997	69. 9	14269	56. 2	8090	77. 8	103977	42. 9	9087	76. 8	118246
Total Area 2	11147	74. 8	149048	34. 7	8738	79. 7	109581	44. 5	19885	76. 9	258629

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1971	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	23	36.6	628	80.9	295	110.5	2670	27.2	318	96.4	3298
Vancouver I.	337	82.9*	4065	0.0	162	72.8	2226	21.6	499	79.3	6291
Charlotte-O	811	82.9	9783	49.1	5	54.7	91	100.0	816	82.6	9874
Charlotte-I	8192	82.5	99299	34.6	495	128.0	3868	92.8	8687	84.2	103167
SE Alaska-O	826	78.5	10516	69.9	1519	69.8	21763	36.8	2345	72.6	32279
SE Alaska-I	0	0.0	0	0.0	4108	66.7	61619	40.0	4108	66.7	61619
Total 2A	23	36.6	628	80.9	295	110.5	2670	27.2	318	96.4	3298
Total 2B	9340	82.5	113147	34.6	662	107.0	6185	75.5	10002	83.8	119332
Total 2C	826	78.5	10516	69.9	5627	67.5	83382	39.2	6453	68.7	93898
Total Area 2	10189	82.0	124291	37.6	6584	71.4	92237	42.3	16773	77.5	216528

1972	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	36	83.6	431	83.3	333	100.7	3308	9.3	369	98.7	3739
Vancouver I.	675	104.2	6477	5.9	132	39.2	3366	3.0	807	82.0	9843
Charlotte-O	1265	77.2	16396	16.2	88	130.7	673	63.9	1353	79.3	17069
Charlotte-I	7870	72.4	108712	28.8	249	84.7	2939	82.0	8119	72.7	111651
SE Alaska-O	671	63.0	10644	45.5	1655	79.3	20878	25.2	2326	73.8	31522
SE Alaska-I	0	0.0	0	0.0	3309	68.0	48630	30.5	3309	68.0	48630
Total 2A	36	83.5	431	83.3	333	100.7	3308	9.3	369	98.7	3739
Total 2B	9810	74.6	131585	25.6	469	67.2	6978	56.4	10279	74.2	138563
Total 2C	671	63.0	10644	45.5	4964	71.4	69508	28.8	5635	70.3	80152
Total Area 2	10517	73.7	142660	27.0	5766	72.3	79794	29.9	16283	73.2	222454

1973	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	9	63.6*	141	0.0	216	71.3	3031	29.7	225	70.9	3172
Vancouver I.	303	63.6	4761	0.9	162	68.0	2382	40.7	465	65.1	7143
Charlotte-O	600	65.6	9140	17.8	79	161.3	490	25.3	679	70.5	9630
Charlotte-I	5763	72.3	79708	34.4	67	55.4	1209	85.4	5830	72.0	80917
SE Alaska-O	689	91.5	7526	63.6	1265	67.9	18638	37.0	1954	74.7	26164
SE Alaska-I	0	0.0	0	0.0	3776	58.6	64423	33.3	3776	58.6	64423
Total 2A	9	63.8	141	0.0	216	71.3	3031	29.7	225	70.9	3172
Total 2B	6666	71.2	93609	31.4	308	75.5	4081	46.5	6974	71.4	97690
Total 2C	689	91.5	7526	63.6	5041	60.7	83061	34.2	5730	63.3	90587
Total Area 2	7364	72.7	101276	34.4	5565	61.7	90173	34.7	12929	67.5	191449

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1974	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	1	51. 6*	19	0. 0	514	60. 2	8543	14. 1	515	60. 1	8562
Vancouver I.	126	51. 6	2441	2. 5	69	58. 7	1175	100. 0	195	53. 9	3616
Charlotte-O	599	61. 0	9813	21. 1	2	18. 0	111	100. 0	601	60. 6	9924
Charlotte-I	3630	65. 6	55359	28. 2	198	106. 2	1864	83. 6	3828	66. 9	57223
SE Alaska-O	617	70. 7	8724	73. 7	1674	54. 6	30683	33. 4	2291	58. 1	39407
SE Alaska-I	0	0. 0	0	0. 0	3314	55. 7	59474	27. 8	3314	55. 7	59474
Total 2A	1	52. 6	19	0. 0	514	60. 2	8543	14. 1	515	60. 1	8562
Total 2B	4355	64. 4	67613	26. 5	269	85. 4	3150	91. 5	4624	65. 3	70763
Total 2C	617	70. 7	8724	73. 7	4988	55. 3	90157	29. 6	5605	56. 7	98881
Total Area 2	4973	65. 1	76356	32. 3	5771	56. 7	101850	31. 1	10744	60. 3	178206

1975	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	460	55. 4	8304	14. 8	460	55. 4	8304
Vancouver I.	462	82. 4*	5608	0. 0	155	61. 9	2506	81. 9	617	76. 0	8114
Charlotte-O	833	82. 4	10112	31. 4	18	62. 3	289	94. 4	851	81. 8	10401
Charlotte-I	5404	67. 8	79703	28. 3	255	87. 7	2909	73. 6	5659	68. 5	82612
SE Alaska-O	670	74. 3	9014	92. 1	1779	51. 4	34617	15. 8	2449	56. 1	43631
SE Alaska-I	0	0. 0	0	0. 0	3794	50. 5	75141	24. 5	3794	50. 5	75141
Total 2A	0	0. 0	0	0. 0	460	55. 4	8304	14. 8	460	55. 4	8304
Total 2B	6699	70. 2	95423	26. 8	428	75. 0	5704	77. 5	7127	70. 5	101127
Total 2C	670	74. 3	9014	92. 1	5573	50. 8	109758	21. 7	6243	52. 6	118772
Total Area 2	7369	70. 6	104437	32. 7	6461	52. 2	123766	24. 9	13830	60. 6	228203

1976	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	5	54. 8*	91	0. 0	233	26. 5	8794	5. 3	238	26. 8	8885
Vancouver I.	380	54. 8*	6929	0. 0	68	42. 3	1607	18. 2	448	52. 5	8536
Charlotte-O	676	54. 8	12326	24. 7	5	96. 1*	52	0. 0	681	55. 0	12378
Charlotte-I	5752	55. 0	104669	29. 7	402	96. 1	4182	39. 6	6154	56. 5	108851
SE Alaska-O	587	45. 6	12884	52. 3	1677	40. 4	41459	14. 9	2264	41. 7	54343
SE Alaska-I	0	0. 0	0	0. 0	3263	42. 1	77509	20. 0	3263	42. 1	77509
Total 2A	5	54. 9	91	0. 0	233	26. 5	8794	5. 3	238	26. 8	8885
Total 2B	6808	54. 9	123924	27. 6	475	81. 3	5841	36. 1	7283	56. 1	129765
Total 2C	587	45. 6	12884	52. 3	4940	41. 5	118968	18. 3	5527	41. 9	131852
Total Area 2	7400	54. 1	136899	29. 5	5648	42. 3	133603	19. 2	13048	48. 2	270502

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1977	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	7	60.4*	116	0.0	200	82.8*	2416	0.0	207	81.8	2532
Vancouver I.	338	60.4*	5595	0.0	25	82.8*	302	0.0	363	61.6	5897
Charlotte-O	644	60.4	10660	25.9	0	0.0	0	0.0	644	60.4	10660
Charlotte-I	4192	62.0	67568	26.9	228	82.8	2755	60.0	4420	62.9	70323
SE Alaska-O	526	68.0	7738	62.8	1019	49.1	20771	11.2	1545	54.2	28509
SE Alaska-I	0	0.0	0	0.0	1641	37.7	43484	23.8	1641	37.7	43484
Total 2A	7	60.3	116	0.0	200	82.8	2416	0.0	207	81.8	2532
Total 2B	5174	61.7	83823	25.0	253	82.8	3057	54.1	5427	62.5	86880
Total 2C	526	68.0	7738	62.8	2660	41.4	64255	19.0	3186	44.3	71993
Total Area 2	5707	62.3	91677	28.5	3113	44.6	69728	20.6	8820	54.6	161405

1978	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	3	66.6*	45	0.0	94	38.9	2417	4.5	97	39.4	2462
Vancouver I.	175	66.6	2629	12.5	16	81.0*	198	0.0	191	67.6	2827
Charlotte-O	482	73.3	6573	27.5	16	81.0*	198	0.0	498	73.5	6771
Charlotte-I	3707	62.2	59630	27.6	211	81.0	2606	52.5	3918	63.0	62236
SE Alaska-O	907	79.9	11347	21.8	1364	62.5	21837	12.3	2271	68.4	33184
SE Alaska-I	0	0.0	0	0.0	2045	46.3	44211	20.0	2045	46.3	44211
Total 2A	3	66.7	45	0.0	94	38.9	2417	4.5	97	39.4	2462
Total 2B	4364	63.4	68832	27.0	243	80.9	3002	45.6	4607	64.1	71834
Total 2C	907	79.9	11347	21.8	3409	51.6	66048	16.9	4316	55.8	77395
Total Area 2	5274	65.7	80224	26.1	3746	52.4	71467	18.4	9020	59.5	151691

1979	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	0	0.0	0	0.0	46	86.3*	533	0.0	46	86.3	533
Vancouver I.	245	50.0	4900	0.5	0	0.0	0	0.0	245	50.0	4900
Charlotte-O	984	62.0	15874	25.6	0	0.0	0	0.0	984	62.0	15874
Charlotte-I	3628	50.0	72583	30.6	0	0.0	0	0.0	3628	50.0	72583
SE Alaska-O	164	102.6	1599	46.0	1670	86.3	19342	10.9	1834	87.6	20941
SE Alaska-I	0	0.0	0	0.0	2696	77.5	34765	25.8	2696	77.5	34765
Total 2A	0	0.0	0	0.0	46	86.3	533	0.0	46	86.3	533
Total 2B	4857	52.0	93357	28.1	0	0.0	0	0.0	4857	52.0	93357
Total 2C	164	102.6	1599	46.0	4366	80.7	54107	20.1	4530	81.3	55706
Total Area 2	5021	52.9	94956	28.7	4412	80.7	54640	19.8	9433	63.1	149596

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1980	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	22	102. 2*	215	0. 0	22	102. 3	215
Vancouver I.	294	37. 2	7906	6. 0	0	0. 0	0	0. 0	294	37. 2	7906
Charlotte-O	854	63. 4	13473	17. 9	0	0. 0	0	0. 0	854	63. 4	13473
Charlotte-I	4502	67. 7	66529	31. 4	0	0. 0	0	0. 0	4502	67. 7	66529
SE Alaska-O	0	0. 0	0	0. 0	996	102. 2	9744	28. 3	996	102. 2	9744
SE Alaska-I	0	0. 0	0	0. 0	2242	75. 3	29769	16. 4	2242	75. 3	29769
Total 2A	0	0. 0	0	0. 0	22	102. 3	215	0. 0	22	102. 3	215
Total 2B	5650	64. 3	87908	28. 0	0	0. 0	0	0. 0	5650	64. 3	87908
Total 2C	0	0. 0	0	0. 0	3238	81. 9	39513	20. 1	3238	81. 9	39513
Total Area 2	5650	64. 3	87908	28. 0	3260	82. 1	39728	19. 9	8910	69. 8	127636

1981	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	202	32. 7	6185	9. 6	202	32. 7	6185
Vancouver I.	315	55. 7*	5659	0. 0	0	0. 0	0	0. 0	315	55. 7	5659
Charlotte-O	754	55. 7	13547	15. 0	0	0. 0	0	0. 0	754	55. 7	13547
Charlotte-I	4585	62. 0	73962	28. 1	0	0. 0	0	0. 0	4585	62. 0	73962
SE Alaska-O	0	0. 0	0	0. 0	1118	168. 0	6653	14. 3	1118	168. 0	6653
SE Alaska-I	0	0. 0	0	0. 0	2892	139. 0	20801	8. 9	2892	139. 0	20801
Total 2A	0	0. 0	0	0. 0	202	32. 7	6185	9. 6	202	32. 7	6185
Total 2B	5654	60. 7	93168	24. 8	0	0. 0	0	0. 0	5654	60. 7	93168
Total 2C	0	0. 0	0	0. 0	4010	146. 1	27454	10. 4	4010	146. 1	27454
Total Area 2	5654	60. 7	93168	24. 8	4212	125. 2	33639	10. 4	9866	77. 8	126807

Appendix Table 1. Catch, CPUE and Effort by Region, Regulatory Area and Country in Area 2.

1982	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	211	39. 3	5364	10. 7	211	39. 3	5364
Vancouver I.	264	21. 1	12496	0. 6	0	0. 0	0	0. 0	264	21. 1	12496
Charlotte-O	659	72. 6	9073	25. 6	0	0. 0	0	0. 0	659	72. 6	9073
Charlotte-I	4313	66. 1	65272	23. 6	0	0. 0	0	0. 0	4313	66. 1	65272
SE Alaska-O	0	0. 0	0	0. 0	1191	144. 4	8249	8. 4	1191	144. 4	8249
SE Alaska-I	0	0. 0	0	0. 0	2294	186. 3	12316	13. 3	2294	186. 3	12316
Total 2A	0	0. 0	0	0. 0	211	39. 3	5364	10. 7	211	39. 3	5364
Total 2B	5236	60. 3	86841	22. 7	0	0. 0	0	0. 0	5236	60. 3	86841
Total 2C	0	0. 0	0	0. 0	3485	169. 5	20565	11. 6	3485	169. 5	20565
Total Area 2	5236	60. 3	86841	22. 7	3696	142. 5	25929	11. 6	8932	79. 2	112770

(*) indicates extrapolated value from adjacent region.

II. Biomass, Surplus Production, and Reproductive Value of the Pacific Halibut Population in Area 2

by

Richard B. Deriso and Terrance J. Quinn II

ABSTRACT

Analyses of halibut catch-effort, age structure, and stock assessment information resulted in estimates of historical abundance, productivity, and reproductive success in the subareas 2A, 2B, and 2C of Regulatory Area 2. One method of estimating historical abundance was based on traditional cohort analysis and CPUE (catch-per-unit-effort) data. A new method, migratory cohort analysis, was derived which incorporated migration rates between subareas. The average percentages of halibut biomass in subareas 2A, 2B, and 2C were historically in the ranges 3-4%, 50-58%, and 39-47%, respectively, while the average percentages of annual surplus production were in the ranges 2-3%, 60-70%, and 30-40%. Estimated survival of young halibut in Area 2 after 1950 was lower than previous years, especially in subarea 2B, indicating a possible decline in resource productivity. Of particular concern is an apparent shift in sex-ratio of the halibut resource of Area 2B during the 1970's which reduced the estimated reproductive value of young female halibut. Hypotheses are offered to account for changes in survival of young and reproductive value, including problems with accuracy of data and regulation changes affecting minimum retention size, but conclusive evidence is not yet available.

II. Biomass, Surplus Production, and Reproductive Value of the Pacific Halibut Population in Area 2

by

Richard B. Deriso and Terrance J. Quinn II

INTRODUCTION

In 1979, the governments of the United States and Canada reached an agreement to phase out reciprocal fishing privileges of their fishermen. A major management implication of the agreement was that separate catch limits be set for each nation's waters. The agreement stipulated that the division of the catch in Regulatory Area 2 of the International Pacific Halibut Commission should be 60% in Canada and 40% in the United States. This division was based on long-term catch information (Hoag et al., Section I of this report). In practice, catch limits are set for three subareas of Area 2: Area 2A — U.S. waters south of the Strait of Juan de Fuca, Area 2B — Canadian waters in Area 2, Area 2C —northern U.S. waters in Area 2.

In this report, we provide estimates of historical abundance and related assessment information in Area 2 by subarea and examine the biological basis for the 60%/40% division of catches between Canadian and U.S. waters in Area 2. Previous estimates of Area 2 abundance were made using catch-per-unit-effort (CPUE) information (Chapman et al. 1962) or cohort analysis of catch-age information (Hoag and McNaughton 1978). A major limitation of the previous CPUE analysis is that it required equilibrium conditions to determine abundance. A major limitation of cohort analysis is that a year-class must be present in a single area throughout its fishable life. Analyses of Pacific halibut abundance must account for substantial migration of fish between subareas.

We develop two distinct procedures for estimating abundance of halibut in subareas of Area 2. The first procedure relies on a subarea breakdown of setline CPUE data as a basis for partitioning total abundance among subareas. Total abundance, in turn, is based on traditional cohort methodology with an updating algorithm for the most recent years. The second procedure, migratory cohort analysis, is a modification of traditional cohort analysis that accounts for fish migration. Migratory cohort analysis is applied to catch-age information to produce direct estimates of subarea abundance. For both procedures, important information about population dynamics is presented in addition to abundance estimation. This information includes surplus production and year-class strength.

Reproductive value of Area 2B halibut is also investigated in this report as a fundamental element of population dynamics. Reproductive value refers to the average number of female progeny produced during the lifetime of a female halibut. Our analysis focuses on recent changes in reproductive value because of its importance to the future growth potential of the resource and because relevant data are now available. The influence of the change in minimum size limit from 26 to 32 inches in 1973 on sex ratio and reproductive value is given special emphasis in this study.

TRADITIONAL COHORT AND CPUE PROCEDURE

In this section, subarea biomass and productivity of halibut are estimated using our first procedure, which consists of two stages. First, we present estimates of total abundance in Area 2. Next, subarea estimates are based on a partitioning of total abundance using relative CPUE data. An advantage of this procedure, as compared to our second procedure, is that abundance estimates are made up to 1980.

Area 2 Abundance and Productivity Estimates

Cohort analysis is a procedure using catch-age information to estimate historical abundance and fishing mortality (Hoag and McNaughton 1978), assuming that no substantial migration into or out of the population area occurs. This assumption is not strictly true for Area 2, because migration occurs from Area 3 to Area 2. In a later section, migratory cohort analysis is developed to overcome this problem, and the impact of migration on these results is shown.

The method requires a prior estimate of mortality from sources other than the halibut commercial fishery, such as natural mortality and mortality from incidental catches, primarily from trawl fisheries. This mortality is set equal to 0.2 in accord with other published work (IPHC 1960, Chapman et al. 1962, Hoag and McNaughton 1978). The method also requires a value for fishing mortality of the oldest age of each year-class. Abundance estimates are back-calculated from the oldest age to age 8. Earlier ages are not included because there is no reliable age-structure information concerning losses from incidental catch, which primarily affects young fish. When cumulative fishing mortality exceeds 1.0, the estimates of abundance for ages beyond that point are only slightly affected by the starting value for fishing mortality. For this reason, estimates in the most recent years are the least reliable. Cohort analysis also produces estimates of fishing mortality for each age each year, requiring no assumptions about age selectivity. No estimates of variability are yet available with this procedure. The sensitivity of the procedure is reviewed by Hoag and McNaughton (1978). They applied cohort analysis to data from IPHC regulatory Areas 2 and 3 between 1935 and 1976.

An updating procedure is required to obtain estimates of abundance for recent years, described in greater detail in Quinn et al., (1982a). The updating procedure, a modification of Doubleday (1976), uses catch-age information from recent years 1967-1980 for ages 8-20 to estimate year-class strength and fishing mortality. Fishing mortality is assumed to factor into age-selectivity and yearly fishing mortality of fully-recruited ages. Based on gear selectivity studies (Myhre 1968), age-selectivity is set to 1.0 for ages 15-20. Age-selectivity of the gear is assumed to be constant over a period of years, in contrast to cohort analysis. Because the minimum size limit changed in 1973, one set of selectivity parameters is used before 1973, and one set of selectivity parameters is used after 1973. Estimates of parameters are obtained using non-linear least squares on logarithmic-transformed catch-age data. To stabilize the estimates, the value of fishing mortality for 1980 is estimated as average catchability for 1973-1980 times fishing effort in 1980. All other estimates of yearly fishing mortality are independent of fishing effort.

Fishing mortality estimates from the updating procedure of the oldest age each year and of all ages in the last year are used as starting values in cohort analysis of the 1947 to 1972 year-classes. For earlier year-classes, the starting value of 0.2 is used in accord with Hoag and McNaughton (1978).

Table 1. **Estimated year-class strength (number of 8 year-olds), and abundance, and biomass of adults (8-20 year-olds) in Area 2.**

YEAR	YEAR-CLASS STRENGTH (thousands)	ABUNDANCE (thousands)	BIOMASS (thousand pounds)
1935	2094	7251	114789
1936	2082	6964	120027
1937	3180	7755	127391
1938	2856	8034	117868
1939	2680	8151	124303
1940	2447	7840	124716
1941	2323	7657	110900
1942	2061	7289	100891
1943	2735	7768	116004
1944	3568	9071	108492
1945	3974	10125	166070
1946	4037	11435	177524
1947	3984	12025	165299
1948	3922	12468	191689
1949	4178	13144	181674
1950	3922	13404	226225
1951	3649	13312	191233
1952	3994	13424	207935
1953	2447	11972	210640
1954	2467	10804	194102
1955	1704	8980	193514
1956	1684	8046	173441
1957	1602	6973	154730
1958	1916	6570	157968
1959	2989	7487	175825
1960	2300	7493	178788
1961	2079	7221	163321
1962	2044	7014	165988
1963	2118	6908	168242
1964	1537	6388	142007
1965	1707	6294	137097
1966	1466	5794	134139
1967	1079	5039	130437
1968	974	4532	119101
1969	1460	4725	122649
1970	1095	4357	105156
1971	1157	4193	114082
1972	1101	4110	94365
1973	969	3829	114644
1974	988	3805	113785
1975	993	3832	106596
1976	953	3739	114510
1977	1138	3877	116922
1978	1151	4101	116879
1979	1219	4351	123084
1980	1025	4333	110508

Results from updated cohort analysis are summarized in terms of year-class strength, adult numerical abundance, and adult biomass. The number of age 8 fish is used as an index of year-class strength. Adults are defined as 8-20 year-olds. Adult numerical abundance is the sum of abundance over age. Adult biomass is the sum of numerical abundance times average fish weight by age.

Estimates of year-class strength, adult abundance, and adult biomass from 1935-1980 are shown in Table 1. Estimated year-class strength was much higher in the period 1945-1952 than in other years. There was a long-term decrease in year-class strength between 1952 and 1967. Since 1967, year-class strength has been fairly constant but at a substantially reduced level compared to earlier years.

Estimated adult abundance increased substantially between 1935 and 1952, decreased to a low point in 1976, and has increased slightly since then. Current adult abundance is about 30% of the estimated maximum over the period 1935-1980.

Estimates of adult biomass follow a similar pattern, but are more variable than estimates of abundance, due to variability in average weight estimates, which are obtained from sampling commercial landings. Current biomass has been fairly constant since 1970 at a level of 50% of the estimated maximum biomass over the period 1935-1980. The percentage is higher for biomass because average weight of halibut has increased.

Annual Surplus Production (ASP) is defined as the excess of what is required to replenish the population biomass each year due to removals from fishing and other causes. If factors affecting the population and the fishery are constant, then biomass increases when catch is held below surplus production, and vice versa. ASP is estimated by the annual change in biomass added to the catch (Quinn et al., in press, a), both of which fluctuate yearly. To remove such extraneous variability, both biomass and ASP estimates are smoothed by a robust, non-linear procedure (Velleman 1980; algorithm

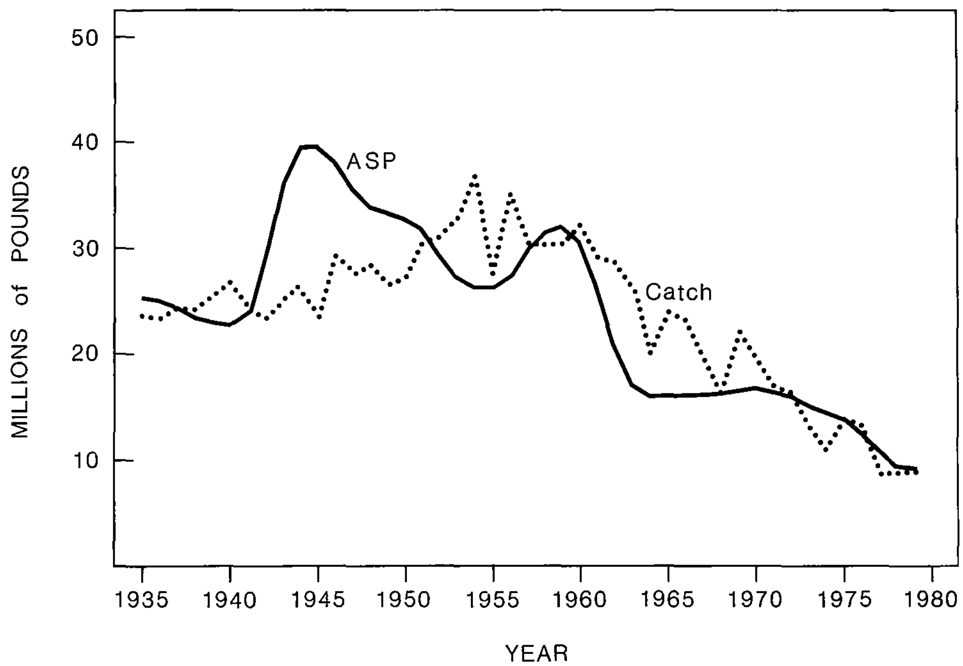


Figure 1. Smoothed Annual Surplus Production (ASP) estimates and catch in Area 2, 1935-1979.

4253H, twice), which is well-suited to data with heavy-tailed variability. These estimates do not include removals from incidental catches since 1960, because information is limited and because it is not yet known to what extent incidental catch losses in Areas 3 and 4 affect recruitment into Area 2. Thus, the estimates reflect the surplus available to the commercial setline fishery rather than total productivity.

Smoothed ASP estimates and catches since 1935 are contrasted in Figure 1 and smoothed biomass is plotted in Figure 2. The increase in biomass in the 1940's created a surplus which was followed by increased catches (Figure 1). When catches exceeded ASP estimates in the 1950's and 1960's, biomass and ASP decreased substantially. In the 1970's catches have been held slightly below ASP.

Fishing mortality estimates from updated cohort analysis are obtained for each age and year. Average fishing mortality of fully-recruited ages (ages 15-20) has ranged between 0.10 and 0.40 and averages 0.20 (Table 2). Average fishing mortality of ages 8-14, which constitute the bulk of the catch, is lower, ranging from 0.08 to 0.25 and averaging 0.16 (Table 2). Average fishing mortality is positively correlated with fishing effort (Table 2), as evidenced by Spearman rank correlation coefficients [0.48 ($P<.001$) for ages 15-20; 0.68 ($P<.001$) for ages 8-14]. There is much unexplained variability in this relationship, however, which may be due to estimation variability or to changes in catchability of fish.

Annual estimates of age selectivity are obtained from cohort analysis results by dividing fishing mortality for each age by the average fishing mortality of fully-recruited ages (assumed to be ages 15-20). These estimates tend to be quite variable from year to year, suggesting that fishermen may shift effort to different components of the age distribution and also that the method is sensitive to errors in the catch data. Selectivity estimates of age 8-11 fish after 1973 are generally lower than previous years, a result of changing the minimum size limit (Table 3).

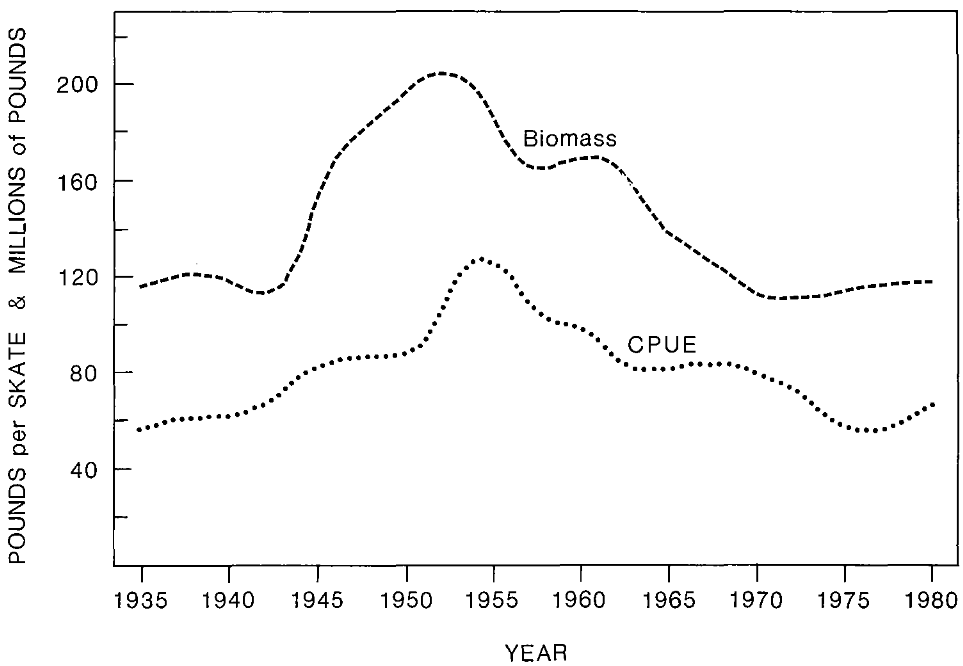


Figure 2. Smoothed catch-per-unit-effort (CPUE) in pounds/skate and smoothed biomass estimates from cohort analysis, 1935-1980.

Table 2. **Estimates of fishing mortality (F) for younger (ages 8-14) and older (ages 15-20) fish and fishing effort (in skates).**

Year	F Ages 8-14	F Ages 15-20	Fishing Effort
1935	0.1981	0.1660	381870
1936	0.2540	0.3783	426756
1937	0.2100	0.3068	392896
1938	0.1851	0.2623	345043
1939	0.2347	0.3357	416975
1940	0.1909	0.2595	422409
1941	0.1889	0.1772	385028
1942	0.2054	0.3352	356744
1943	0.1419	0.1407	342493
1944	0.2390	0.2975	299718
1945	0.1289	0.1857	297715
1946	0.1574	0.1895	347883
1947	0.1656	0.2350	318632
1948	0.1407	0.1838	311351
1949	0.1454	0.1983	306646
1950	0.1329	0.1252	307816
1951	0.1584	0.2482	352648
1952	0.1610	0.1858	333075
1953	0.1760	0.2487	252177
1954	0.2033	0.2498	263070
1955	0.1453	0.1230	226216
1956	0.2074	0.2145	263807
1957	0.1984	0.2133	301446
1958	0.1801	0.2265	295711
1959	0.1687	0.1898	306671
1960	0.1704	0.1643	296062
1961	0.1790	0.1590	298304
1962	0.1864	0.1725	339421
1963	0.1567	0.1575	326139
1964	0.1359	0.1543	251772
1965	0.1849	0.1888	276823
1966	0.1901	0.2257	279179
1967	0.1460	0.1420	242101
1968	0.1296	0.1592	189294
1969	0.1790	0.2360	270647
1970	0.1804	0.2805	258438
1971	0.1260	0.1578	213977
1972	0.1631	0.1925	221292
1973	0.1091	0.1805	192169
1974	0.1006	0.1690	178808
1975	0.1384	0.2220	230518
1976	0.1220	0.2613	274251
1977	0.0831	0.1423	162952
1978	0.0803	0.1008	152193
1979	0.0863	0.0977	155046
1980	0.0807	0.1370	127047

Table 3. Estimates from cohort analysis of average age selectivity for three time periods in Area 2.

	TIME PERIODS		
Age	Years 1935-1966	Years 1967-1972	Years 1973-1980
8	.64	.61	.27
9	.80	.70	.42
10	.88	.80	.57
11	.89	.85	.66
12	.93	.88	.83
13	.98	.95	.84
14	.95	.92	.92
15	.96	1.00	1.04
16	.96	1.04	1.08
17	1.09	1.04	1.05
18	1.01	0.88	1.03
19	.94	.94	.83
20	1.00	1.10	.97

Catchability, the ratio of fishing mortality to fishing effort, represents the probability of catching a fish with a unit of effort. There are considerable fluctuations in catchability estimates over time and between younger and older fish. In order to examine trends, catchability estimates are smoothed by Velleman's procedure and plotted in Figure 3. Estimates of catchability are similar in the period 1935-1952 which was a time of fairly constant catches (Figure 1) and a growth of stock (Figure 2). This period was followed by a period of high catchability (1953-1957) when the highest catches since the early 1920's were taken. A period of lower catchability (1958-1965) accompanied declining catches and ASP. During the 1958-1965 period, older fish became less catchable compared to younger fish. Since 1965, older fish have become more catchable, but younger fish have become less catchable, especially after the change in the minimum size limit in 1973.

The standard index of halibut biomass is CPUE — an accurate index when catchability is constant. For smoothed Area 2 data, CPUE and biomass show the same trend over the period 1935-1980 (Figure 2). The good relationship between biomass based on catch-age analysis and CPUE based on fishing success information provides support for their use in examining changes in biomass. Current stock biomass in Area 2 is low, but slightly above the historical low level found in the early 1930's. There are discrepancies between the two measures of biomass, however, which probably result from the short-term trends in catchability and selectivity. Several years of CPUE data are needed to establish a trend in abundance because of year-to-year fluctuations in catchability. Catch-age analysis is a necessary counterpart to CPUE information, because it does not assume constant catchability, except to obtain the most recent estimates of abundance.

Additional analyses not published in this report explore the effect of the parameter for mortality (X) from causes other than fishing. When X is increased from 0.20 to 0.25, year-class strength estimates increase, fishing mortality (F) estimates decrease, and age-selectivity estimates decrease slightly. When X is decreased from 0.20 to 0.15, the opposite occurs. Total mortality, the sum of F and X, is about the same for all three cases. Thus, this method produces accurate estimates of total mortality, but the correct partitioning into F and X requires a precise estimate of X. Because abundance is related to the ratio of catch and F, an underestimate of F will produce an overestimate of abundance and vice versa.

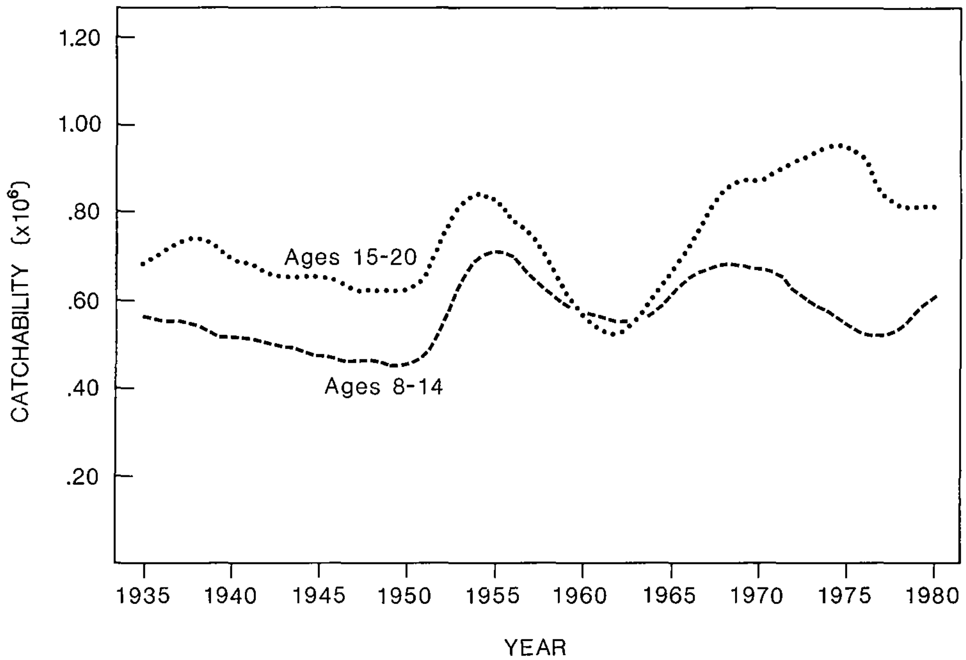


Figure 3. Smoothed estimates of average catchability of ages 8-14 and 15-20, 1935-1980.

Subarea Abundance and Productivity Estimates

In this section, biomass estimates for Area 2 are partitioned into subareas according to relative habitat and relative changes in density measured by CPUE. Annual surplus production for each subarea is determined from historical commercial setline catches and changes in estimated biomass.

CPUE is a measure of stock density in the area of fishing. A density measure must be multiplied by the area occupied by the stock (termed utilized habitat) to obtain a measure of biomass that can be compared between areas (Quinn et al. 1982). Utilized habitat was estimated from the compilation of daily fishing locations using vessel logbook data from 1930 to 1975. The percentages of utilized habitat for Areas 2A, 2B, and 2C are 3.7%, 57.5%, and 38.8%, respectively (Hoag et al., Section I of this report). Current habitat used by halibut is greatly reduced from the mid-1950's due to a lower abundance of stocks, but these values will be used for all years as a relative indicator between subareas. Independent estimates of relative habitat from catch data are currently under investigation.

The annual proportion of Area 2 biomass, called relative biomass, in each of the three subareas is estimated by the equation

$$P_r = a_r CPUE_r / \sum_{s=2A}^{2C} a_s CPUE_s$$

Table 4. **Smoothed relative biomass in Subareas 2A, 2B, and 2C, 1935-1980.**

	SUBAREAS		
Year	2A	2B	2C
1935	0.0262	0.5576	0.4162
1936	0.0268	0.5637	0.4095
1937	0.0280	0.5780	0.3939
1938	0.0290	0.5888	0.3822
1939	0.0294	0.5912	0.3794
1940	0.0299	0.5860	0.3841
1941	0.0308	0.5756	0.3937
1942	0.0315	0.5697	0.3988
1943	0.0318	0.5708	0.3973
1944	0.0322	0.5809	0.3869
1945	0.0334	0.5960	0.3706
1946	0.0363	0.6012	0.3625
1947	0.0396	0.5971	0.3633
1948	0.0410	0.5896	0.3694
1949	0.0397	0.5784	0.3819
1950	0.0366	0.5683	0.3951
1951	0.0346	0.5648	0.4006
1952	0.0340	0.5674	0.3986
1953	0.0337	0.5750	0.3913
1954	0.0336	0.5831	0.3833
1955	0.0336	0.5859	0.3805
1956	0.0340	0.5857	0.3804
1957	0.0357	0.5848	0.3795
1958	0.0381	0.5873	0.3746
1959	0.0392	0.5951	0.3657
1960	0.0386	0.6012	0.3602
1961	0.0368	0.6033	0.3598
1962	0.0352	0.6035	0.3614
1963	0.0346	0.6004	0.3650
1964	0.0353	0.5940	0.3707
1965	0.0371	0.5869	0.3760
1966	0.0389	0.5825	0.3787
1967	0.0398	0.5804	0.3798
1968	0.0415	0.5778	0.3807
1969	0.0445	0.5749	0.3806
1970	0.0467	0.5750	0.3783
1971	0.0470	0.5800	0.3729
1972	0.0450	0.5876	0.3674
1973	0.0403	0.5963	0.3635
1974	0.0362	0.6086	0.3551
1975	0.0342	0.6232	0.3426
1976	0.0319	0.6329	0.3352
1977	0.0290	0.6289	0.3421
1978	0.0269	0.5967	0.3764
1979	0.0256	0.5389	0.4355
1980	0.0245	0.4773	0.4982

where P_r is relative biomass, a_r is relative utilized habitat, and $CPUE_r$ is CPUE in subarea r. Relative biomass is then smoothed across time by Velleman's (1980) procedure to remove variability caused by year-to-year fluctuations in CPUE.

Estimated relative biomass for each subarea is given in Table 4. Average relative biomass in Area 2A is 3.5% between 1935 and 1980. However, fishing and logbook information for this subarea is limited and results may not be highly accurate. Area 2B has the highest average at 58.4% while Area 2C averages 38.1% relative biomass. Generally, relative biomasses in Area 2B and Area 2C are negatively correlated, ranging from a ratio of 63:33 (2B:2C) in 1976 to 48:50 only four years later in 1980. The recent change in estimated relative biomass between Area 2B and Area 2C is without historical precedent. Until further studies on factors affecting reliability of CPUE are completed, we cannot regard recent subarea biomass estimates reliable.

Estimates of subarea biomass are obtained by multiplying relative subarea biomass by total Area 2 biomass (Table 5). Estimates for the 1935-1970 period are separated from the 1971-1980 period for comparability with results from our second procedure. Subarea biomass follows Area 2 biomass trends very closely. Estimates of biomass after 1973 should be viewed with caution for several reasons. The change in the minimum size limit in 1973 shifted effort from younger fish to older fish in Area 2B, thus affecting the stock component measured by CPUE. In addition, recent estimates of biomass lack precision because young adult halibut have been present in the fishery for only a few years.

Annual surplus production (ASP) for each subarea is estimated by the sum of catch and the annual change in subarea biomass, followed by data smoothing over time, as was done previously for Area 2 as a whole. Results for 1935 to 1980 are given in Table 5, but recent estimates should be viewed with caution because of problems discussed earlier about the accuracy of recent biomass estimates. In Area 2A, ASP declined from over 1 million pounds before 1950 to only 100-200 thousand pounds

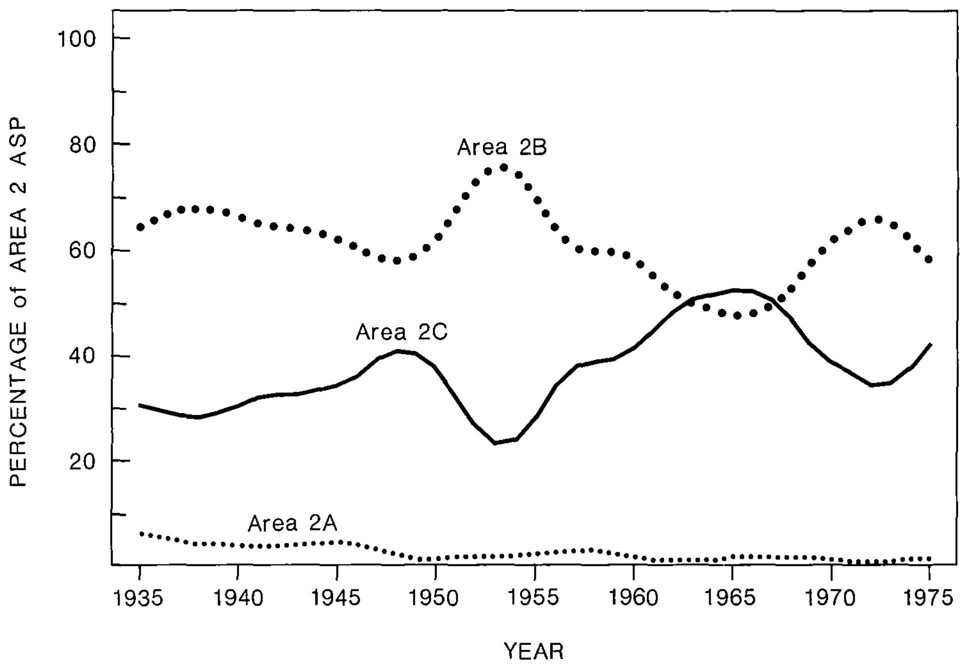


Figure 4. Percentage of total Area 2 ASP by subareas, 1935-1975.

Table 5. **Estimated biomass and annual surplus production (millions of pounds) for subareas in Area 2, 1935-1980.**

YEAR	BIOMASS 2A	BIOMASS 2B	BIOMASS 2C	BIOMASS AREA 2	ANNUAL SURPLUS PRODUCTION 2A	ANNUAL SURPLUS PRODUCTION 2B	ANNUAL SURPLUS PRODUCTION 2C	ANNUAL SURPLUS PRODUCTION AREA 2
1935	3.1	65.1	48.7	116.8	1.6	16.2	7.7	25.4
1936	3.2	67.0	48.2	118.4	1.3	16.4	7.5	25.2
1937	3.4	69.6	47.6	120.6	1.1	16.4	7.1	24.6
1938	3.5	71.2	47.0	121.6	1.0	15.9	6.7	23.6
1939	3.6	71.1	46.4	121.1	1.0	15.6	6.5	23.1
1940	3.6	69.1	45.7	118.4	0.9	15.4	6.6	22.9
1941	3.5	66.2	44.9	114.7	0.9	15.9	7.4	24.3
1942	3.5	65.0	44.6	113.2	1.1	18.9	9.5	29.5
1943	3.7	66.8	45.5	116.0	1.5	23.0	11.9	36.4
1944	4.2	75.5	49.8	129.5	1.7	24.8	13.3	39.7
1945	5.2	89.9	56.6	151.7	1.7	24.5	13.6	39.8
1946	6.2	100.6	62.0	168.9	1.5	23.1	13.7	38.3
1947	6.9	105.6	65.1	177.7	1.1	21.0	13.7	35.7
1948	7.3	108.3	68.2	183.8	0.7	19.8	13.6	34.1
1949	7.4	109.9	72.6	189.9	0.5	19.8	13.2	33.5
1950	7.3	112.2	77.4	196.9	0.5	20.3	12.2	33.0
1951	7.1	115.2	80.6	203.0	0.5	21.0	10.4	31.9
1952	7.0	116.9	81.4	205.3	0.4	21.2	8.0	29.7
1953	6.9	117.4	80.1	204.4	0.4	20.6	6.4	27.4
1954	6.7	115.7	76.9	199.3	0.5	19.9	6.2	26.5
1955	6.3	109.4	71.5	187.3	0.5	18.8	7.2	26.5
1956	6.0	101.5	65.9	173.5	0.6	17.7	9.3	27.6
1957	6.0	97.2	62.6	165.8	0.7	18.0	11.3	30.0
1958	6.2	97.4	61.6	165.3	0.7	18.8	12.2	31.7
1959	6.4	99.9	61.5	167.8	0.7	19.0	12.3	32.0
1960	6.5	102.0	61.4	169.8	0.5	17.8	12.3	30.5
1961	6.2	102.3	61.2	169.7	0.3	14.2	11.4	25.8
1962	5.9	100.2	60.2	166.3	0.1	10.4	9.7	20.2
1963	5.5	94.7	57.7	157.9	0.1	8.4	8.5	17.0
1964	5.2	87.3	54.4	146.9	0.1	7.8	8.3	16.2
1965	5.1	81.3	51.9	138.2	0.2	7.6	8.5	16.3
1966	5.1	77.5	50.4	133.0	0.2	7.6	8.5	16.3
1967	5.1	74.4	48.8	128.4	0.2	7.9	8.2	16.3
1968	5.2	70.9	46.8	122.9	0.2	8.6	7.7	16.5
1969	5.2	67.4	44.5	117.2	0.1	9.6	7.0	16.7
1970	5.1	64.9	42.6	112.6	0.1	10.3	6.4	16.8
Avg.	5.4	89.1	58.1	152.6	0.7	16.4	9.6	26.7
Pcntg.	3.5	58.3	33.0	100.0	2.6	61.4	36.0	100.0
1971	5.1	64.3	41.4	110.8	0.1	10.6	5.9	16.6
1972	4.9	65.0	40.8	110.7	0.1	10.5	5.4	15.9
1973	4.6	66.3	40.1	111.0	0.1	9.8	5.2	15.1
1974	4.1	68.4	39.4	112.0	0.1	8.8	5.4	14.4
1975	3.9	70.7	39.1	113.7	0.1	7.6	6.0	13.7
1976	3.6	72.2	39.4	115.2	0.1*	5.7*	6.8*	12.6
1977	3.4	72.2	40.7	116.3	0.0*	2.8*	8.1*	10.8
1978	3.2	68.9	44.8	116.9	0.0*	0.0*	9.5*	9.5
1979	3.0	62.9	51.1	117.0	-0.1*	-1.6*	10.7*	9.0
1980	2.9	57.3	56.7	116.9	—	—	—	—
Avg.	3.9	66.8	43.3	114.0	0.1	6.0	7.0	13.1
Pcntg.	3.4	58.6	38.0	100.0	0.8	45.8	53.4	100.0

(*) unreliable values

since 1960. ASP in Area 2B increased during the population increase in the early 1940's, decreased from 25 million pounds to under 10 million pounds by 1962, and oscillated between 8 and 10 million pounds between 1962 and 1975. ASP has oscillated considerably in Area 2C, ranging from 6 to 14 million pounds between 1935 and 1960 and declining from 12 million pounds in 1960 to about 5 million pounds in 1973. The percentages of total Area 2 ASP by subarea have oscillated considerably between 1935 and 1975 (Figure 4). Area 2B accounted for 60% to 70% of total Area 2 ASP before 1960 and from 50% to 60% between 1960 and 1975. Only 2% or 3% of total ASP is accounted for by Area 2A.

MIGRATORY COHORT PROCEDURE

Traditional cohort analysis is a method of estimating age-specific abundance of a *closed* population from catch-at-age data. If there is net immigration into an area, then abundance is overestimated with this method (Hoag and McNaughton 1978). Pacific halibut is a migratory species, and halibut caught in Regulatory Area 2 likely spent part of their lifetime in Regulatory Areas 3 and 4 (Skud 1977). Cohort analysis was modified to account for migration in our second procedure. Let Θ_{ij} be the (i,j) element of a transition matrix Θ (where Θ_{ij} = fraction of a year- class in area j that annually migrates to area i). The population's dynamics can then be quantified by the following equation:

$$\underset{\sim}{N}_{t+1} = \Theta\,(\underset{\sim}{N}_t\ e^{-m} - \underset{\sim}{C}_t\ e^{-m/2})$$

where

$\underset{\sim}{N}_{t+1}$ = vector of area-specific abundance (numbers of fish) of a year-class,

$\underset{\sim}{C}_t$ = vector of area-specific catches of a year-class,

m = annual natural mortality rate.

By inverting the above equation, we can sequentially estimate year-class abundance with a method we call "migratory cohort analysis":

$$\Theta^{-1}\,\underset{\sim}{N}_{t+1}e^{m} + \underset{\sim}{C}_t e^{m/2} = \underset{\sim}{N}_t$$

When Θ is the identity matrix this equation reduces to the traditional cohort method.

Migration estimates in Table 6 were used in our migratory cohort analysis. The methodology used to obtain these estimates is discussed in detail elsewhere (Deriso, unpublished). Estimates in Table 6 are similar to those presented in IPHC (1981). Since migration of halibut appears to vary with age, three different transition matrices were used to quantify movement of halibut in age groups (6, 7, 8), (9, 10, 11), and (12, 13, 14). Those age groups correspond respectively with release length groups (65-80 cm), (80-120), and (120 and larger). Some migration probably occurs for halibut older than 14 years of age, but it appears to be negligible. The migratory cohort procedure was applied to age data according to the method given above; multiple transition matrices are handled by choosing the matrix in Table 6 that matches the age group identified in the equation by the subscript (t).

Migratory cohort analysis shares a limitation present in traditional cohort analysis. Namely, estimates of year-class abundance can be made only after a year-class has been present in the fishery for several years. Because of that limitation, abundance estimates were not made after 1970. An updating procedure is currently under development.

Biomass estimates were obtained by multiplying area-specific weight by area-specific numbers of halibut, as in our first procedure. Smoothed weight-at-age estimates from setline catches in Regulatory Areas 2 and 3 were used. Considerable year-to-year variation is present even in these smoothed weight estimates, which reflects, among other things, changes in sex-ratio of halibut caught, changes in growth, and measurement error. We used these smoothed weights directly in our analysis and caution the reader that some of the interannual biomass variations are attributable to variable weight estimates.

Table 6. Estimates of annual migration probabilities for halibut in three release size groups.

	Area To: Release Size Group (65-80cm)					
Area From	2A	2B	2C	3A	3B	4
2A*	1.0	0.0	0.0	0.0	0.0	0.0
2B	.0004	.9960	.0026	.0010	0.0	0.0
2C	0.0	.0401	.9534	.0065	0.0	0.0
3A	.0012	.0178	.0217	.9342	.0251	0.0
3B	0.0	.0203	.0464	.1602	.7731	0.0
4	0.0	.0194	.0377	.1371	.0327	.7731

	Area To: Release Size Group (80-120cm)					
Area From	2A	2B	2C	3A	3B	4
2A*	1.0	0.0	0.0	0.0	0.0	0.0
2B	.0010	.9911	.0058	.0021	0.0	0.0
2C	0.0	.0244	.9716	.0040	0.0	0.0
3A	.0008	.0013	.0140	.9575	.0162	0.0
3B	0.0	.0131	.0300	.1036	.8533	0.0
4	0.0	.0125	.0244	.0887	.0211	.8533

	Area To: Release Size Group (120+cm)					
Area From	2A	2B	2C	3A	3B	4
2A*	1.0	0.0	0.0	0.0	0.0	0.0
2B	.0024	.9779	.0144	.0053	0.0	0.0
2C	0.0	.0190	.9779	.0031	0.0	0.0
3A	.0006	.0088	.0107	.9675	.0124	0.0
3B	0.0	.0100	.0229	.0790	.8881	0.0
4	0.0	.0096	.0186	.0677	.0161	.8880

*Assumed values because of insufficient number of releases in 1950-1969 time period.

Subarea Abundance and Productivity Estimates

Estimates of the relative biomass of 6-20 year-old halibut are displayed in Figure 5. Year-to-year fluctuations are apparent in biomass of halibut of Areas 2A, 2B, and 2C. Historically, relative biomass in Area 2B has been larger than in Area 2C or 2A, as shown by the following long-term averages for each subarea:

Subarea	Migratory Cohort 6-20 year-olds (Figure 5)
2A	3%
2B	54%
2C	43%

In some years about 50% of the Area 2 biomass is present in Area 2B, while 60% is present in other years. The basic conclusion to be drawn from this analysis is that there does not appear to be a fixed percentage of biomass in any one area, but rather that it has fluctuated historically in the 50% to 60% range for Area 2B and in the 40% to 50% range for Area 2C.

Biomass of adult halibut (8-20 year-olds) was also calculated with the migratory cohort method. Relative biomass estimates are slightly different from estimates obtained above with 6-20 year-olds, as seen in Table 7. Relative biomass in Area 2B is larger than in Area 2C on the average:

Subarea	Migratory Cohort 8-20 year-olds (Table 7)
2A	3%
2B	50%
2C	47%

The principal reason that Area 2B averages only 50%, as compared to the 54% in Figure 5, is that the commercial fishery in Area 2B historically caught a larger proportion of young halibut than the fishery of Area 2C. This is documented in Table 8 where the ratio of small halibut to large halibut caught commercially is listed.

Productivity, as quantified by annual surplus production (ASP), measures the amount of available catch that can be sustained by the stock in any given year without causing a decline from the previous year's abundance. ASP estimates for 8-20 year-old halibut were calculated from migratory cohort analysis (Table 7). During the period 1935-1970, Area 2B averaged 63.6% of ASP available to Regulatory Area 2, and ranged from 46% in 1964 to 82% in 1936. ASP estimates for age 6-20 year-old halibut are about 3% higher in Area 2B and 3% lower in Area 2C than in the percentages listed in Table 7.

The historically greater biomass and ASP of Area 2B compared to elsewhere in Area 2 is due primarily to higher recruitment there. The number of 7-year-old halibut, as calculated with migratory cohort analysis (Table 8), is higher in Area 2B than in Area 2C for every year from 1935 to 1970.

Areas 2B and 2C both show a similar pattern of increasing recruitment from the 1930's into the 1940's and a gradual decreasing recruitment into the 1970's. The large

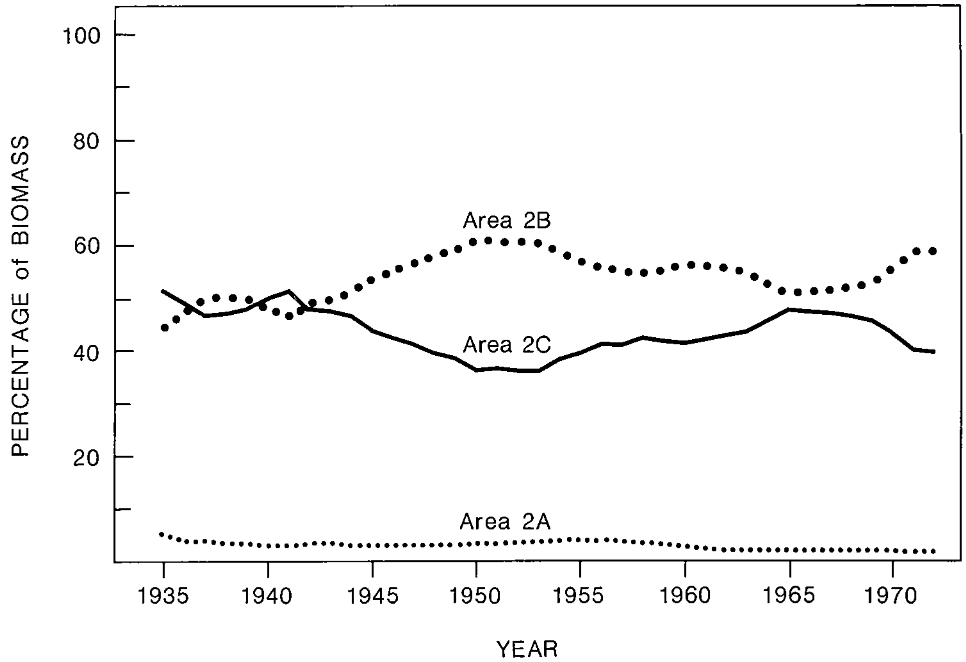


Figure 5. Estimates of relative halibut biomass in Areas 2A, 2B, and 2C, as calculated with migratory cohort analysis.

year-classes of the 1930's and 1940's have not been observed at any other time. This pulse in recruitment does not appear to be related to egg production, which was not extraordinarily high for those year-classes. In fact, the strong year-classes were apparently the result of high juvenile survival (Figure 6), for reasons unknown at the present time.

Data and estimation error could account for part of the high juvenile survival estimates, because age composition data were missing during the earlier years in some regions (see section on sensitivity analysis for more details). Estimation error might also result from problems in associating progeny by area with their "true parents"; survival estimates were generated by calculating the ratio of area-specific abundance of 7-year-olds to the calculated egg production seven years earlier in that area. Calculated egg production was simply the sum of age-specific egg productions, which were approximated by abundance at age times average fecundity at age.

Another hypothesis to explain the survival history of young halibut is that survival has been abnormally low since the 1940's due to removals by incidental catches from other fisheries, primarily the trawl fishery. However, incidental catches of young halibut were small prior to 1960 (Hoag 1971, 1976) and thus it is doubtful that they were responsible for low survival of young during the late 1940's and 1950's.

Table 7. **Biomass and Annual Surplus Production of 8-20 year-old halibut in Areas 2A, 2B, and 2C, as calculated with migratory cohort analysis (in millions of pounds).**

	Biomass				Annual Surplus Production			
Year	2A	2B	2C	Total	2A	2B	2C	Total
1935	5.6	38.3	62.8	106.7	0.8	13.8	8.9	23.5
1936	4.6	37.9	64.2	106.7	0.8	20.3	3.6	24.7
1937	4.4	44.4	59.1	107.9	0.5	19.7	4.6	24.8
1938	4.0	48.9	55.9	108.8	0.4	16.1	4.4	20.9
1939	3.5	49.0	53.2	105.7	0.4	14.1	7.5	22.0
1940	2.6	45.4	54.2	102.2	0.6	13.3	7.9	21.8
1941	2.2	41.0	54.4	97.6	0.8	12.9	6.6	20.3
1942	2.4	37.4	53.8	93.6	1.4	18.7	13.1	33.2
1943	3.1	41.7	58.5	103.3	1.6	25.7	13.5	40.8
1944	3.5	51.4	63.9	118.8	1.2	24.6	18.2	44.0
1945	3.8	60.9	71.8	136.5	1.2	30.1	14.3	45.6
1946	4.3	76.5	77.6	158.4	1.4	25.7	12.4	39.5
1947	4.7	83.8	80.0	168.5	1.1	24.7	11.3	37.1
1948	5.3	90.8	81.9	178.0	1.0	26.9	10.2	38.1
1949	5.9	100.0	82.3	188.2	0.8	22.0	4.6	27.4
1950	6.1	105.7	77.5	189.3	0.9	20.4	7.5	28.8
1951	6.3	108.6	76.1	191.0	1.0	24.7	6.3	32.0
1952	6.7	113.2	72.5	192.4	0.8	13.3	3.4	17.5
1953	6.9	105.8	66.4	179.1	0.8	17.5	11.5	29.8
1954	7.1	99.6	69.5	176.2	0.5	11.9	6.5	18.9
1955	6.8	86.5	65.0	158.3	0.2	12.0	8.5	20.7
1956	6.3	79.8	65.0	151.1	0.1	12.2	11.0	23.3
1957	5.9	71.9	61.4	139.2	0.0	14.7	9.6	24.3
1958	5.3	68.9	58.7	132.9	0.4	24.1	13.7	38.2
1959	5.2	74.4	61.3	140.9	0.0	16.6	14.2	30.8
1960	4.3	74.0	62.6	140.9	0.0	16.2	11.4	27.6
1961	3.4	72.1	61.3	136.8	0.1	16.4	8.8	25.3
1962	3.1	72.4	57.8	133.3	0.2	11.6	10.4	22.2
1963	2.8	68.9	55.1	126.8	0.1	8.2	8.5	16.8
1964	2.5	61.2	53.7	117.4	0.1	8.4	9.6	18.1
1965	2.3	57.5	56.2	116.0	0.2	9.0	8.3	17.5
1966	2.3	54.2	52.8	109.3	0.1	6.6	6.2	12.9
1967	2.2	49.3	47.3	98.8	0.0	8.6	6.4	15.0
1968	2.1	47.7	44.5	94.3	0.2	11.0	9.3	20.5
1969	2.2	48.1	48.1	98.4	0.1	11.1	5.0	16.2
1970	2.1	46.0	44.2	92.7	0.1	14.0	4.8	18.9
Average	4.2	67.0	62.0	133.2	0.6	16.6	8.9	26.1
Percent of Total	3.2	50.3	46.5	100.0	2.3	63.6	34.1	100.0

Table 8. Ratio of setline catches (number of halibut younger than 9 years of age divided by number of halibut 9 years of age and older) and estimated number of 7-year-old halibut in Areas 2B and 2C. Abundance given in units of thousands of fish.

YEAR	RATIO OF CATCHES		SEVEN-YEAR-OLDS	
	2B	2C	2B	2C
1935	1.29	1.36	1305.40	919.16
1936	1.48	0.25	2418.60	897.58
1937	1.81	0.07	2218.60	664.40
1938	1.89	0.08	1886.40	911.48
1939	1.29	0.08	1431.50	1013.30
1940	1.28	0.08	1306.00	1002.20
1941	1.40	0.38	1142.40	905.64
1942	1.33	0.14	1958.70	1562.40
1943	3.61	0.14	2807.20	1244.10
1944	1.30	0.14	2525.20	1822.60
1945	2.35	0.14	3188.60	1548.60
1946	1.46	0.14	3161.20	1250.40
1947	0.97	0.14	2889.60	1277.00
1948	1.02	0.14	3196.80	1102.80
1949	0.59	0.16	2898.10	907.57
1950	0.46	0.06	2656.60	917.81
1951	0.35	0.10	2885.10	922.71
1952	0.40	0.06	1639.90	554.81
1953	0.29	0.36	1482.20	749.31
1954	0.42	0.14	1083.90	420.05
1955	0.72	0.26	1068.00	499.47
1956	0.86	0.37	976.33	479.51
1957	1.10	0.17	1080.90	532.21
1958	1.55	0.33	1705.60	987.51
1959	1.90	0.54	1104.30	777.51
1960	1.18	0.34	1092.60	602.48
1961	1.11	0.31	1301.40	615.33
1962	1.04	0.32	969.36	614.03
1963	1.00	0.45	725.36	578.63
1964	0.68	0.38	716.62	713.60
1965	0.72	0.42	608.67	499.02
1966	0.75	0.26	508.72	402.86
1967	1.02	0.34	534.74	404.72
1968	0.96	0.38	683.99	611.33
1969	1.48	0.37	596.29	406.54
1970	1.39	0.21	814.98	371.19
1971	2.29	0.30	—	—
1972	1.32	0.33	—	—
1973	0.55	0.13	—	—
1974	0.30	0.14	—	—
1975	0.21	0.17	—	—
1976	0.50	0.15	—	—
1977	0.41	0.15	—	—
1978	0.49	0.25	—	—
1979	0.37	0.18	—	—
1980	0.33	0.31	—	—
Average	1.07	0.25	1626.92	824.69

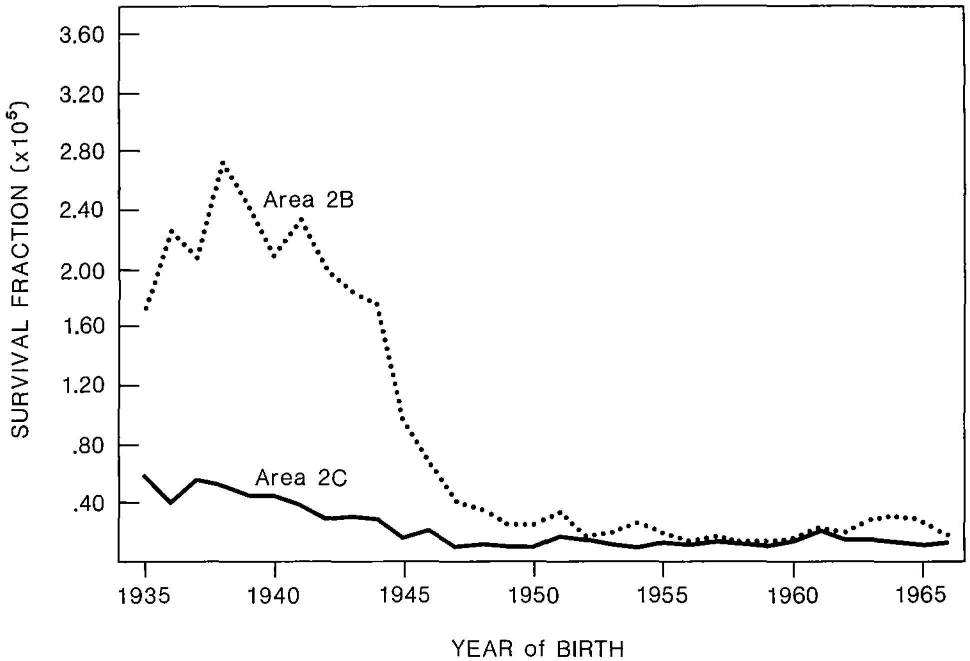


Figure 6. Estimates of survival of halibut from egg-stage to age 7 years, by area, as calculated with migratory cohort analysis. Estimates given for Area 2B and Area 2C halibut.

Despite these caveats, it is clear that a shift occurred in survival of halibut in Area 2. If survival remains at the low levels of recent years, we cannot expect halibut of Area 2 to produce as many recruits as in earlier years. It also appears that productivity per spawner in Area 2B now approximates that of Area 2C, which implies that the traditional relationship in productivity between Area 2B and Area 2C may change in the future.

Sensitivity Analysis of Results to Assumptions About Missing Age Data

In order to construct historical age composition estimates, age composition for certain regions each year was "borrowed" from adjacent regions because of missing data. In this section, we examine the effect of an alternate scheme for filling in missing age composition data on results obtained above with our primary missing data algorithm.

The primary missing data scheme was based upon analyses of age composition data in Hoag and McNaughton (1978) and Quinn et al. (in press, b). Age composition data are processed for six biological regions in Area 2: Columbia, Vancouver, Charlotte-Inside, Charlotte-Outside, SE Alaska-Inside, and SE Alaska-Outside. Quinn et al. (in press, b) found that Charlotte-Inside generally had smaller fish than other regions and suggested using other Area 2 regions when missing data occurred, as shown in Table 9.

Table 9. Two algorithms for filling in missing data for regions in Area 2.

Region	Years With Missing Data	Replacement Region: Primary Scheme	Replacement Region: Alternate Scheme
Columbia	All	Vancouver	Same
Vancouver	1935, 1937, 1940, 1947, 1950, 1951, 1969, 1974, 1977, 1979	Charlotte-Outside SE Alaska-Outside Yakutat	Charlotte-Inside
Charlotte-Outside	Before 1949, 1951, 1960	SE Alaska-Outside Yakutat	Same
Charlotte-Inside	None		
SE Alaska-Inside	Before 1957	Charlotte-Outside SE Alaska-Outside Yakutat	Charlotte-Inside
SE Alaska-Outside	1936-1940, 1943-1948, 1950, 1955	Yakutat	Same
Yakutat	1944-1948	Average of 1943-1949 Area 3 data	Same

The alternate scheme uses the region Charlotte-Inside for missing data in Vancouver and SE Alaska-Inside (Table 9). This scheme agrees with the analysis of Hoag and McNaughton (1978) for Vancouver based upon 1935-1949 data, although Quinn et al. (in press, b) suggested using outside waters for Vancouver based upon 1935-1978 data. Although Charlotte-Inside is the most adjacent region to SE Alaska-Inside, recent age data are not similar for those two regions (Quinn et al., in press, b).

For both schemes, subarea estimates of age composition were constructed as follows. Age composition from the Columbia region was projected to the Area 2A catch. Average age composition weighted by catch in numbers of Vancouver, Charlotte-Outside, and Charlotte-Inside was used for Area 2B. Weighted-average age composition of SE Alaska-Outside and -Inside was used for Area 2C.

Age data from the alternate scheme were employed to provide an alternate estimate of biomass by area in Regulatory Area 2. Results here are similar to those obtained earlier: the percentage of 6-20 year-old biomass in Area 2B averaged 58%, as compared to the 54% calculated from our primary algorithm, and 8-20 year-old biomass averaged 55% in Area 2B, compared to 50% obtained earlier. Annual surplus production is slightly higher with the alternate scheme than with the primary scheme. However, a pronounced change occurred in survival estimates of Area 2C juvenile halibut; both Areas 2B and 2C now show a precipitous drop in survival during the 1940's (Figure 7). We conclude that the use of Charlotte-Inside age composition data for missing composition in the inside SE Alaska region caused this survival shift, and also appears

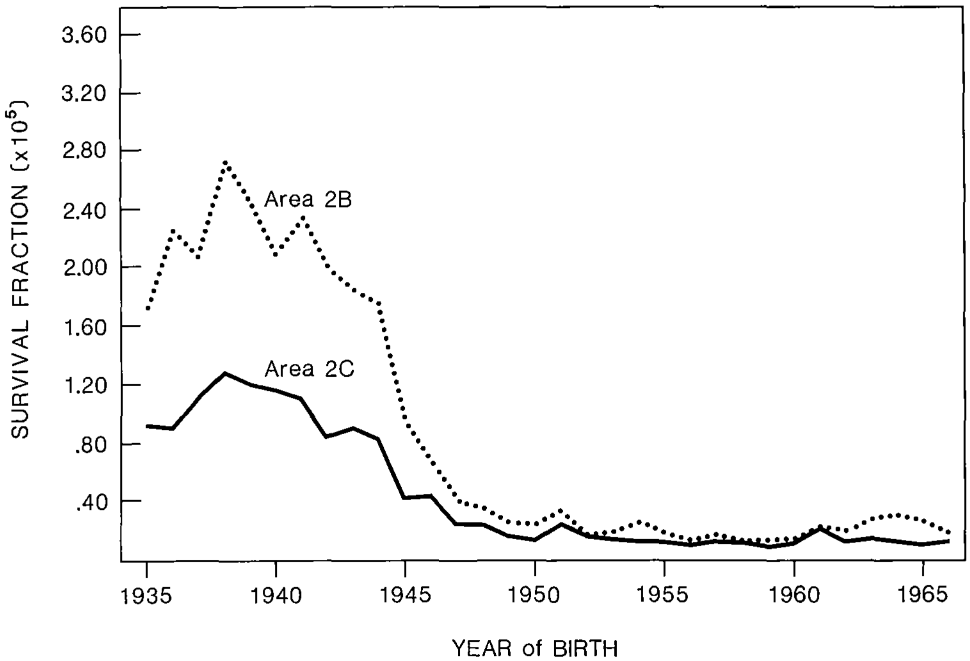


Figure 7. Estimates of survival from egg-stage to age 7 years, as calculated with migratory cohort analysis using alternative age composition. Estimates given for survival of Area 2B and Area 2C halibut.

to be the main reason for the Area 2B survival drop in both the alternate and primary missing data algorithms. The lack of agreement between Areas 2B and 2C survival estimates occurs only in the period before 1950. Thus, survival estimates before 1950 should be viewed with caution in light of the sensitivity of results to incomplete age composition data.

DISCUSSION AND COMPARISON OF RESULTS FROM THE TWO PROCEDURES

Results from both procedures show biomass and annual surplus production is higher on the average in Area 2B than in Area 2C or 2A for the 1935 to 1970 time period. ASP estimates were similar for both procedures with Area 2B averaging 61.4% of Area 2 ASP in the first procedure versus 63.6% in the migratory cohort method. However, average biomass differed between the two methods with Area 2B averaging 58.3% of Area 2 biomass in the first procedure versus 50.3% in the second method.

Total Area 2 biomass is somewhat higher in the traditional cohort procedure than in migratory cohort analysis (152.6 versus 133.2 million pounds for the 1935-1970 average). On the other hand, ASP of Area 2 is similar with the two methods (26.7 in traditional cohort versus 26.1 million pounds in migratory cohort for the 1935-1970 average). The lower biomass in the migratory cohort method was expected since recruitment into Area 2 occurs for most ages of halibut. Traditional cohort analysis assumes fish caught in Area 2 were always present in Area 2 during their adult lifetime. The similarity of average ASP estimates between procedures is due to similarity in net biomass change over the 1935 to 1970 time period. Both procedures show a slightly lower biomass in 1970 as compared to biomass of Area 2 halibut in 1935. Calculation of average ASP over those 36 years is based on the net biomass change plus commercial catches during the time period.

The procedures employed in our study have been useful for examining long-term trends in subarea biomass and ASP. However, estimates from these methods are not accurate for examining changes after 1970. In our first method, for example, estimates of utilized habitat are needed to partition abundance among subareas. Our measure of utilized habitat, namely fishing grounds, is admittedly a long-term habitat measure, at best. In our second method, we have no reliable updating procedure as yet. But even when one becomes available, temporal shifts in migration rates of halibut would be difficult to detect and quantify for use in migratory cohort analysis.

REPRODUCTIVE VALUE

Reproductive value of a newly born female is defined here as the expected number of female progeny produced by this individual during her lifetime. If reproductive value of average females at birth exceeds one for a period of time, then abundance of females and, most likely, of males will increase; whereas declining populations are characterized as having reproductive value less than one. This quantity is intrinsically related to the basic productivity of a stock. The three key factors that determine reproductive value of the newly born are (1) individual fecundity, (2) young female survival (from birth to age of adults), and (3) adult female survival. This section will focus on survival of adult halibut in recent years with special attention paid to possible effects of the change in minimum retention size in 1973. Empirical data on sex-ratio and reproductive value are examined from the Area 2B stock before and after 1973, and a theoretical analysis addresses potential effects of the minimum size limit. This analysis expands the results in Myhre (1974) by linking yield per recruit analysis with reproductive value constraints.

Comparison of Reproductive Value Before and After the 1973 Minimum Size Change

Standardized setline halibut surveys have been conducted during the years 1963-1966 and every year since 1977 (Hoag et al. 1980). These data provide basic information on catches by age and sex of halibut obtained over a uniform grid of fishing stations in the Kodiak region of Area 3A and in the Charlotte region of Area 2B. Our analysis will focus on Area 2B, although some Area 3 results are given for comparison. Catch curve regression analysis (Seber 1973) was applied to these catch-at-age data, which had been smoothed with Velleman's procedure, to obtain the following estimates of total mortality rate for halibut aged 9 years and older. These estimates are given below, along with calculated standard deviations. Our smoothing procedure was applied to original data in order to remove extraneous variability, and this causes the listed standard deviations to be lower than those obtained with original data.

Sex	Data set	Z Total Mortality	Standard Deviation
Female	1977-80, Area 2B	.285	.0135
Female	1965-66, Area 2B	.150	.0118
Male	1977-80, Area 2B	.254	.0098
Male	1965-66, Area 2B	.325	.0148
Female	1977-80, Area 3A	.293	.0181
Female	1963-66, Area 3A	.323	.0216

These mortality rate estimates suggest that mortality of adult female halibut in Area 2B has increased substantially in the 1977-1980 period as compared to the estimate for 1965-1966, while mortality of adult males has decreased. Mortality of Area 3A females has been similar in the two time periods. One hypothesis to account for these results is that the increase in minimum size in 1973 from 26 inches to 32 inches (heads-on length) shifted the Area 2B fishery away from small halibut to larger halibut, which are usually female. No similar change would be expected in Area 3A as it has historically caught large halibut, irrespective of the minimum size limit. Violation of assumptions in catch curve regression analysis is an alternative hypothesis to account for the mortality estimates. Two basic assumptions in catch curve analysis are that year-classes present in the fishery experience similar annual mortalities, although these may be sex-specific, and that recruitment to the population shows no time trend. Both of these assumptions are likely to be violated to some extent in all our regressions.

A shift in mortality of adult females induces a shift in reproductive value, unless a compensating shift occurs in either fecundity or survival of younger halibut. There is evidence of a 50-year shift in both individual fecundity (Schmitt and Skud 1978) and survival of juvenile (see Figure 6). However, we have no data to suggest that either fecundity by age or survival of juveniles (age 0 to age 5 years) has changed substantially in the last 20 years. A shift in mortality of female halibut aged 5-8 years might be expected, however, since the increase in minimum size would presumably reduce mortality on small female halibut.

A new method was developed in order to estimate the change in mortality of partially recruited female halibut between age 5 and age 9. A new method is necessary since conventional catch curve analysis assumes that individuals are all fully recruited and vulnerable to the fishing gear. Young halibut show a pattern of increasing recruitment with age into the commercial fishery. We digress for a moment to develop the theoretical basis for this new method.

Let $Z(i,x)$ = total mortality rate per year for individuals of age i during time period x,
ΔZ = mortality rate change between two time periods x and y,
$N(i,x)$ = number of individuals of age i during time period x,
$C(i,x)$ = catch of individuals of age i during time period x.

By assuming population stationarity, the abundance is related to mortality as

$$\ln[N(j,x)/N(i,x)] = \sum_{k=i}^{j-1} Z(k,x)$$

and since $Z(k,y) = \Delta Z + Z(k,x)$, we can write

$$\ln[N(j,y)/N(i,y)] = (j-i)\Delta Z + \sum_{k=i}^{j-1} Z(k,x).$$

The difference of those equations then provides an estimate for ΔZ as

$$\Delta Z(j-i) = \ln[N(j,y)/N(i,y)] - \ln[N(j,x)/N(i,x)]$$

and zero intercept regression of this equation estimates ΔZ. The data on catches, $C(i,x)$, is substituted for $N(i,x)$ in the regression. That substitution can be made since multiplicative gear selectivity factors and fishing effort cancel out each other in the right-hand side of the above equation.

Application of the above method (with i=5 and j=9) estimates the change in total mortality of $\Delta Z = -.097$ (standard deviation = .008) from the 1965-1966 time period to the 1977-1980 time period for Area 2B female halibut.

Reproductive value calculations were made to investigate whether the decline in mortality of young adults offsets the higher mortality of old adult females. In order to look at the change in reproductive value between the 1965-1966 data and the 1977-1980 data, calculations were made which employ the estimates of change in total mortality of age 5-8 females, total mortality of age 9+ females, and average fecundity.

The method for calculating changes in reproductive value will be explained here since it is a procedure original to this paper. The first step is to calculate reproductive value of 5-year-old individuals using the following formula:

$$\text{reproductive value of 5-year-olds} = \sum_{i=5}^{20} f_i \exp[-\sum_{j=5}^{i-1} Z(j,y)]$$

where $Z(j,y)$ = total annual mortality rate of j year-old females in time period y,
f_i = fecundity of i year-olds.

Several algebraic simplifications can be made to that formula since females are sexually immature prior to 9 years of age. We factor survival between ages 5 and 9 from the formula and sum subscript i from age 9 to age 20.

Percent change in reproductive value of 5-year-old halibut between the two time periods is found by taking reproductive value, as calculated in the above formula, for time period y (1977-1980) and dividing this by reproductive value in time period x (1965-1966). Algebraic simplification of the ratio can be made by noting that the difference in annual mortality of age 5 to age 9 females (labeled earlier as ΔZ) is the only juvenile mortality factor that is not a common divisor of the ratio's numerator and denominator. The simplified formula for percent change in reproductive value is given by the following equation:

$$\text{Percent change} = \frac{\exp(-4\Delta Z) \sum_{i=9}^{20} f_i \exp[-\sum_{j=9}^{i-1} Z(j,y)]}{\sum_{i=9}^{20} f_i \exp[-\sum_{j=9}^{i-1} Z(j,x)]} \times 100$$

Reproductive value of age 5 female halibut in the Charlotte survey area now is 62% of the 1965-1966 value, according to estimates obtained with the percent change formula above. Parameter values used in our application of this formula were the Z and

ΔZ estimates given earlier and the fecundity estimates given in Quinn (1981). A minimum change in reproductive value of 91% was obtained by changing all Z and ΔZ parameters two standard deviations, which shows the sensitivity of these results to statistical error.

The hypothesis that the sex composition in Area 2B has changed was investigated using standardized stock assessment data. Sex-ratio estimates for recent surveys (1977-1980) in Area 2B differ substantially from the ratio estimates obtained from surveys in 1965-1966 (Figure 8). In contrast, our calculations show no such shift has occurred in Area 3A survey data. These results are consistent with mortality estimates presented earlier: mortality estimates of females in Area 3A are approximately the same in both time perods (1963-1966 versus 1977-1980) while mortality of females is higher in recent Area 2B surveys as compared to mortality estimates in 1965-1966 Area 2B surveys.

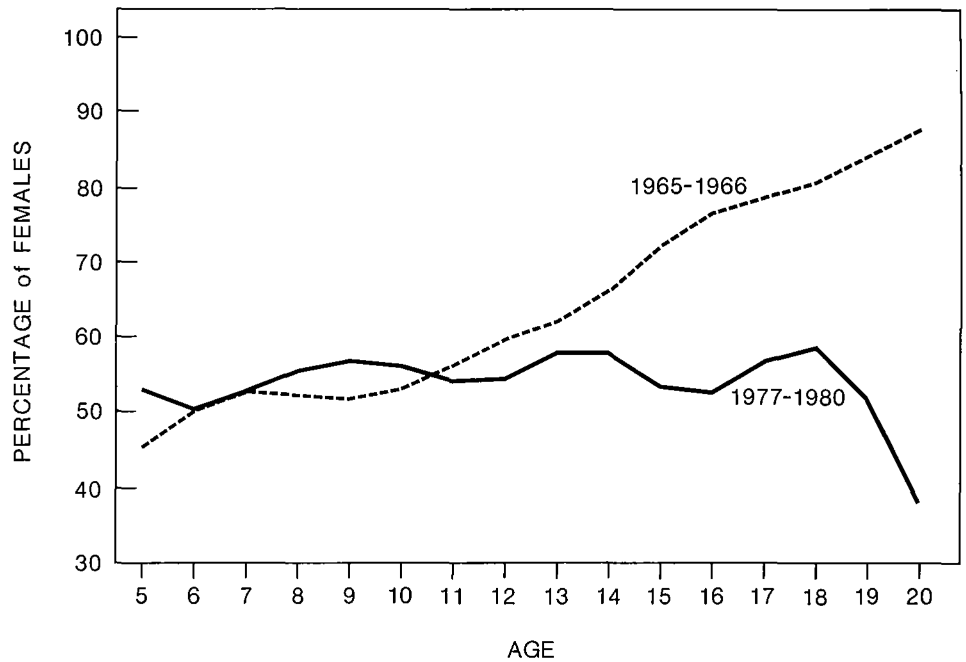


Figure 8. Percentage of females by age in Area 2 stock survey catches for the 1965-1966 surveys and 1977-1980 surveys.

A reduction in survival of female halibut of Area 2 is a matter of concern. Although results given earlier are based on limited information, they suggest that a reduction has occurred in Area 2 spawning stock. Let us examine two facts that shed light on this problem: (1) female halibut have higher growth rates than male halibut (see Table 11), and (2) age of recruitment into the fishery is size-dependent. Those facts give managers of the halibut resource a variable (minimum size) that can be manipulated to bring about changes in sex-ratio of catches in order to affect sex-specific fishing mortality rates. For example, large minimum size limits will cause most male halibut to be smaller than legal size and, thus, legislate a fishery dependent upon female halibut. From this perspective, a fishery on small halibut should increase the proportion of male halibut in the catches.

Analysis was made of commercial catch data to see if the sex composition of catches has changed since the 1973 minimum size change. Indirect evidence that the

Table 10. **Average weight (pounds) by age of the commercial catch in Area 2B, 1965-1980.**

	Age																	
Year	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1965	4.3	9.5	9.2	12.0	14.2	16.0	18.2	21.4	27.8	30.1	36.2	38.8	50.1	48.0	49.7	56.4	53.1	67.9
1966	4.4	8.0	9.7	10.7	11.9	13.6	17.0	20.2	22.2	26.9	28.4	31.9	30.6	46.9	40.9	52.9	38.8	52.3
1967	5.9	8.0	9.1	10.9	12.7	15.6	17.2	20.8	25.1	27.9	32.0	38.0	32.7	44.9	52.7	56.4	57.0	75.4
1968	5.9	8.9	11.0	13.6	13.2	18.6	23.3	27.3	30.1	33.6	34.3	40.4	39.7	44.8	47.0	43.6	54.6	46.1
1969	5.8	8.5	11.6	13.2	14.7	16.4	22.2	29.9	31.8	36.1	39.2	39.9	45.5	48.6	55.4	55.2	55.0	65.3
1970	6.0	7.9	10.4	14.4	16.1	19.2	21.6	28.5	34.3	36.3	40.6	41.1	45.5	51.1	50.2	51.9	61.3	51.6
1971	4.3	7.0	8.9	11.5	12.9	13.2	16.6	17.5	26.1	31.4	38.0	44.6	67.1	53.5	55.9	74.3	84.0	85.6
1972	4.7	6.6	9.1	11.5	14.2	16.2	18.9	21.1	25.2	33.6	39.3	36.7	44.9	47.0	61.8	60.1	59.1	64.0
Average	5.2	8.0	9.9	12.2	13.7	16.1	19.4	23.3	27.8	32.0	36.0	38.9	44.5	48.1	51.7	56.4	57.9	63.5
1973	4.2	9.4	8.7	11.6	13.9	18.2	21.1	26.2	31.3	35.0	40.9	41.7	52.5	52.5	48.2	62.7	82.5	59.9
1974	—	6.3	10.1	12.7	17.0	18.8	21.4	26.8	32.4	39.6	45.4	58.1	60.4	64.5	65.4	59.8	70.1	82.6
1975	—	6.0	9.9	14.4	16.2	19.4	22.1	26.8	31.2	37.3	42.1	48.4	54.4	54.9	57.2	67.6	72.3	70.6
1976	—	5.2	10.3	11.7	15.2	17.6	22.0	25.6	29.3	37.1	43.1	47.2	61.6	66.1	76.1	72.6	85.7	85.3
1977	—	5.8	7.8	13.2	14.7	19.6	22.4	27.4	33.2	38.6	41.8	54.0	65.7	72.5	56.6	89.8	102.5	69.5
1978	—	7.6	9.6	11.8	15.7	17.7	21.6	25.6	29.1	37.2	46.7	51.2	61.3	66.3	79.7	81.2	88.3	78.6
1979	—	5.9	8.3	11.9	14.2	16.5	19.6	22.0	26.8	33.9	38.6	43.2	56.1	59.9	74.3	84.6	57.9	106.8
1980	—	5.8	8.6	11.0	13.6	14.8	18.0	22.2	27.2	30.6	35.0	41.9	52.1	55.8	68.3	74.1	68.7	85.0
Average	4.2	6.5	9.1	12.3	15.0	17.8	21.0	25.3	30.1	36.2	41.7	48.2	58.0	61.6	65.7	74.1	78.5	79.8
Difference	-1.0	-1.5	-0.7	0.1	1.3	1.7	1.6	2.0	2.2	4.2	5.7	9.3	13.5	13.4	14.0	17.7	20.6	16.3

proportion of females in the catch has increased comes from information about the average weight by age of the commercial catch. Weight-age data are shown for Area 2B during the 8 years before the minimum size change in 1973 and the 8 years after the minimum size change (Table 10). Average weight by age was significantly greater in the latter period, as evidenced by two-way analysis of variance of average weight and year-group ($P<.001$). The increase in average weight was abrupt between 1972 and 1973

Table 11. Average weight (pounds) by age of males and females from stock assessment surveys in Hecate Strait in 1965-1966 and 1977-1980.

	Males			Females		
Age	1965-1966	1977-1980	Difference	1965-1966	1977-1980	Difference
1	—	—	—	—	—	—
2	—	—	—	1.3	—	—
3	3.2	2.8	-0.4	3.5	4.9	1.4
4	3.1	3.9	0.8	5.3	6.3	1.0
5	5.2	5.0	-0.2	6.0	9.4	3.4
6	5.8	7.8	2.0	10.3	13.1	2.8
7	8.9	7.7	-0.8	14.1	14.2	0.1
8	10.6	10.3	-0.3	20.3	15.1	-5.2
9	15.4	10.9	-4.5	27.4	20.0	-7.4
10	20.3	13.0	-7.3	34.4	26.9	-7.5
11	21.1	14.8	-6.3	45.8	30.7	-15.1
12	25.4	18.0	-7.4	52.5	43.2	-9.3
13	28.0	19.1	-8.9	62.9	49.2	-13.7
14	31.9	20.0	-11.9	71.2	60.8	-10.4
15	53.2	25.2	-28.0	78.1	73.1	-5.0
16	53.9	27.2	-26.7	89.3	72.0	-17.3
17	54.7	22.4	-32.3	94.8	84.3	-10.5
18	—	35.7	—	85.8	101.7	25.9
19	39.8	38.2	-1.6	113.8	94.7	-19.1
20	—	45.3	—	104.7	119.8	15.1

and thus does not appear to be explained by an increase in growth rate. Further evidence that growth rate does not account for this change is a comparison of average weight by age of males and females from stock assessment survey data which reveals a negative difference, if any, between 1965-1966 and 1977-1980 (Table 11). The only explanation we can offer for the significant difference in average weight in the commercial catch is that the proportion of females in the catch was higher. Since females are larger than males, a shift in sex-ratio of the catch changes average weight in the catch. A similar change in weight occurs in the Area 2C commercial catch but there have been no stock assessment surveys in Area 2C.

A rough method of estimating the sex-ratio of the catch from these data provides further evidence for increased females in the catch. The average weight of the catch, W_c, is made up of the average weight of males, W_m, and of females, W_f, determined by the proportion of each sex in the catch, which may be written

$$W_c = (1-p)\, W_m + pW_f,$$

where p is the proportion of females. This equation rewritten as a function of p is

$$p = (W_c - W_m)/(W_f - W_m).$$

The percentage of females for each age in Area 2B estimated by this method is listed in Table 12. The method does not work for younger ages because of minimum size restrictions on gear. Also due to the sensitivity of the method, values less than 0% or greater than 100% are possible and should be treated as 0% or 100%, respectively. For older ages, the percentage of females in the catch ranged between 0 and 35% before 1973 and 45 to 100% after 1973. Although this method produced variable results, there is a consistently higher percentage of older females in the catch after 1973.

An analytical model based upon a Leslie-matrix age-structure approach (Quinn 1981) was constructed to investigate whether the changes in the proportion of females in the population observed from stock assessment surveys could actually result from levels of differential mortality between sexes in the catch. Estimates of 1973 population size from cohort analysis and 1965-1966 sex-ratio estimates (Figure 8) were used to start the projection. Average mortality from commercial fishing in Area 2 has averaged 0.15 between 1973 and 1980 and was applied in the model to females, while three cases were considered for male mortality (0.0, 0.05, and 0.10). Age selectivity was assumed to increase linearly between ages 8 and 12. The proportion of females in the population as a function of age was projected from the model for each case. In each succeeding year after 1973, the proportion of simulated females decreases, especially for older ages, as a result of the differential mortality applied to females. By 1980, the proportion of females in all three cases is below 50% for most ages. In all three cases, the average proportion of simulated females for 1977-1980 is below the proportion observed from stock assessment surveys. Thus, the low percentage of females observed in stock assessment surveys is theoretically possible, based on a higher mortality for females than for males.

Additional analyses were made to see how minimum size limits might affect reproductive value and, hence, long-term equilibrium yield. A linear spawner-recruit relationship was coupled to a sex-specific, yield per recruit model for this investigation into the effects of shifts in sex-ratio of catch and age of recruitment on equilibrium yield. Survival of young was fixed at the median value of 4.8163×10^{-6} obtained from estimates during the years of birth 1945-1971. Other parameters needed for this analysis are age-specific average weight (Table 11), fecundity (Quinn 1981), and average length. Length plays an important role in this analysis because it is used to determine age at entry corresponding to a specific minimum size. A power curve has been found to be useful for analysis of halibut lengths (McCaughran 1981) and so it was used here (Table 13).

Results of the minimum size analysis are given in Table 14 for scenarios covering a range of different model assumptions. These results are based on equilibrium fishing mortality rates, calculated within the analysis, that hold the modelled population at a stationary level. Age of entry is based on the model on ages in Table 13 where sex-specific size is just above the minimum retention size. Release mortality in Table 14 is used to study sensitivity of results by applying this mortality to ages given in the Table; it is a measure of the mortality halibut experience when released from setline gear because of sublegal size. Higher combined yields are usually obtained with the 65 cm (26 in) size limit, although the increase is usually less than 10% as compared with a 81.5 cm (32 in) size limit. A larger minimum size limit increased yield only when release mortality was very small. The similarity of yields available with different size limits

Table 12. Estimated percentage of females in the catch for each age based on the average weight (pounds) of males, females, and the commercial catch, Area 2B.

	AGE: YEARS 1965-1972																	
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Male Wgt.	3.2	3.1	5.2	5.8	8.9	10.6	15.4	20.3	21.1	25.4	28.0	31.9	53.2	53.9	54.7	X	39.8	X
Female Wgt.	3.5	5.3	6.0	10.3	14.1	20.3	27.4	34.4	45.8	52.5	62.9	71.2	78.1	89.3	94.8	85.8	113.8	104.7
Average Wgt.	5.2	8.0	9.9	12.2	13.7	16.1	19.4	23.3	27.8	32.0	36.0	38.9	44.5	48.1	51.7	56.4	57.9	63.5
Percent Female	667	223	587	142	92	57	33	21	27	24	23	18	-35	-16	-7	X	24	X
	AGE: YEARS 1973-1980																	
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Male Wgt.	2.8	3.9	5.0	7.8	7.7	10.3	10.9	13.0	14.8	18.0	19.1	20.0	25.2	27.2	22.4	35.7	38.2	45.3
Female Wgt.	4.9	6.3	9.4	13.1	14.2	15.1	20.0	26.9	30.7	43.2	49.2	60.8	73.1	72.0	84.3	101.7	94.7	119.8
Average	4.2	6.5	9.1	12.3	15.0	17.8	21.0	25.3	30.1	36.2	41.7	48.2	58.0	61.6	65.7	74.1	78.5	79.8
Percent Female	67	108	93	85	112	156	111	88	96	72	75	69	68	77	70	58	71	46

X - indicates no data.

suggests that factors such as the relatively high economic value of large halibut over smaller ones may be more important in determining an "optimal" size limit.

Table 13. Average length-at-age (cm) for female and male halibut caught during 1977-1980 standardized stock assessment surveys in Area 2.

	Females		Males	
Age	Observed	Estimated(1)	Observed	Estimated(2)
4	68.3	62.7	59.5	57.0
5	76.5	71.8	63.4	63.2
6	84.6	80.3	73.1	68.7
7	87.4	88.1	73.1	73.7
8	88.8	95.6	79.2	78.4
9	96.6	102.7	80.6	82.7
10	105.9	109.5	85.2	86.8
11	110.9	116.0	88.8	90.7
12	122.7	122.3	93.4	94.4
13	128.1	128.4	95.8	97.9
14	137.1	134.3	102.1	101.3
15	144.7	140.1	104.3	104.6
16	143.0	145.7	106.6	107.8
17	152.9	151.1	102.0	110.8
18	162.4	156.5	115.7	113.7
19	156.8	161.7	118.8	116.6
20	168.3	166.8	127.0	119.4

(1) estimated with equation: length = a (age) ^{b}, a = 27.01, b = .608

(2) length = a (age)^{b}, a = 30.18, b = .459

Discussion

Empirical evidence presented in this section suggests that major changes have occurred since 1973 in sex-specific fishing mortality and reproductive value of Area 2B halibut. Mortality of adult female halibut, as well as the proportion of females in commercial catches, has increased significantly in recent years according to analyses of setline survey and catch data from Area 2B. These empirical results indicate changes more substantial than those expected from our theoretical calculations. Our calculations in Table 14 show that the proportion of yield from males does not change so greatly with a minimum size change when fishing mortality depends only on the size of fish. Either some assumptions in our theoretical model are incorrect, the empirical results are erroneous, or a combination of those factors has occurred. Current research is focused on developing new methods and obtaining new evidence to help resolve this problem. Particularly promising are new methods of estimating sex-ratio of catches based on characteristics of halibut otoliths. This should provide the data needed to examine the sex-ratio in catches from particular fishing grounds and allow us to determine whether fishing mortality is strictly size-dependent.

Table 14. Results of analysis of minimum size limit. Yields are given as lifetime yield (pounds) per egg for males and females.

Minimum size (cm)	Equilibrium Fishing rate	Females		Males		Combined Yield	Remarks
		Yield (10^{-5})	Age of entry	Yield (10^{-5})	Age of entry		
65	.0601	1.398	5	.5809	6	1,9709	base case
70	.0601	1.398	5	.5422	7	1.9402	release mortality = 0
80	.0669	1.453	6	.4876	9	1.9406	release mortality = 0
81.5	.0750	1.500	7	.5304	9	2.0304	release mortality = 0
81.5	.0798	1.364	7-16	.5512	9	1.9158	release mortality = 0; 150 cm maximum legal size
81.5	.0715	1.409	7	.4964	9	1.9054	release mortality = .015 for age 5, .015 for age 6
81.5	.0703	1.379	7	.4854	9	1.8644	release mortality = .02 for age 5, .02 for age 6
81.5	.0639	1.233	7	.4315	9	1.6645	release mortality = .04 for age 5, .04 for age 6
100	.1016	1.5831	9	.3400	14	1.9231	release mortality = 0
65	.0633	1.4123	4,5,6	.5798	5,6,7	1.9926	vulnerability increases linearly: 25%, 50%, 75%, 100%; release mortality = 0
81.5	.0805	1.5126	6,7,8	.5290	8,9,10	2.0416	vulnerability as above; release mortality = 0
81.5	.0750	1.3914	6,7,8	.4841	8,9,10	1.8755	vulnerability as above; release mortality = .02 for ages 5, 6

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LITERATURE CITED

Chapman, Douglas G., R.J. Myhre, and G.M. Southward. 1962. Utilization of Pacific halibut stocks: Estimation of maximum sustainable yield, 1960. International Pacific Halibut Commission, Report No. 31: 35 p.

Doubleday, W.G. 1976. A least squares approach to analysing catch at age data. ICNAF Research Bulletin No. 12: 69-81.

Hoag, Stephen H. 1971. Effects of domestic trawling on the halibut stocks of British Columbia. International Pacific Halibut Commission, Scientific Report No. 53: 18 p.

__________ 1976. The effect of trawling on the setline fishery for halibut. International Pacific Halibut Commission, Scientific Report No. 61: 20 p.

Hoag, Stephen H., and R.J. McNaughton. 1978. Abundance and fishing mortality of Pacific halibut, cohort analysis, 1935-1976. International Pacific Halibut Commission, Scientific Report No. 65: 45 p.

Hoag, Stephen H., G.H. Williams, R.J. Myhre, and I.R. McGregor. 1980. Halibut assessment data: Setline surveys in the North Pacific Ocean, 1963-1966 and 1976-1979. International Pacific Halibut Commission, Technical Report No. 18: 42 p.

International Pacific Halibut Commission. 1960. Utilization of Pacific halibut stocks: Yield per recruitment. International Pacific Halibut Commission, Report No. 28: 52 p.

McCaughran, D.A. 1981. Estimating growth parameters for Pacific halibut from mark-recapture data. Can. J. Fish. Aquat. Sci. 38(4): 394-398.

Myhre, Richard J. 1969. Gear selection and Pacific halibut. International Pacific Halibut Commission, Report No. 51: 35 p.

__________ . 1974. Minimum size and optimum age of entry for Pacific halibut. International Pacific Halibut Commission, Scientific Report No. 55: 15 p.

Quinn, T.J., II. 1981. The use of Leslie-type age-structure models for the Pacific halibut population. Pages 217-242 in (D.G. Chapman and V.F. Gallucci, editors) Quantitative Population Dynamics, Int. Coop. Pub. House, Fairland, Maryland.

Quinn, T.J., II, S.H. Hoag, and G.M. Southward. 1982. Comparison of two methods of combining catch-per-unit-effort data from geographic regions. Can. J. Fish. Aquat. Sci. 39: 837-846.

Quinn, T.J., II, R.B. Deriso, S.H. Hoag, and R.J. Myhre. In press, a. A summary of methods of estimating annual surplus production for the Pacific halibut fishery. Int. North Pac. Fish. Comm. Special Scientific Sessions, 1982.

Quinn, T.J., II, E.A. Best, L. Bijsterveld, and I.R. McGregor. In press, b. Sampling Pacific halibut *(Hippoglossus stenolepis)* landings for age composition: History, evaluation, and estimation. International Pacific Halibut Commission, Scientific Report No. 68.

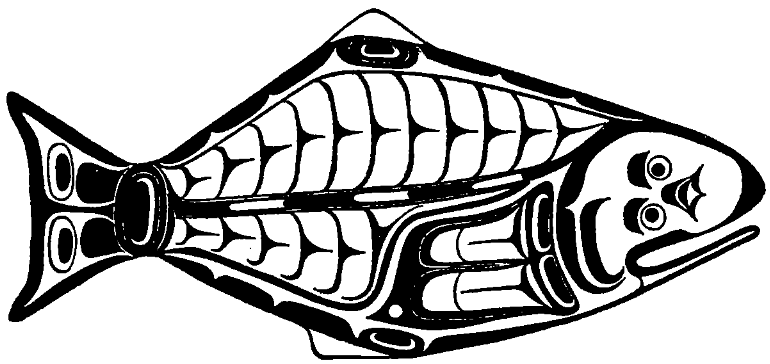
Schmitt, Cyreis C., and B.E. Skud. 1978. Relation of fecundity to long-term changes in growth, abundance and recruitment. International Pacific Halibut Commission, Scientific Report No. 66: 31 p.

Seber, G.A.F. 1973. The estimation of animal abundance and related parameters. Griffin Co., London. 506 p.

Skud, Bernard E. 1975. Revised estimates of halibut abundance and the Thompson-Burkenroad debate. International Pacific Halibut Commission, Scientific Report No. 56: 36 p.

__________ . 1977. Drift, migration, and intermingling of Pacific halibut stocks. International Pacific Halibut Commission, Scientific Report No. 63: 42 p.

Velleman, P.F. 1980. Definition and comparison of robust nonlinear data smoothing algorithms. J. Am. Stat. Assoc. 75: 609-615.



HALIBUT CREST — *adapted from designs used by Tlingit, Tsimshian and Haida Indians.*

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1950	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	703	101. 4	6936	14. 8	703	101. 4	6936
Vancouver I.	973	66. 5	14629	5. 9	572	86. 1	6644	29. 7	1545	72. 6	21273
Charlotte-O	823	108. 2	7604	49. 1	46	120. 6	381	59. 8	869	108. 8	7985
Charlotte-I	12192	87. 5	139354	56. 1	2879	102. 9	27970	76. 1	15071	90. 1	167324
SE Alaska-O	136	104. 8	1298	80. 4	3070	90. 7	33843	41. 4	3206	91. 2	35141
SE Alaska-I	0	0. 0	0	0. 0	5603	81. 5	68742	40. 2	5603	81. 5	68742
Total 2A	0	0. 0	0	0. 0	703	101. 4	6936	14. 8	703	101. 4	6936
Total 2B	13988	86. 6	161587	52. 2	3497	99. 9	34995	68. 3	17485	88. 9	196582
Total 2C	136	104. 8	1298	80. 4	8673	84. 5	102585	40. 7	8809	84. 8	103883
Total Area 2	14124	86. 7	162885	52. 4	12873	89. 1	144516	46. 7	26997	87. 8	307401

1951	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	585	110. 8	5279	19. 8	585	110. 8	5279
Vancouver I.	788	32. 1	24516	0. 3	478	73. 6	6495	57. 6	1266	40. 8	31011
Charlotte-O	1032	119. 1	8667	60. 6	1	61. 2	16	100. 0	1033	119. 0	8683
Charlotte-I	13830	85. 6	161585	55. 5	3960	91. 4	43310	78. 5	17790	86. 8	204895
SE Alaska-O	531	135. 4	3922	63. 2	3290	98. 2	33509	38. 1	3821	102. 1	37431
SE Alaska-I	0	0. 0	0	0. 0	6103	95. 6	63842	40. 2	6103	95. 6	63842
Total 2A	0	0. 0	0	0. 0	585	110. 8	5279	19. 8	585	110. 8	5279
Total 2B	15650	80. 4	194768	53. 1	4439	89. 1	49821	76. 4	20089	82. 1	244589
Total 2C	531	135. 4	3922	63. 2	9393	96. 5	97351	39. 5	9924	98. 0	101273
Total Area 2	16181	81. 4	198690	53. 4	14417	94. 6	152451	50. 0	30598	87. 1	351141

1952	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U. S. -South	0	0. 0	0	0. 0	617	97. 0	6361	20. 4	617	97. 0	6361
Vancouver I.	663	12. 5	53040	0. 0	336	73. 7	4561	32. 4	999	17. 3	57601
Charlotte-O	1117	158. 5	7046	62. 3	35	118. 0	297	56. 3	1152	156. 9	7343
Charlotte-I	14768	110. 4	133782	57. 0	3748	116. 2	32249	80. 2	18516	111. 5	166031
SE Alaska-O	585	105. 1	5565	77. 3	2888	88. 5	32640	56. 4	3473	90. 9	38205
SE Alaska-I	0	0. 0	0	0. 0	6051	105. 9	57136	44. 9	6051	105. 9	57136
Total 2A	0	0. 0	0	0. 0	617	97. 0	6361	20. 4	617	97. 0	6361
Total 2B	16548	85. 4	193868	55. 1	4119	111. 0	37107	76. 1	20667	89. 5	230975
Total 2C	585	105. 1	5565	77. 3	8939	99. 6	89776	48. 7	9524	99. 9	95341
Total Area 2	17133	85. 9	199433	55. 8	13675	102. 6	133244	55. 7	30808	92. 6	332677

(*) indicates extrapolated value from adjacent region.

Appendix Table 1. Catch, CPUE, and Effort by Region, Regulatory Area, and Country in Area 2.

1953	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	0	0.0	0	0.0	502	135.7	3698	23.2	502	135.7	3698
Vancouver I.	816	149.3*	5466	0.0	368	93.7	3925	42.4	1184	126.1	9391
Charlotte-O	1151	149.3	7710	49.5	22	173.8*	127	0.0	1173	149.7	7837
Charlotte-I	15821	130.7	121081	61.8	5626	173.8	32378	82.9	21447	139.8	153459
SE Alaska-O	273	103.8	2631	61.4	2423	102.0	23766	54.8	2696	102.1	26397
SE Alaska-I	0	0.0	0	0.0	5709	116.8	48896	52.3	5709	116.8	48896
Total 2A	0	0.0	0	0.0	502	135.7	3698	23.2	502	135.7	3698
Total 2B	17788	132.5	134257	58.1	6016	165.1	36430	80.1	23804	139.5	170687
Total 2C	273	103.8	2631	61.4	8132	111.9	72662	53.0	8405	111.6	75293
Total Area 2	18061	131.9	136888	58.2	14650	129.9	112790	63.1	32711	131.0	249678

1954	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	0	0.0	0	0.0	853	170.6	5001	18.1	853	170.6	5001
Vancouver I.	1293	138.9	9310	4.6	700	117.8	5942	28.9	1993	130.7	15252
Charlotte-O	1408	157.9	8915	56.2	5	158.5	32	100.0	1413	157.9	8947
Charlotte-I	14561	130.3	111772	58.6	7018	171.6	40896	82.2	21579	141.3	152668
SE Alaska-O	223	136.4	1635	46.4	2778	140.5	19774	51.6	3001	140.2	21409
SE Alaska-I	0	0.0	0	0.0	7952	134.4	59156	49.2	7952	134.4	59156
Total 2A	0	0.0	0	0.0	853	170.6	5001	18.1	853	170.6	5001
Total 2B	17262	132.8	129997	54.4	7723	164.8	46870	77.5	24985	141.3	176867
Total 2C	223	136.4	1635	46.4	10730	135.9	78930	49.8	10953	136.0	80565
Total Area 2	17485	132.8	131632	54.3	19306	147.6	130801	59.5	36791	140.2	262433

1955	Canada				United States				Total		
Region	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates	% Logs	Catch 000 Lbs	CPUE Lbs	Effort Skates
U.S.-South	0	0.0	0	0.0	612	123.3	4965	28.3	612	123.3	4965
Vancouver I.	693	121.2	5717	13.6	655	127.3	5144	39.8	1348	124.1	10861
Charlotte-O	952	150.1	6344	88.0	0	0.0	0	0.0	952	150.1	6344
Charlotte-I	10893	122.6	88872	66.1	5458	126.4	43192	78.9	16351	123.8	132064
SE Alaska-O	260	121.9	2133	59.0	2112	132.5	15938	62.8	2372	131.3	18071
SE Alaska-I	0	0.0	0	0.0	6171	114.0	54141	66.0	6171	114.0	54141
Total 2A	0	0.0	0	0.0	612	123.3	4965	28.3	612	123.3	4965
Total 2B	12538	124.2	100933	64.9	6113	126.5	48336	74.7	18651	124.9	149269
Total 2C	260	121.9	2133	59.0	8283	118.2	70079	65.2	8543	118.3	72212
Total Area 2	12798	124.2	103066	64.8	15008	121.6	123380	67.6	27806	122.8	226446

(*) indicates extrapolated value from adjacent region.