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The Incidental Catch of Halibut
by Foreign Trawlers

by

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ABSTRACT

Halibut are harvested primarily with setlines in the northeast Pacific Ocean and the Bering Sea, but also are caught incidentally by trawlers that fish for other groundfish. Japanese and U.S.S.R. trawling increased substantially during the 1960's and early 1970's, but reliable statistics on the halibut catch were not reported by the trawl fisheries. Data on the incidence of halibut were collected by sampling the groundfish catch, and the total halibut catch was estimated by extrapolating the incidence to the entire fishery. The results show that the halibut catch by foreign trawlers increased sharply during the 1960's and early 1970's, was highest in the Bering Sea during the winter, and consisted mostly of fish younger than those in the setline fishery.

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INTRODUCTION

Nearly all of the catch of Pacific halibut (*Hippoglossus stenolepis*) was by domestic setline vessels (Canada and the United States) before 1960. During the 1960's, however, trawling by the domestic fleet increased off British Columbia, and foreign (Japan and U.S.S.R.) trawling expanded in the northeast Pacific and the Bering Sea. These trawl fisheries were directed at groundfish species other than halibut, but halibut were an incidental or by-catch. The incidental catch weakened the management control of the International Pacific Halibut Commission (IPHC) and, in part, offset conservation measures that were instituted in the setline fishery (Bell, 1970; Skud, 1973).

IPHC was not able to assess the effect of trawling on halibut stocks because reliable statistics were not available. The halibut catch by Soviet trawlers often is included with other miscellaneous species. Halibut caught in the domestic trawl fishery are not recorded in the trawl catch because they are discarded at sea. IPHC prohibits retention by domestic trawlers because many of the halibut caught by trawlers are below the optimum size that produces maximum yield (Bell, 1956; Myhre, 1969). Japan also is prohibited from retaining trawl-caught halibut in most of the Bering Sea east of 175° W longitude and is prohibited from retaining all halibut, regardless of method of capture, in the northeast Pacific. These regulations primarily are the result of negotiations with Canada and the United States and stem from Japan's membership in the International North Pacific Fisheries Commission (INPFC). Even though regulations require that domestic and Japanese trawlers discard halibut, many die from injuries received during capture (Hoag, 1975).

Although the incidental catch of halibut by trawlers was not reported directly, data on the incidence of halibut were collected by sampling the groundfish catch. During the 1960's, IPHC sampled the catch by domestic trawlers. The incidence of halibut varied with area, season, and target species, and the annual catch of halibut by domestic trawlers was estimated to be about 1,500 m.t. (Hoag, 1971). Several programs were conducted to estimate the incidence of halibut in the foreign catch. The results from these programs provided a base for estimating the magnitude of the halibut catch, evaluating its impact on the domestic setline fishery, and establishing conservation measures to reduce the catch of halibut by foreign trawlers. The purpose of this report is to examine the incidence by area, season, and gear and estimate the annual catch of halibut by foreign trawlers in the northeast Pacific and the Bering Sea. The results in this report have been used by Hoag (1976) to assess the effect of trawling on the domestic setline fishery and by IPHC to examine means of reducing the incidental catch. Because the incidence of halibut varies with area and season, IPHC proposed that certain critical areas be closed to trawling when the incidental catch of halibut was high, and through negotiations with Canada and the U.S., Japan and the U.S.S.R. have agreed to most of the proposed closures (IPHC, 1976).

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FOREIGN TRAWL FISHERY

Alverson, Pruter, and Ronholt (1964), Chitwood (1969), and Kasahara (1972) describe the development of the Japanese and Soviet trawl fisheries in the Bering Sea and the northeast Pacific. The Japanese began small-scale trawling in the Bering Sea in 1930, but ceased fishing in 1941 with the advent of World War II. Fishing resumed in 1954 and was directed at yellowfin sole (*Limanda aspera*) on the eastern Bering Sea flats during the summer and fall. The annual groundfish catch was less than 25,000 m.t. before 1958, but increased to over 400,000 m.t. in 1961 when the fishery expanded. The abundance of yellowfin sole declined sharply in the early 1960's, and the catch fell to about 25,000 m.t. in 1963. The fishery then switched to walleye pollock (*Theragra chalcogramma*) and increased again in the late 1960's and early 1970's. The Japanese groundfish catch in the Bering Sea exceeded 1,500,000 m.t. in 1971.

Japan began trawling in the northeast Pacific in 1963. The fishery expanded slowly due, in part, to Canadian and U.S. concern about possible detrimental effects on halibut but by 1967 was spread throughout the northeast Pacific. Effort was directed primarily at Pacific ocean perch (*Sebastes alutus*), and the annual groundfish catch by Japan in the northeast Pacific reached about 100,000 m.t. by the early 1970's.

The Japanese trawl fishery is divided into three fleets:

1. The mothership trawl fleet consists of pair trawlers, stern trawlers, side trawlers, and Danish seiners that deliver to accompanying processing vessels and is licensed to operate only in the Bering Sea.
2. The independent trawl fleet (also known as the northern seas or North Pacific trawl fleet) consists of large stern trawlers that process their own catch and is licensed to operate in the Bering Sea and the northeast Pacific.
3. The land-based trawl fleet (also known as the land-based dragnet or Hokutensen fleet) consists of independent trawlers which are not permitted to transship their catch in offshore waters and is licensed to operate north of 48° N latitude and west of 170° W longitude.

The U.S.S.R. began trawling in the Bering Sea in 1959. Effort was directed primarily at yellowfin sole and was concentrated during the winter on the continental shelf in the southeastern Bering Sea. In contrast to Japan, the U.S.S.R. continued to fish for yellowfin sole throughout the 1960's and did not switch to walleye pollock until 1971. Their annual groundfish catch increased from about 100,000 m.t. in the 1960's to over 300,000 m.t. in the early 1970's.

The U.S.S.R. began fishing in the northeast Pacific in 1962. Effort was directed at Pacific ocean perch and increased rapidly until 1965 when the groundfish catch reached 400,000 m.t. The catch then declined to less than 50,000 m.t. in 1969. In the early 1970's, the U.S.S.R. began fishing walleye pollock, Atka mackerel (*Pleurogrammus monopterygius*), and several species of flounder. Fishing was concentrated near Kodiak Island during the winter, and the annual catch was about 100,000 m.t. in 1972-1973. The U.S.S.R. also fished extensively for Pacific hake (*Merluccius productus*), but this fishery was not considered in this report because it is concentrated off Oregon and California, south of productive halibut grounds, and employs off-bottom trawls which probably catch few halibut. The Soviet fleet consists mostly of stern trawlers that process their own catch and side trawlers that deliver to accompanying processing vessels.

The Republic of Korea also has developed a trawl fishery in the Bering Sea and northeast Pacific since 1967, but this fishery is small relative to the Japanese and Soviet fisheries and was not considered in this report.

ESTIMATING THE INCIDENTAL CATCH

Data on the incidence, size, and age of halibut were collected primarily on Japanese motherships and independent trawlers. Only a few observers were permitted on Soviet trawlers. The catch from over 1,000 vessel-days of fishing was sampled, most by Canadian, United States, and IPHC scientists in programs arranged through INPFC or bilateral agreements and coordinated by the U.S. National Marine Fisheries Service (NMFS). The Japanese catch was sampled during 1963-1969 in the northeast Pacific Ocean and during 1973-1975 in the Bering Sea. The U.S.S.R. catch was sampled during 1974-1975 in the Bering Sea and the northeast Pacific. The Fisheries Agency of Japan (FAJ) also sampled the Japanese catch during 1969-1973 in the Bering Sea. Results from these programs were presented in unpublished documents at annual meetings of INPFC and reviewed by scientists from Canada, Japan, the United States, and IPHC.

The groundfish catch by individual motherships or independent trawlers usually exceeded 100 m.t. per day, and an enumeration of the halibut in the catch was not possible. Two sampling methods were developed to estimate the halibut catch (Miller et al, 1976). One was to shovel a sample of the catch into baskets, weigh the contents, and record the number of halibut. This method provided an accurate estimate of the incidence of halibut, but allowed less than 2 m.t. of catch to be sampled per day (usually less than 2% of the daily catch). The other method was to monitor the conveyor belt that transports the catch from the unloading bin to the factory. This method resulted in sampling 50 to 150 m.t. of the catch per day but was less accurate because the weight of fish on the belt was not always known and some of the halibut occasionally were missed and not counted. The estimates from the two methods, however, were usually similar, an indication that both methods provided a reliable measure of the halibut incidence.

Halibut generally were a small part of the catch, and the incidence was expressed as the number of halibut per metric ton of total catch. Catch per unit of effort was not calculated because precise effort data were not available. We combined the data from all sources and examined the incidence and size of halibut by area, month, and gear type. Statistical areas are shown in Figure 1. We then estimated the total catch of halibut by multiplying the observed incidence (number per metric ton) times the reported catch of groundfish (metric tons).

The estimates of the incidental catch do not account for the possibility that trawlers occasionally fish specifically for halibut. When halibut are concentrated, they are a potential target species for trawls because their value is several times that of other groundfish. Halibut were not a target species when scientists were aboard, but the sampling may not have been representative of the entire fleet as Canadian and U.S. fishermen and enforcement officers occasionally have observed trawlers operating on productive halibut grounds and noted halibut catches of over a metric ton per haul. Further, Japanese vessels have been observed illegally retaining halibut and several have been apprehended. To the extent that foreign trawlers fish specifically for halibut, the estimates are less than the actual catch.

Data on the incidence of halibut were meager or lacking in many months, areas, and years. Because of these limitations, several assumptions were required to

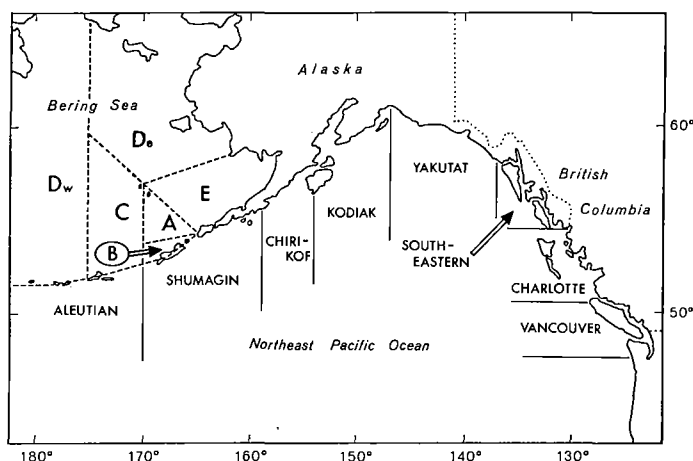


Figure 1. Statistical areas in the Bering Sea and the northeast Pacific Ocean.

estimate the halibut catch. First, data were available for only a few years, and it was necessary to assume that annual differences in the incidence were inconsequential and combine data from all years. Annual differences, however, occurred in the gear, the target species, and the abundance of halibut and other groundfish, and each of these factors could affect the incidence of halibut. In fact, the abundance of halibut generally declined during the 1960's and early 1970's (IPHC, 1976), and gear modifications (Takahashi, 1974) have increased the catch of the target species. As a result, we may have overestimated the halibut catch during the 1970's and underestimated the catch during the 1960's. The error, however, may be small as the abundance of other groundfish also declined during this period. A decline in the abundance of other groundfish would tend to compensate for the error caused by a decline in halibut abundance, i.e., the incidence of halibut was expressed as the number of halibut per metric ton of groundfish.

Because data from Soviet trawlers were not sufficient to estimate their incidental catch, the incidence on Soviet trawlers was assumed to be the same as that observed on Japanese trawlers. This assumption may not be valid because observations suggest that Soviet trawls are fished off bottom more frequently than Japanese trawls. The problem of estimating the U.S.S.R. catch was further complicated in that the statistics of the total groundfish catch by U.S.S.R. trawlers are of questionable accuracy. R. C. Naab (NMFS, personal communication) reported major discrepancies in the magnitude and location of the U.S.S.R. catch when compared with the fishery activities documented by aerial surveillance reports. Also, the U.S.S.R. did not report their catch every year and reported it only for large areas in other years. For these reasons, estimates for the U.S.S.R. are less reliable than those for Japan.

INCIDENTAL CATCH IN THE BERING SEA

Japanese Mothership-Independent Trawl Fleet

We examined the catch of halibut separately for the mothership-independent trawl fleet and for the land-based fleet. Further, we divided the history of the mothership-independent trawl fleet into two periods and examined the halibut catch separately for each period. The first period was from 1954 to 1963 when the Japanese fished primarily for yellowfin sole on the Bering Sea flats (Areas De

and E) during the summer and fall. The second period was from 1964 to 1974 when the Japanese fished primarily for walleye pollock along the edge of the continental shelf.

During the first period, direct observations were not available and, therefore, an accurate estimate of the incidence and size of halibut could not be made. The catch of halibut, however, probably was high because Novikov (1964) showed that halibut are distributed widely over the Bering Sea flats during the summer and that the distribution of halibut and yellowfin sole is similar. K. S. Ketchen of the Pacific Biological Station, Fisheries and Marine Service, Canada (personal communication) estimated the annual halibut catch from 1954 to 1963 by assuming that 0.5% of the annual flounder catch was halibut and that the average weight of halibut was 0.62 kg. (Ketchen's estimates were reviewed by scientists from Canada, Japan, and the United States at the 1964 annual meeting of INPFC and were included in the proceedings from the meeting.) This percentage and average weight were from data collected during exploratory fishing by the U.S. Bureau of Commercial Fisheries (now NMFS) and is equivalent to an incidence of 8.1 halibut per metric ton. Ketchen's estimates suggest that the halibut catch increased to over 3,000,000 fish (2,000 m.t.) in 1961 and then declined sharply:

	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
Numbers (000's)	84	68	165	165	271	840	2,560	3,280	2,290	202
Metric Tons	52	42	102	102	168	520	1,590	2,303	1,420	125

These estimates are not precise, but probably cannot be improved because of a lack of observations. Ketchen considered the estimates "conservative" and data from research surveys by FAJ and IPHC indicate that the halibut catch may have been several times higher. For example, Best (1970) showed an incidence of 43.6 halibut per metric ton in Area E during May-August 1963, and FAJ (1967) showed an incidence of 19.4 halibut per metric ton in Areas D and De during May-June 1966. The age composition of the incidental catch is unknown; most of the halibut caught during the research surveys were 3 or 4 years old.

Estimates during the second period of the mothership-independent trawl fleet are more reliable because direct observations on the incidence and size of halibut were available. The catch from about 800 fishing days was sampled during 1969-1974, and the incidence and size of halibut were examined by area, month, and vessel type. Differences by vessel type generally were small or not consistent. Catches from different vessels delivering to the same mothership usually could not be separated, but a few observations suggest that the incidence was higher for Danish seines than for pair trawls. Also, in the southeastern Bering Sea, the incidence of halibut was higher on motherships than on independent trawlers, and IPHC (1974) speculated that the difference might be due to large bobbins (rollers) that often are used by independent trawlers to raise the groundline off the bottom. However, data on bobbin size were usually not available, and the average incidence in other areas of the Bering Sea was similar for the two vessel types. Therefore, the data from all vessel types were combined and the incidence was examined by area and month.

Data were available in 50 of 72 possible area-month blocks (6 areas for 12 months) and in nearly all blocks where the Japanese fishery was substantial (Table 1). The average incidence was about two fish per metric ton but differed considerably among blocks. The highest incidence (over 25 per metric ton) occurred

Table 1. The average incidence and weight of halibut in Japanese trawls in the Bering Sea, by month and area, 1969-1974.

Month	Area					
	A	B	C	De	Dw	E
	Incidence (Number per metric ton)					
January	—	—	0.054	—	0.070	25.437
February	0.163	—	2.787	—	0.196	2.629
March	5.779	4.930	0.476	—	0.720	8.073
April	2.935	1.341	1.465	—	0.012	2.516
May	7.145	6.976	1.022	—	0.131	3.062
June	—	0.000	1.155	—	1.114	1.987
July	—	—	0.040	0.013	0.066	0.000
August	0.021	—	0.157	0.013	0.103	—
September	0.008	0.000	0.187	—	0.007	—
October	0.018	0.000	0.023	—	0.037	0.022
November	0.064	—	—	—	0.049	1.266
December	0.014	—	0.249	—	0.074	27.643
	Weight (kg)					
January	—	—	3.20	—	2.28	0.39
February	0.69	—	1.14	—	5.90	1.07
March	0.90	0.81	1.46	—	2.66	0.48
April	0.93	0.80	1.00	—	0.68	1.33
May	0.64	0.41	1.22	—	1.59	1.13
June	—	—	2.76	—	6.11	1.94
July	—	—	3.01	3.50	7.45	—
August	17.73	—	7.42	3.50	2.03	—
September	7.30	—	3.68	—	4.44	—
October	3.55	—	8.70	—	4.70	2.38
November	1.33	—	—	—	5.15	2.17
December	0.66	—	5.37	—	2.57	0.85

in Area E during December-January, and the incidence generally was over two fish per metric ton in the southeastern Bering Sea (Areas A, B, and E) from December to May. The incidence usually was less than one fish per metric ton in other areas and months and was lowest in Areas De and Dw.

The high incidence in the southeastern Bering Sea was expected as Novikov (1964) showed that halibut concentrate in this area at depths of 100 to 450 meters during the winter. Pollock and yellowfin sole also concentrate at these depths during the winter and are fished by Japanese and U.S.S.R. trawlers. The incidence was highest near Unimak Pass, declined from early to late winter in Area E, and increased from early to late winter in Areas A and B. These differences probably are related to water temperature and depth. Because Area E is shallower than Areas A and B, the halibut concentrate in Area E when the water first begins to cool. They then move into the deeper water of Areas A and B later in the winter when the water is coldest. The incidence was low during the summer because most of the halibut disperse over the Bering Sea flats (Areas De and E) at depths of less than 100 meters (Dunlop et al, 1964), whereas the trawl fleets continue to fish along the edge of the continental shelf at depths generally over 100 meters. (As mentioned previously, the fleet fished on the flats before 1964.)

We also examined the size and age of halibut in the catch by the mothership-independent trawl fishery. The average weight of halibut ranged from 0.4 kg to 17.7 kg among area-month blocks (Table 1), and the overall average was 3.0 kg. Halibut were larger during the summer than the winter, an indication that the larger halibut tend to stay along the edge of the shelf during the summer. The size of halibut also varied with vessel type. The average weight was higher for independent trawlers (3.0 kg) than for motherships (1.8 kg) fishing in the same areas and months. Figure 2 shows the length and age distribution of all halibut sampled. Most of the fish were 30 to 60 cm long and 4 to 7 years old; modal length and age were 42 cm and 4 years, respectively. Because all samples were combined, the figure more closely reflects the size and age distribution in the southeastern Bering Sea during the winter when the incidence of halibut was high and samples were large. The proportion of males and females in the catch was about the same.

To estimate the annual incidental catch, we multiplied the incidence and weight of halibut in each area-month block by the respective Japanese groundfish catch. As previously mentioned, annual differences in the incidence were assumed to be insignificant and the average of all years was used. The Japanese groundfish catch was obtained from unpublished documents by FAJ (Far Seas Fisheries

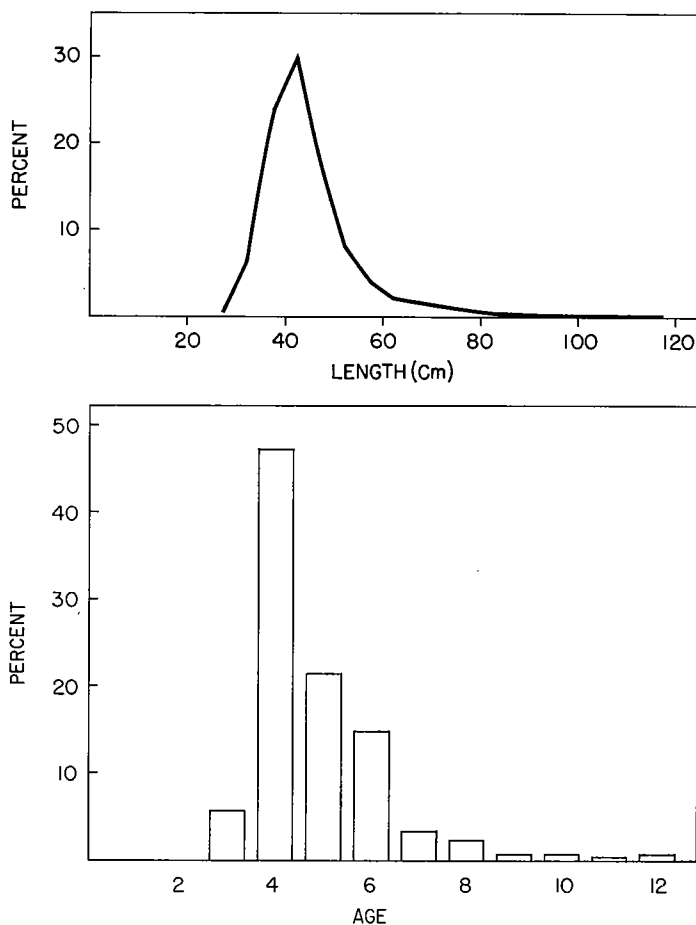


Figure 2. Length and age distribution of halibut caught by the Japanese mothership-independent trawl fleet in the Bering Sea.

Research Laboratory, Shimizu, Japan) that were submitted to INPFC. If the incidence and weight were unknown, we combined blocks and used the averages for December-May (4.073 halibut per m.t., 1.54 kg per halibut) and June-November (0.223 halibut per m.t., 4.94 kg per halibut). This procedure was used to account for seasonal changes in the incidence, but did not appreciably affect the estimates because the fishery was small in most blocks where the incidence and weight were unknown. The results show that the annual catch of halibut increased from 266,000 fish (412 m.t.) in 1964 to 3,465,000 fish (3,484 m.t.) in 1971 and then declined to 1,614,000 fish (1,807 m.t.) in 1974 (Table 2). In the early 1970's, about 90% of the catch occurred in Areas A and E during December to May. Although Japan usually does not report its incidental catch east of 175° W where retention of halibut is prohibited, substantial catches were reported west of 175° W (Area Dw) where retention is allowed. We compared the reported catch with the estimated catch of halibut from Area Dw:

Halibut Catch	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Reported (m.t.)....	1,525	1,564	640	1,171	1,278	920	550	1,950	1,273	1,346	338
Estimated (m.t.)....	21	7	9	11	24	16	31	68	195	258	211

The estimated catch is substantially less than the reported catch, an indication that we grossly underestimated the halibut catch or that the reported catch for Area Dw was too high. One explanation is that the data collected were not

Table 2. Estimated catch of halibut by the Japanese mothership-independent trawl fishery in the Bering Sea.

Year	Area						Total
	A	B	C	De	Dw	E	
1964: Numbers	43,000	0	36,000	7,000	7,000	173,000	266,000
Metric Tons	59	0	62	19	21	251	412
1965: Numbers	68,000	11,000	34,000	12,000	3,000	166,000	294,000
Metric Tons	54	15	105	42	7	217	440
1966: Numbers	176,000	30,000	11,000	8,000	4,000	274,000	503,000
Metric Tons	210	43	29	30	9	372	693
1967: Numbers	726,000	16,000	30,000	12,000	4,000	381,000	1,169,000
Metric Tons	650	19	100	44	11	517	1,341
1968: Numbers	667,000	3,000	80,000	15,000	7,000	633,000	1,405,000
Metric Tons	644	3	207	54	24	833	1,765
1969: Numbers	1,133,000	26,000	35,000	15,000	6,000	864,000	2,079,000
Metric Tons	1,053	16	114	58	16	919	2,176
1970: Numbers	1,281,000	17,000	260,000	35,000	13,000	892,000	2,498,000
Metric Tons	1,142	12	628	100	31	846	2,759
1971: Numbers	2,206,000	15,000	283,000	4,000	22,000	935,000	3,465,000
Metric Tons	1,862	13	669	11	68	861	3,484
1972: Numbers	2,422,000	59,000	272,000	1,000	57,000	302,000	3,113,000
Metric Tons	2,173	50	583	2	195	256	3,259
1973: Numbers	1,394,000	76,000	229,000	1,000	67,000	710,000	2,477,000
Metric Tons	1,206	55	425	2	258	621	2,567
1974: Numbers*	741,000	11,000	210,000	3,000	51,000	598,000	1,614,000
Metric Tons*	673	9	433	12	200	480	1,807

*Preliminary data for November-December.

representative and there is a non-sampled segment of the fishery with an extremely high incidental catch. However, samples were available in this area during all months and consistently showed a low incidence. Therefore, we consider a more likely explanation is that the catch reported in Area Dw includes halibut that were illegally retained east of 175° W. Scientists have observed halibut being illegally retained by Japanese trawlers fishing east of 175° W.

Japanese Land-Based Fleet

Direct observations were not available on the incidence and size of halibut in the land-based fleet. This fleet, however, operates primarily in areas where halibut may be legally retained and substantial catches of halibut were reported by FAJ (R. A. Fredin, NMFS, personal communication). The catch was reported only in weight, and we estimated the catch in numbers by assuming an average weight per fish of 3.0 kg (the average in the mothership-independent trawl fishery). Table 3 shows that the annual catch increased sharply during 1962-1967, peaked at 1,909,000 fish (5,728 m.t.) in 1971, and then declined to 527,000 fish (1,581 m.t.) in 1974. Most of the catch was from Area Dw, although a substantial catch

Table 3. Annual catch of halibut by the Japanese land-based trawl fishery in the Bering Sea.

Year	Area				Total
	C	De	Dw	Unknown	
1962: Numbers	0	0	37,000	0	37,000
Metric Tons	0	0	112	0	112
1963: Numbers	0	0	220,000	0	220,000
Metric Tons	0	0	659	0	659
1964: Numbers	0	0	426,000	0	426,000
Metric Tons	0	0	1,278	0	1,278
1965: Numbers	0	23,000	424,000	15,000	462,000
Metric Tons	0	69	1,272	45	1,386
1966: Numbers	0	0	805,000	39,000	844,000
Metric Tons	0	0	2,415	118	2,533
1967: Numbers	5,000	0	1,671,000	92,000	1,768,000
Metric Tons	14	0	5,012	275	5,301
1968: Numbers	115,000	6,000	1,053,000	20,000	1,194,000
Metric Tons	345	18	3,160	59	3,582
1969: Numbers	180,000	9,000	1,007,000	2,000	1,198,000
Metric Tons	539	26	3,022	7	3,594
1970: Numbers	96,000	3,000	1,792,000	2,000	1,893,000
Metric Tons	288	9	5,375	5	5,677
1971: Numbers	572,000	10,000	1,327,000	0	1,909,000
Metric Tons	1,717	30	3,981	0	5,728
1972: Numbers*	—	—	1,226,000	0	1,226,000
Metric Tons*	—	—	3,678	0	3,678
1973: Numbers*	—	—	830,000	0	830,000
Metric Tons*	—	—	2,489	0	2,489
1974: Numbers*	—	—	527,000	0	527,000
Metric Tons*	—	—	1,581	0	1,581

*Data are only available by 10° bands of longitude; catches from Areas C and De, if any, are included with the catch from Area Dw.

was reported occasionally from Area C. Catches from Area C were either illegal or were erroneously reported.

Based on the reported catch, the incidence of halibut in the land-based fleet is much higher than in the mothership-independent trawl fleet. In the land-based fleet, halibut usually represent 5% to 10% of the annual catch. This range is equivalent to about 15 to 30 halibut per metric ton (based on an average weight of 3.0 kg per fish) and is about 100 times greater than the incidence observed in the mothership-independent trawl fishery for the same area. The difference in the incidence may be attributed partly to the target species, i.e., the land-based fishery catches more flatfish and less pollock, or that land-based trawlers occasionally fish specifically for halibut.

Although the halibut catch by land-based trawlers was large, their effect on the domestic setline fishery may be small. Land-based trawlers primarily fish in the western Bering Sea (west of 175° W longitude), whereas the domestic setline fishery concentrates in the eastern Bering Sea. The migration of halibut from the western to the eastern Bering Sea apparently is not significant as IPHC estimated that only 1.2% of the halibut tagged in the western Bering Sea migrated to the eastern Bering Sea (unpublished document submitted to INPFC in 1973).

U.S.S.R. Fleet

Data on the incidence of halibut in the Soviet catch are too limited to provide accurate estimates of the incidental catch. In 1975, the catch from two independent trawlers was sampled, and the results suggested that the incidence of halibut in the Soviet catch may be lower than in the Japanese catch. For example, the incidence in the Soviet catch during March in Area A was 0.046 halibut per metric ton — much less than the incidence (3.355 per metric ton) observed in the Japanese catch in the same area and month during 1974. The incidence on the other Soviet trawler (February, Area C) also was low (0.077 per metric ton), but this vessel was conducting research and not fishing commercially. The Soviet trawlers fished the net slightly off bottom, and this probably explains the low incidence of halibut. The incidence that was observed, however, probably is lower than that for the fleet. Before 1971, the U.S.S.R. primarily fished for flatfish that are not effectively caught with off-bottom trawls. The fishery has since switched to pollock, but flatfish still represent about 15% of the catch.

Although the incidence of halibut in the Soviet catch is not known and may be less than in the Japanese catch, we used the incidence observed on Japanese vessels to estimate the general magnitude of the Soviet halibut catch. The Soviet groundfish catch was not available for each area-month block and even their annual catch, reported by the Food and Agriculture Organization of the United Nations, was available only as a combined catch for the northeast Pacific and the Bering Sea. We did, however, obtain estimates of the annual groundfish catch in the Bering Sea from several sources. For 1959-1966, we used the annual flounder catch reported by Fadeev (1970) and Chitwood (1969); most of the groundfish catch probably was flounder during these years. For 1967-1974, we used the annual catch of all species, except herring, provided through U.S.-U.S.S.R. fisheries agreements (H. A. Larkins, NMFS, personal communication).

Although the limitations of the U.S.S.R. groundfish data precluded us from estimating the catch in each area-month block, we did adjust for seasonal differences in the incidence. Surveillance reports (R. C. Naab, NMFS, personal communication)

indicate that most of the U.S.S.R. fishery occurred from November to May. Therefore, we used only the incidence from the Japanese fishery during this period; the average incidence and weight were 4.0 halibut per metric ton and 1.5 kg per fish. The results show that the estimated annual catch of halibut averaged about 500,000 fish (750 m.t.) during 1959-1970 and then increased sharply to about 1,500,000 fish (2,000 m.t.) during 1971-1974 (Table 4). Most of this catch probably occurred in the southeastern Bering Sea.

Table 4. Estimated U.S.S.R. catch of halibut in the Bering Sea.

Year	Groundfish Catch (m.t.)*	Estimated Halibut Catch	
		Numbers	m.t.
1959	62,200	249,000	374
1960	96,000	384,000	576
1961	154,200	617,000	926
1962	139,600	558,000	837
1963	92,400	370,000	555
1964	79,300	317,000	476
1965	90,000	360,000	540
1966	100,000	400,000	600
1967	122,900	492,000	738
1968	98,800	395,000	592
1969	162,100	648,000	972
1970	159,600	638,000	957
1971	384,600	1,538,000	2,307
1972	363,000	1,452,000	2,178
1973	331,100	1,324,000	1,987
1974	409,700	1,638,800	2,458

* 1959-1966: Flounder only.

1967-1974: All species except herring.

INCIDENTAL CATCH IN THE NORTHEAST PACIFIC OCEAN

Japanese Fleet

In the northeast Pacific, Japan utilizes only independent trawlers, and data on the incidence and size of halibut were collected during 1963-1969 from about 3,000 hauls. These data were summarized by area, month, and trawl type (groundfish or shrimp). The incidence of halibut (Table 5) averaged about five fish per metric ton and generally was higher than in the Bering Sea. Data were not available for many area-month blocks, but some differences were apparent. As in the Bering Sea, the incidence was highest during the winter and spring although data were not available during November-January, months that had a high incidence in the Bering Sea. The incidence from February to May averaged about 10 halibut per metric ton and exceeded 20 per ton in several areas. The incidence from June to October generally was less than one halibut per metric ton.

The incidence in shrimp trawls was considerably higher than in groundfish trawls and declined less from winter to summer than did the incidence in groundfish trawls. This difference may be due to the depth fished. Groundfish trawls were fished primarily at depths of 200-400 meters, compared to depths of 100-200 meters for shrimp trawls. Data from research surveys with trawls (Hughes, 1974; Hughes and Alton, 1974) show that halibut occur over a broad range of depths but usually are concentrated at depths of 100-300 meters during the winter and

Table 5. The average incidence and weight of halibut in Japanese trawls in the northeast Pacific by month, area, and trawl type, 1963-1969.

INPFC Areas— Trawl Type and Area	Month								
	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Groundfish Trawls	Incidence (Number per metric ton)								
Shumagin	0.404	10.932	4.724	2.235	0.300	1.038	—	—	3.750
Chirikof	22.142	1.200	22.680	2.010	0.354	0.181	0.902	1.035	0.128
Kodiak	3.138	4.566	6.729	8.411	0.601	0.255	0.228	0.526	2.337
Yakutat	—	—	14.250	—	—	0.841	0.460	0.237	—
Southeastern	—	—	—	—	—	0.174	0.056	—	—
Charlotte	—	—	—	1.188	1.391	0.068	0.044	—	—
Vancouver	—	—	—	0.000	—	—	0.000	—	—
Shrimp Trawls									
Shumagin	—	—	—	8.906	5.083	3.500	—	—	—
Chirikof	7.500	—	—	—	8.388	2.165	4.884	—	—
Kodiak	11.249	—	37.127	36.475	29.300	—	4.455	3.019	—
Groundfish Trawls*	Weight (kg)								
Shumagin	3.55	2.00	2.18	1.98	2.10	2.50	—	—	1.86
Chirikof	8.45	8.41	2.04	5.22	2.60	13.36	13.90	—	—
Kodiak	2.77	1.81	2.59	2.61	7.09	15.56	6.69	4.87	3.05
Yakutat	—	—	3.41	—	—	9.20	13.45	12.10	—
Southeastern	—	—	—	—	—	13.50	—	—	—
Shrimp Trawls									
Shumagin	—	—	—	2.40	2.40	2.40	—	—	—
Chirikof	5.20	—	—	—	1.10	4.89	5.61	—	—
Kodiak	4.54	—	0.93	2.50	3.18	—	3.30	2.84	—

*Data not available in Charlotte-Vancouver areas.

spring and less than 100 meters during the summer. These data indicate that halibut inhabit shallower water than that fished by groundfish trawls during the summer. The depth fished by groundfish trawls does differ with the target species. Japanese trawlers have fished for Pacific ocean perch that generally inhabit depths over 200 meters, but if the target changed to species that inhabit shallower water, then the incidence of halibut probably would be higher during the summer than the winter. This relationship was found in Canadian and U.S. trawl catches off British Columbia, i.e., the incidence was highest in the summer when the fleet fished for shallow-water species (Hoag, 1971).

Differences in the incidence among areas were difficult to assess, but appear to be either not pronounced or not consistent. Most of the observations were from the Shumagin to Kodiak areas, and observations from other areas were limited primarily to the summer months when the incidence was low. Data from IPHC surveys (Hughes, 1974) show that halibut are widely distributed throughout the northeast Pacific and indicate that differences in the incidence among broad areas probably are small.

Halibut caught by Japanese trawlers were larger in the northeast Pacific than in the Bering Sea. The average weight was about 4 kg, but varied with month and type of trawl (Table 5). Halibut were largest when caught during the summer by

groundfish trawls; the average weight exceeded 10 kg in several areas and months. The difference in the size may be related to depth. The length- and age-frequency distributions of halibut sampled on Japanese trawlers are shown in Figure 3. Most of the halibut were 30 to 80 cm long and 4 to 8 years old. The modal length and age were the same as in the Bering Sea fishery, i.e., 42 cm and 4 years old, but the frequency of large and old fish was slightly higher in the northeast Pacific.

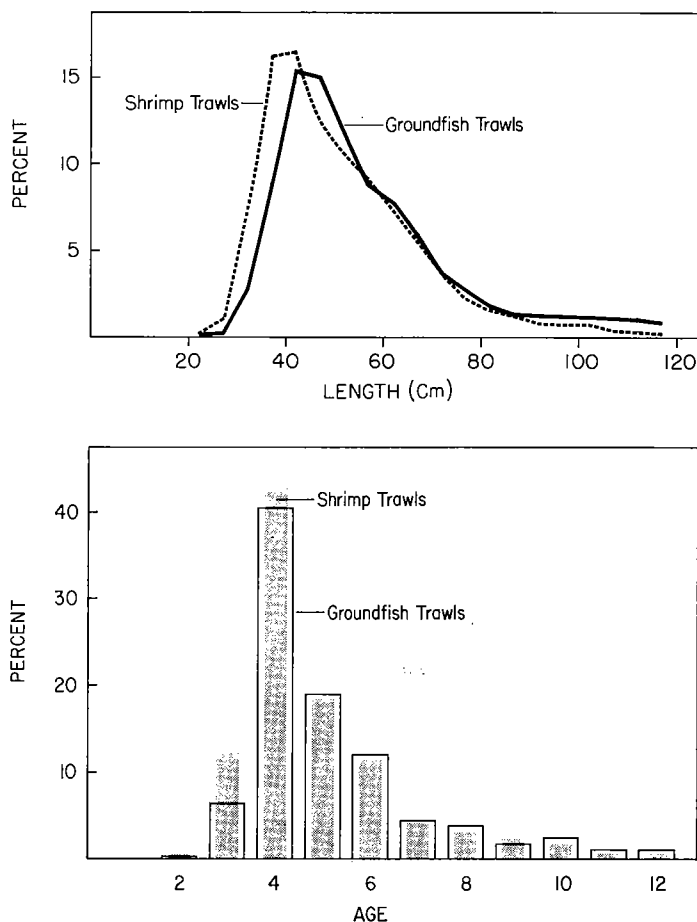


Figure 3. Length and age distribution of halibut caught by Japanese trawls in the northeast Pacific Ocean.

The halibut catch from 1964 to 1974 was estimated by multiplying the incidence and weight of halibut in each area-month block by the respective Japanese groundfish and shrimp catch. The Japanese groundfish and shrimp catches were obtained from unpublished documents by FAJ (Far Seas Fisheries Research Laboratory, Shimizu, Japan) that were submitted to INPFC. In area-month blocks where the incidence and weight were not available, we used the average among blocks for December-May and June-November:

	<u>Groundfish Trawls</u>		<u>Shrimp Trawls</u>	
	<u>December-May</u>	<u>June-November</u>	<u>December-May</u>	<u>June-November</u>
Number per Metric Ton	7.0	0.7	20.3	7.6
Weight (kg)	3.6	8.2	3.1	3.2

The halibut catch in the Aleutian area was estimated by applying the incidence observed in the adjacent Shumagin area. The catch from the Bering Sea that occurs along the Aleutian Islands was included in the Aleutian area. The estimated catch of halibut by Japanese trawlers in the northeast Pacific increased from 1964 to 1968 and thereafter averaged about 350,000 fish (1,200 m.t.) (Table 6). The catch in 1973 and 1974 was about 500,000 fish (1,800 m.t.). Most of the catch occurred from December to May and from the Aleutian to Yakutat areas.

Table 6. Estimated catch of halibut by Japanese trawlers in the northeast Pacific.

Year	Area								
	Aleutian	Shumagin	Chirikof	Kodiak	Yakutat	S.E. Alaska	Charlotte	Vancouver	Total
1964: Numbers	38,000	8,000	3,000	68,000	0	0	0	0	117,000
Metric Tons	138	25	13	214	0	0	0	0	390
1965: Numbers	82,000	65,000	27,000	37,000	0	0	0	0	211,000
Metric Tons	242	168	120	136	2	0	0	0	668
1966: Numbers	42,000	64,000	119,000	56,000	1,000	1,000	12,000	14,000	309,000
Metric Tons	125	187	391	213	6	4	46	50	1,022
1967: Numbers	11,000	50,000	88,000	97,000	42,000	33,000	25,000	18,000	364,000
Metric Tons	43	148	533	288	190	142	102	103	1,549
1968: Numbers	26,000	3,000	36,000	45,000	169,000	47,000	44,000	19,000	389,000
Metric Tons	122	9	181	141	675	188	177	74	1,567
1969: Numbers	23,000	24,000	30,000	59,000	75,000	34,000	47,000	9,000	301,000
Metric Tons	82	85	68	182	328	160	183	34	1,122
1970: Numbers	23,000	36,000	58,000	45,000	47,000	52,000	2,000	1,000	264,000
Metric Tons	66	132	377	144	196	217	13	9	1,154
1971: Numbers	30,000	41,000	17,000	70,000	47,000	50,000	2,000	2,000	259,000
Metric Tons	95	129	118	209	213	204	13	14	995
1972: Numbers	22,000	28,000	30,000	89,000	89,000	84,000	29,000	15,000	386,000
Metric Tons	72	81	115	249	361	335	110	64	1,387
1973: Numbers	14,000	21,000	162,000	72,000	116,000	85,000	46,000	3,000	519,000
Metric Tons	54	49	513	212	469	330	172	17	1,816
1974: Numbers*	38,000	32,000	113,000	111,000	84,000	31,000	69,000	4,000	482,000
Metric Tons*	109	75	534	355	332	139	263	33	1,840

*Preliminary data for November-December.

During 1975, additional data on the incidence and size of halibut were collected on Japanese trawlers in the northeast Pacific. The incidence was similar to that observed during the 1960's and varied with season and target species. The incidence generally was over two halibut per metric ton during the winter and less than one per metric ton during the summer. The 1975 data included several samples from the Yakutat to Vancouver areas where data from the 1960's were limited. The incidence in these areas was similar to that in the more western areas and supported conclusions drawn from Table 5 that area differences are not pronounced in the northeast Pacific. The incidence was higher when the vessels fished for rock sole (*Lepidopsetta bilineata*) and arrowtooth flounder (*Atheresthes stomias*) than when they fished for Pacific ocean perch. During the 1960's, Japanese trawlers targeted primarily on Pacific ocean perch, but also targeted on flatfish in recent years. The size of halibut was similar to that during the 1960's and about 75% were males. Information on the sex composition was not collected during the 1960's.

U.S.S.R. Fleet

As in the Bering Sea, observations on the incidence of halibut in the Soviet catch were limited. The groundfish catch was not reported by area-month blocks and was of questionable accuracy. Observations were available from only two trawlers that fished the Kodiak area (November 1974-February 1975). The incidence and average weight of halibut by month were:

	<u>November</u>	<u>December</u>	<u>January</u>	<u>February</u>
Number per Metric Ton	0.250	1.833	3.146	1.327
Weight (kg)	15.8	5.0	9.8	2.1

The incidence was lower in the Soviet catch than in the Japanese catch but, except for February, observations were not available during the same months for comparison. Also, the catch by Soviet trawlers was atypical of the Japanese fishery and the traditional Soviet fishery, i.e., the target species was Atka mackerel rather than Pacific ocean perch. In 1973, surveillance reports (R. C. Naab, NMFS, personal communication) indicated that the fishery was directed at pollock and flounder (species unknown) and photographs show halibut in the catch (Figure 4).



U.S. NATIONAL MARINE FISHERIES SERVICE

Figure 4. Halibut in the catch of a U.S.S.R. trawler off Kodiak Island, February 1973.

Because data on the incidence of halibut in the Soviet fishery are meager, the incidence in the Japanese fishery was used to estimate the annual catch of halibut by Soviet trawlers. This procedure, however, may have overestimated the halibut catch. Soviet vessels were observed using off-bottom trawls (that may catch few halibut) during the 1960's when the fishery was directed at Pacific ocean perch (S. J. Westrheim, Pacific Biological Station, Fisheries and Marine Service, Canada, personal communication). The extent to which off-bottom trawls were used and their incidence of halibut is unknown, but an overestimate of the incidental catch, in

part, may be offset by occasional directed catches of halibut. Also, data from net calibration studies with the Canadian research vessel *G. B. Reed* and the Soviet research vessel *Ogon* suggest that the incidence may be only slightly less in the Soviet catch (Westrheim and Fadeev, 1974). The incidence of halibut was not given, but the percentage of flatfish (all species) was only slightly less in the *Ogon's* catch, 10.0% compared to 11.5%.

Although the Soviet fishery was not distributed equally among area-month blocks, the fishery occurred in most areas and months, and we applied the average incidence and weight (among all blocks) in the Japanese fishery to the annual Soviet catch. (The average incidence was 3.2 halibut per metric ton for groundfish trawls and 12.5 halibut per metric ton for shrimp trawls.) The U.S.S.R. groundfish catch from 1962 to 1966 was obtained from Chikuni (1975) and includes only the catch of Pacific ocean perch. The catch from the Bering Sea along the Aleutian Islands also was included. For 1967-1974, we used the annual catch of all species, except hake, provided through U.S.-U.S.S.R. bilateral meetings (H. A. Larkins, NMFS, personal communication). The annual shrimp catch was obtained from Chitwood (1969) and from Forrester, Beardsley, and Takahashi (in press). Table 7 shows that the estimated incidental catch increased from 208,000 halibut (1,290 m.t.) in 1962 to 1,403,000 halibut (8,435 m.t.) in 1965 and then declined to about 300,000 fish (2,000 m.t.) in the late 1960's and early 1970's. Most of the catch was by groundfish trawls and, although it cannot be separated accurately by area, surveillance reports indicate that most occurred in the Aleutian to Yakutat areas.

Table 7. Estimated U.S.S.R. catch of halibut in the northeast Pacific.

Year	Groundfish Trawls			Shrimp Trawls			All Gear	
	Groundfish Catch* (m.t.)	Halibut Catch Numbers	Halibut Catch m.t.	Shrimp Catch (m.t.)	Halibut Catch Numbers	Halibut Catch m.t.	Halibut Catch Numbers	Halibut Catch m.t.
1962	65,000	208,000	1,290	0	0	0	208,000	1,290
1963	150,000	480,000	2,976	0	0	0	480,000	2,976
1964	291,000	931,000	5,772	4,000	50,000	160	981,000	5,932
1965	411,000	1,315,000	8,153	7,000	88,000	282	1,403,000	8,435
1966	245,300	785,000	4,867	10,500	131,000	419	916,000	5,286
1967	141,800	454,000	2,815	11,400	143,000	458	597,000	3,273
1968	113,000	362,000	2,244	2,900	36,000	115	398,000	2,359
1969	64,800	207,000	1,283	5,200	65,000	208	272,000	1,491
1970	81,800	262,000	1,624	4,200	52,000	170	314,000	1,794
1971	44,600	143,000	887	4,700	59,000	188	202,000	1,075
1972	121,300	388,000	2,416	3,200	40,000	128	428,000	2,544
1973	81,400	260,000	1,612	1,700	21,000	67	281,000	1,679
1974	105,900	339,000	2,101	1,700	21,000	67	360,000	2,168

*1962-1966: Pacific ocean perch only.

1967-1974: All species except hake.

TOTAL INCIDENTAL CATCH

Estimates of the incidental halibut catch, shown in previous sections of the report, are summarized in Table 8. In the Bering Sea, the total incidental catch increased to 11,519 m.t. in 1971 and then declined to 5,846 m.t. in 1974; the majority of the catch was by Japan, although the proportion taken by the U.S.S.R. has increased in recent years. In the northeast Pacific, the total incidental catch increased to 9,101 m.t. in 1965 and then declined to 2,070 m.t. in 1971. The catch has been less than 4,000 m.t. since 1968. The majority of the catch in the northeast Pacific was by the U.S.S.R.

Table 8. Summary of the estimated halibut catch (m.t.) by foreign trawlers in the Bering Sea and the northeast Pacific, 1954-1974.

Year	BERING SEA				NORTHEAST PACIFIC		
	Japan		U.S.S.R.	Total	Japan	U.S.S.R.	Total
	Mothership-Independent Fleet	Land-Based Fleet					
1954	52			52			
1955	42			42			
1956	102			102			
1957	102			102			
1958	168			168			
1959	520		374	894			
1960	1,590		576	2,166			
1961	2,303		926	3,229			
1962	1,420	112	837	2,369		1,290	1,290
1963	125	659	555	1,339		2,976	2,976
1964	412	1,278	476	2,166	390	5,932	6,322
1965	440	1,386	540	2,366	668	8,435	9,103
1966	693	2,533	600	3,826	1,022	5,286	6,308
1967	1,341	5,301	738	7,380	1,549	3,273	4,822
1968	1,765	3,582	592	5,939	1,567	2,359	3,926
1969	2,176	3,594	972	6,742	1,122	1,491	2,613
1970	2,759	5,677	957	9,393	1,154	1,794	2,948
1971	3,484	5,728	2,307	11,519	995	1,075	2,070
1972	3,259	3,678	2,178	9,115	1,387	2,544	3,931
1973	2,567	2,489	1,987	7,043	1,816	1,679	3,495
1974	1,807	1,581	2,458	5,846	1,840	2,168	4,008

SUMMARY

Japanese and U.S.S.R. trawl fisheries expanded in the Bering Sea and the northeast Pacific during the 1960's and early 1970's. These fisheries were directed at groundfish species other than halibut, but halibut were taken as an incidental catch. Assessment of the effect of trawling was hampered because the halibut catch was not reported. However, data on the incidence of halibut were collected by sampling the groundfish catch, and the total halibut catch was estimated by extrapolating the incidence to the entire trawl catch. Data were limited and several assumptions were required to estimate the catch. The estimates do not account for the possibility that trawlers occasionally fish specifically for halibut or that the incidence of halibut may have changed annually. Further, data from Soviet trawlers were meager, and their incidental catch was estimated from the incidence observed on Japanese trawlers. Although several assumptions are not completely valid, the potential errors are partly offsetting.

The results showed that the incidence of halibut varied by area and season and generally was high (over five halibut per metric ton of groundfish) in the southeastern Bering Sea and the northeast Pacific during the winter and spring. In the Bering Sea, the estimated incidental catch increased to about 7,000,000 fish (11,500 m.t.) in 1971, the peak year. About 75% of this catch was by the Japanese mothership-independent trawl fleet in the eastern Bering Sea and the Japanese land-based fleet in the western Bering Sea. In the northeast Pacific, the estimated catch increased to about 1,500,000 fish (9,000 m.t.) in 1965 and then declined to about 600,000 fish (2,500 m.t.) in the late 1960's. During the peak years, most of the catch was by U.S.S.R. trawlers. In both areas, most of the halibut were younger and smaller than those generally caught by setlines; modal age and size were 4 years and 42 cm.

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