

**REPORT OF THE
INTERNATIONAL
PACIFIC HALIBUT COMMISSION**

**APPOINTED UNDER THE CONVENTION BETWEEN CANADA AND THE
UNITED STATES OF AMERICA FOR THE PRESERVATION OF THE
NORTHERN PACIFIC HALIBUT FISHERY**

NUMBER 29

**REGULATION AND INVESTIGATION
OF THE PACIFIC HALIBUT
FISHERY IN 1959**

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FOREWORD

The terms of the 1953 Convention between the United States and Canada for the Preservation of the Halibut Fishery of the Northern Pacific Ocean and Bering Sea provide that the International Pacific Halibut Commission, formerly designated the International Fisheries Commission, shall publish a report of its activities and investigations from time to time.

The present report, the twenty-ninth published by the Commission, is the thirteenth in a series of annual reports that was begun in 1947 to provide a summary of the Commission's activities and the more significant results of its investigations during the year.

As the nature of this report precludes the inclusion of extensive background material, the reader desiring additional information is referred to earlier reports.

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HALIBUT FISHERY IN 1959**
by
INTERNATIONAL PACIFIC HALIBUT COMMISSION

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INTRODUCTION

The International Pacific Halibut Commission is responsible for the management of the halibut fishery on the Pacific Coast of North America, from northern California to southern Bering Sea. It was established as the International Fisheries Commission, an investigational organization, under a treaty signed by Canada and the United States in 1923. It was continued, with regulatory powers, under succeeding treaties of 1930, 1937 and 1953.

The terms of the present treaty make the Commission responsible for developing the stocks of Pacific halibut to levels which will permit the maximum sustained yield and for maintaining the stocks at those levels. They authorize the Commission to apply specific types of regulation and require it to justify its regulatory actions by scientific investigations.

The responsibilities of the Commission have been augmented indirectly by the International North Pacific Fisheries Convention, signed in 1953 by Canada, Japan and the United States. Abstention provisions of that Convention require Canada and the United States not only to develop the stocks of halibut and maintain them at levels of maximum productivity but also to demonstrate that they are being fully utilized at each stage of this development.

Management of the fishery, based upon scientific research, has now been in effect for twenty-nine years. The density of the halibut stocks and the sustainable annual catches have been increased gradually from low and declining levels to high levels. The fishery, which had reached an unprofitable state prior to management, has been restored to a highly profitable condition. The total catch in 1959 was 71.5 million pounds, the highest ever taken in one year.

During the rebuilding period, increases in the number of vessels fishing and much larger catches per trip sharply reduced the length of the fishing season. It became evident that, because the stocks of halibut on the different grounds were not equally available at all times of the year, some were no longer contributing to the fishery in the proportion of which they were capable.

To permit extending the period of the year over which halibut could be caught, the Commission was given authority in the 1953 Convention to establish multiple open seasons with intervening closed periods in any year. The use of multiple open seasons was adopted in 1954 but has been discontinued in some areas where the period of fishing has been sufficiently extended by a voluntary between-trip lay-in program instituted by the fleet in 1956. The resultant extension of the fishing season has increased the annual yields from grounds that had been underfished.

To develop the fishery on the distant grounds off Shumagin Islands and westward and in Bering Sea, this region was opened to halibut fishing one month earlier in 1958 and 1959 than grounds elsewhere on the Pacific Coast, and was continued open after other areas were closed by reason of attainment of their catch limits.

The average of the 1954 to 1959 catches was 65 million pounds, 6.5 million pounds greater than the annual average for the preceding five-year period and 21 million pounds greater than the total in 1931, the year preceding regulation. The difference in the average annual catch during the 1954 to 1959 period from the catch of 1931 was worth about \$3,800,000 annually to the fishermen, one and one-half times the total funds made available by both countries for the Commission during the 35 years of its existence.

ACTIVITIES OF THE COMMISSION

In 1959 the Commission continued the management of the fishery and the comprehensive program of statistical and biological research upon which the 1953 Halibut Convention requires regulation to be based.

The members of the Commission from Canada in 1959 were: Dr. William M. Sprules, Ottawa, Ontario, elected Chairman; Mr. Harold S. Helland, Prince Rupert, British Columbia; and Mr. Richard Nelson, Vancouver, British Columbia. United

States members were: Mr. Seton H. Thompson, Washington, D.C., Vice-Chairman until his resignation in August; Mr. Andrew W. Anderson, Washington, D.C., who succeeded Mr. Thompson and was elected Vice-Chairman in November; Mr. Mattias Madsen, Seattle, Washington; and Mr. William A. Bates, Ketchikan, Alaska.

The Commission held its regular annual meeting at its office and laboratory headquarters in Seattle, Washington, from January 26 to 29 inclusive, to examine the results of regulations and investigations in 1958, to consider and approve the research program for 1959, to deal with administrative and budgetary matters, to confer with industry representatives regarding the regulation of the fishery and to adopt regulations for 1959.

On January 26, a joint meeting was held with all branches of the fishing industry to review events in the fishery and the results of investigations in 1958, and to discuss these and suggestions that had been received regarding the regulation of the fishery in 1959. On January 29 the Commission met with the Industry Advisory Group consisting of representatives of the fishermen, vessel owners and dealers in Washington, British Columbia and Alaska. On January 27 it conferred separately with the dealers and with representatives of the vessel owners' and fishermen's organizations.

At the ninth and last session of the annual meeting on January 29 the Commission considered all regulatory proposals in the light of conditions within the stocks and in the industry and adopted regulations for 1959. A summary of the regulations that were being recommended to the two governments was released on the following day for the information of the industry and the public.

During the fishing season the Commission determined the dates upon which it deemed the area catch limits would be attained, announced these dates in advance and closed the areas accordingly.

The annual report upon the investigation and regulation of the Pacific halibut fishery in 1958 was published. A technical report, relative to the utilization of the stocks of halibut, was prepared for the information of the two governments and for publication by the Commission early in 1960.

THE REGULATIONS IN 1959

The Pacific Halibut Fishery Regulations adopted by the Commission for 1959 were approved by the Governor General of Canada on March 5 and by the President of the United States on March 31 and became effective on the latter date.

There were no substantial changes in the regulations from those of 1958 except that fishing grounds in the channels of southeastern Alaska were closed to halibut fishing during the second season in Area 2. There were indications that the removals in recent years from those stocks had been in excess of the replacements, as had been the case on the Cape Scott-Goose Islands grounds where closure during the second season was continued in 1959.

The five regulatory areas in 1959, shown in Figure 1, were the same as in 1958: Area 1A, the waters off northern California and southern Oregon, south of Heceta Head, Oregon; Area 1B, the waters off Oregon and Washington between Area 1A and Willapa Bay, Washington; Area 2, the waters off Washington, British Columbia and southeastern Alaska between Area 1B and Cape Spencer, Alaska; Area 3A, the waters off Alaska between Cape Spencer and Kupreanof Point, near the Shumagin Islands, Alaska; Area 3B, all convention waters west of Area 3A including those of the Bering Sea.

Catch limits of 26,500,000 pounds during the first season in Area 2 and 30,000,000 pounds during the single season in Area 3A were the same as in 1958. Fishing in other areas and other seasons was again controlled by length of season.

The following other regulatory provisions were also continued: the minimum size limit of 26 inches heads-on, or five pounds heads-off for halibut; the prohibition of the use of dory gear and nets of any kind in fishing for halibut; the termination after

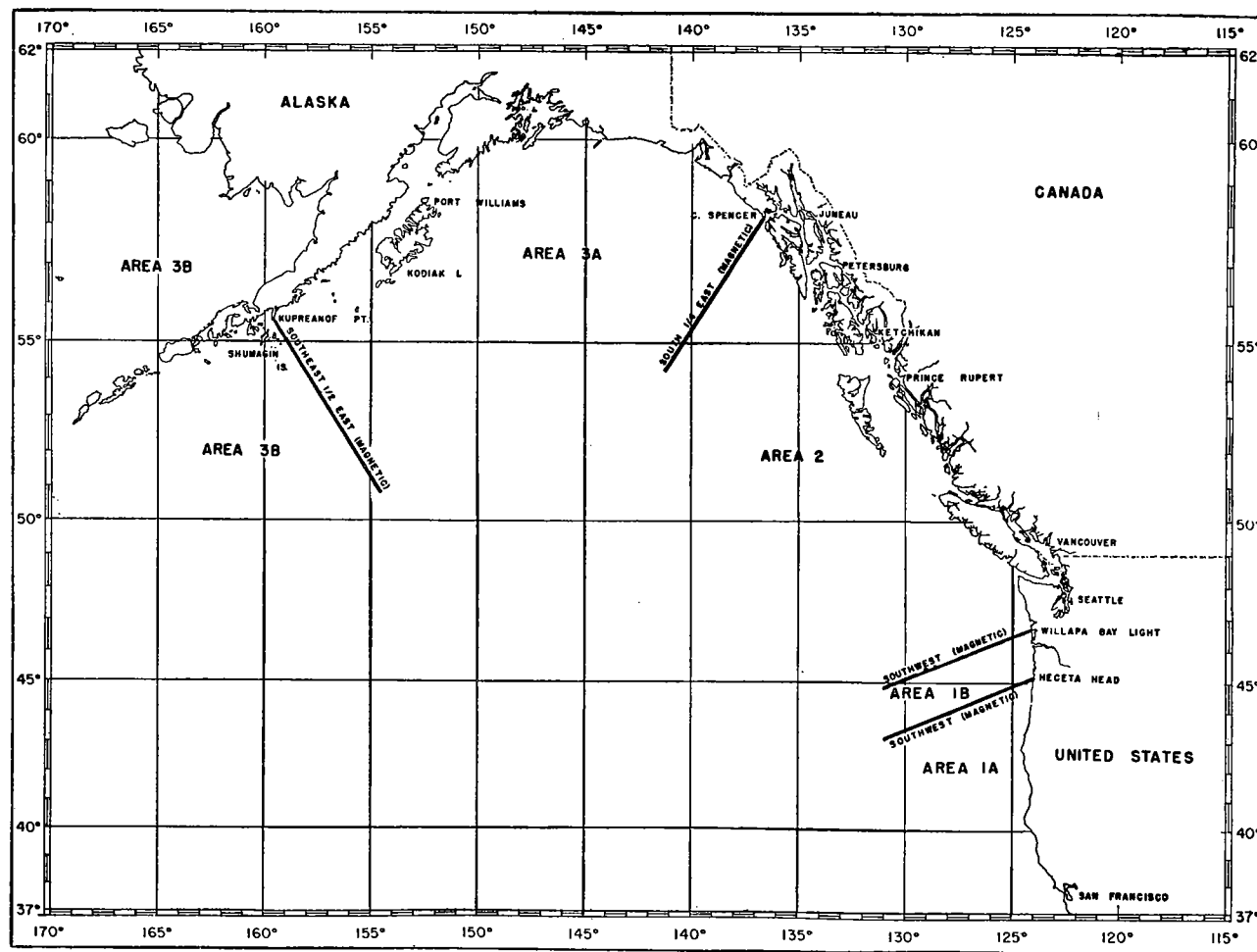


Figure 1. Pacific Coast of North America showing regulatory areas defined by the International Pacific Halibut Commission in 1959

November 15 of permits for the retention and possession of halibut caught incidentally by setline gear during fishing for other species in Areas 1A, 1B, 2, 3A and 3B; and, the beginning of the statutory closed season after November 30 in any area that might still be open by reason of the non-attainment of the catch limit which otherwise determined its closure.

The fishing season in Area 3B was opened on April 1; all other areas opened on May 1. The first seasons in Areas 1B and 2 were terminated on July 8 and the single season in Area 3A on August 1, at which dates it was deemed that the catch limits set for Areas 2 and 3A respectively would be attained. The second season of seven days in Areas 1B and 2 commenced on August 22. Areas 1A and 3B were closed to halibut fishing on October 16.

STATISTICS OF THE FISHERY

Landings by Regulatory Areas

Landings in thousands of pounds during 1959 are shown in the following table compared with landings for recent years and with those of 1931, the year immediately prior to the commencement of regulation by the Commission. The totals include catches made in contravention of the regulations.

United States and Canadian Catches by Regulatory Areas, in Thousands of Pounds

Year	Areas 1A and 1B	Area 2			Areas 3A and 3B			All Areas		
	U.S.	U.S.	Canada	Total	U.S.	Canada	Total	U.S.	Canada	Total
1931	923	14,609	7,018	21,627	20,907	765	21,672	36,439	7,783	44,222
1956	604	20,291	15,121	35,412	21,014	10,475	31,489	41,909	25,596	67,505
1957	446	16,261	14,365	30,626	19,934	10,349	30,283	36,641	24,714	61,355
1958	357	15,505	15,053	30,558	20,433	13,865	34,298	36,295	28,918	65,213
1959	198	16,229	14,233	30,462	24,018	16,810	40,828	40,445	31,043	71,488

In Areas 1A and 1B, lying south of Willapa Bay off the Oregon and northern California coasts, the total catch has declined steadily in spite of the fact that Area 1A, south of Heceta Head, Oregon, has remained open to continuous halibut fishing from May to mid-October in recent years. Since 1957 there has been a withdrawal of a few small boats that had been consistent producers in the region. Also, in recent years there has been some reduction in the amount of halibut landed in the region in contravention of the regulations.

In Area 2 the season continued to be extended, chiefly a result of the voluntary between-trip lay-in program of the fleets which was instituted in 1956. The effective length of the season in 1956 was 38 days, the fleet having delayed its departure 8 days after the legal opening date of May 1. In 1957, due to changes in the lay-in program, the length of the season was 47 days. In 1958 and 1959 it was further extended to 59 and 68 days respectively due to the reduced size of fares from some sections of the area and the failure of an increasing number of large vessels to follow their former practice of fishing in Area 2 for one or two trips before beginning operations in Area 3A.

Prior to the inauguration of the fleets' lay-in program the season in Area 2 had been reduced to 21 days in 1954 and 24 days in 1955.

During the first fishing season in Area 2, commencing on May 1 and terminating on July 8 in 1959, the catch amounted to 27,276,000 pounds, 876,000 pounds over the catch limit of 26,500,000 pounds. In 1958 the first season catch was 235,000 pounds above the catch limit. These excesses represented less than one day's fishing by the fleet on the grounds at the end of the season.

The catch during the seven-day second season in Area 2, that commenced on August 22 in 1959 and terminated August 29, was considerably lower than for previous

years. Dates of the seasons, the numbers of vessels and the catches in thousands of pounds by the United States and Canadian fleet since 1954, when the second season was instituted, are shown in the following table.

Catches in Thousands of Pounds from Area 2 during Second Season and Number of Vessels Operating, 1954-1959

Year	Season of Fishery	Canadian		United States		Total	
		Catch	Vessels	Catch	Vessels	Catch	Vessels
1954	Aug. 1-8	3,979	89	5,403	141	9,382	230
1955	Aug. 14-23	2,015	61	3,361	127	5,376	188
1956	Sept. 9-16	2,684	73	4,917	231	7,601	304
1957	July 29-Aug. 5	1,961	47	2,301	107	4,262	154
1958	Aug. 31-Sept. 7	1,364	44	2,060	116	3,424	160
1959	Aug. 22-29	1,320	42	1,249	54	2,569	96
TOTALS		13,323		19,291		32,614	

The large catch in 1954 arose from the fact that some grounds had not been fished to any significant extent in recent times and possessed a large accumulated stock. Also, the availability of fish on all grounds in Area 2 was particularly high that year, the salmon trolling fleet alone accounting for a catch of 1.5 million pounds during the 8-day second season.

In subsequent years the gradual reduction of the accumulation and a decrease in the number of boats fishing resulted in lower total catches during the second season. The closure of the Cape Scott-Goose Islands grounds in 1958 and 1959 also contributed to the general decline in production. In 1959 the decline was increased by a sharp reduction in the size of the Alaska Area 2 fleet, caused by the closure of the inside waters of southeastern Alaska during the second season.

Since 1954 a total of 32.6 million pounds has been caught in Area 2 during the second seasons. This represents 17 percent of the total catch from the area during the first and second seasons combined.

Included in the total production from Area 2 in 1959 are 517,000 pounds of halibut caught incidentally during setline fishing for other species, chiefly blackcod. A stronger market for the latter species in 1959 increased such incidental catches over the 1958 total of 399,000 pounds.

The Area 2 catch from all sources in 1959 was 30.5 million pounds, about the same as in 1958 and 1957.

In Areas 3A and 3B, which include all grounds west of Cape Spencer as well as Bering Sea, the combined catch in 1959 totaled 40.8 million pounds, the largest amount taken during the history of the region. The previous high record was 34.3 million pounds in 1958.

In Area 3A alone during the single season from May 1 to August 1 the catch amounted to 30,340,000 pounds, 340,000 pounds above the 30-million-pound catch limit. In 1958 there was a deficit from the catch limit of 270,000 pounds.

The length of the 1959 season in Area 3A was 92 days compared to 119 days in 1958 and 144 days in 1957. Recent increases in the size of the Area 3A fleet and increased effectiveness of the gear, resulting from the use of octopus bait, are tending to counteract the combined effects of the fleet's between-trip lay-in program and an increase in the permitted catch limit which extended the season much beyond the 1950-1953 average of 58 days.

In Area 3B, a total of 10.5 million pounds was taken in 1959 compared to 4.6 million pounds in 1958. The 1959 catch was the largest catch ever taken in that region.

Of the Area 3B catch in 1959, Bering Sea contributed 4.2 million pounds, nearly twice the 1958 total which was the highest to that time. About 2.1 million pounds of the Bering Sea catch were taken between April 1 and April 30 before the opening

of Area 3A. About 95 percent of the 1959 catch in Bering Sea was taken prior to the end of June.

From the section of Area 3B south of the Alaska Peninsula 6.3 million pounds were taken in 1959, greatly exceeding the 1958 total of 2.4 million pounds and surpassing the previous record high of 3.6 million pounds taken in 1946. About 90 percent of the catch from this section of Area 3B was taken subsequent to the end of June and chiefly in August, September and October after the closure of Area 3A.

The Pacific Coast catch from all areas in 1959 totaled 71.4 million pounds, exceeding the previous all-time high total of 71.2 million pounds in 1954. The high catch of 1954 resulted from the institution of the second season in Area 2 which produced a catch of 9.4 million pounds. The greater catch of 1959 was due to the record high catch of 10.5 million pounds from Area 3B, which more than offset the record low production of 2.6 million pounds from the second season in Area 2.

LANDINGS BY PORTS

The distribution of halibut landings in thousands of pounds from all areas according to regions and ports or groups of ports is shown for 1959 in the following table, with comparable data for 1957 and 1958.

Landings in Thousands of Pounds from All Areas by Region and Ports by United States and Canadian Vessels

Ports	1957			1958			1959		
	U.S.	Can.	Total	U.S.	Can.	Total	U.S.	Can.	Total
California and Oregon	573	—	573	456	276	732	308	—	308
Seattle	14,800	818	15,618	15,478	1,825	17,303	17,366	2,890	20,256
Other Wash.	738	386	1,124	445	138	583	234	55	289
Vancouver	—	5,651	5,651	—	5,610	5,610	—	5,752	5,752
Vancouver I.	—	1,340	1,340	—	1,705	1,705	—	1,920	1,920
Prince Rupert	1,869	13,820	15,689	579	14,322	14,901	263	14,396	14,659
Other B.C.	—	1,492	1,492	—	2,156	2,156	—	1,865	1,865
S.E. Alaska	15,246	787	16,033	15,854	1,255	17,109	17,799	1,939	19,738
Central Alaska	3,415	420	3,835	3,483	1,631	5,114	4,475	2,226	6,701
TOTALS	36,641	24,714	61,355	36,295	28,918	65,213	40,445	31,043	71,488

During the past three years Seattle and central Alaska ports show a sharp increase in both total receipts and the share of the total coast catch landed in those ports. Receipts in southeastern Alaska ports also increased from 1957 to 1959 but the region's share of the total catch remained about the same.

Landings in Prince Rupert declined slightly but that port's share of the total coast catch declined from 25 percent in 1957 to 20 percent in 1959.

Canadian landings in United States ports, including Alaska, totaled 7.1 million pounds and were the highest on record. The previous record total was 5.1 million pounds in 1958.

CATCH PER UNIT FISHING EFFORT

All halibut vessels of five net tons or over are required to keep records showing the date, the fishing location, the amount of gear fished and the estimated catch of halibut in pounds for each fishing operation. These records are collected and analyzed to determine the average catch per standardized unit of fishing effort in the various areas and subsections thereof and in the different seasons. The resultant returns per unit of effort are compared with those of earlier years to ascertain whether changes in relative abundance have occurred and to measure the magnitude of such changes.

In Area 2 the catch per unit effort in 1959 was approximately the same as in 1958 and maintained the long-term trend. Due to currently higher annual removals the

trend is now only slightly upward in contrast to the sharper rise that occurred during the first two decades of regulation. Each section of Area 2 has followed the same pattern, and present levels are in line with or above the long-term trend. The year-to-year changes, however, have not been uniform from one bank to another.

The catch per unit effort on the Cape Scott and Goose Islands grounds in 1959 remained at the 1958 level, and a decline from the abnormally high levels of 1953 and 1954 ceased. In Hecate Strait there was a decline from 1958 but the level did not fall below the long-term trend for the region. Both inside and outside southeastern Alaska, the catch per unit effort improved over 1958 and was also in line with long-term trends.

The Masset grounds showed a low catch per unit effort, but the fishery there was too limited to provide a reliable average.

The catch per unit effort in Area 3A continued the stable level of the preceding 8 years when due allowances were made for an unusually high availability of fish at the beginning of the 1959 season and for an increasing use of octopus bait which improves the efficiency of the gear.

In the Pacific section of Area 3B the catch per unit effort in 1959 was about the same as in 1958. In the Bering Sea section the catch per unit for the whole season was also substantially the same as in 1958. However, the seasonal decline was more rapid than in 1958, possibly a consequence of the large removals in 1958 and 1959.

COMPOSITION OF THE CATCHES

Continuous observations upon the composition of the stocks are required to provide information regarding the number of spawners and recruits and the rates of growth and mortality. A detailed knowledge of these factors is essential in managing the fishery to secure the maximum justifiable yield currently and to develop the stocks to levels of maximum sustainable yield in the future.

Studies of stock composition are based on representative samples of length and corresponding samples of otoliths obtained from the commercial catches at the time of landing. These market samples are supplemented as frequently as possible with samples taken at sea where sex and stage of maturity can also be determined in the unviscerated fish.

Market sampling has been conducted intensively by the Commission at Seattle since 1935 and has provided a long, uninterrupted series of observations of changes in the size and age composition for some important grounds. It was begun in Prince

Summary of Market Sampling in 1959 showing Number of Trips Sampled and Numbers of Measurements and Otoliths Obtained according to Area of Origin of Trips

Fishing Area	Number of Trips				Samples Obtained	
	Seattle	Prince Rupert	Petersburg	Total	Total Meas.	Otoliths
Area 2						
Washington-Vancouver I.	3	—	—	3	1,339	385
Cape Scott-Goose Is.	17	—	—	17	9,295	2,381
Dixon Entrance	2	4	—	6	1,912	692
Hecate Strait	5	17	—	22	10,550	2,871
Southeastern Alaska	3	6	52	61	19,620	5,107
Total Area 2	30	27	52	109	42,816	11,436
Areas 3A and 3B						
Cape Spencer-Cape Cleare	7	18	2	27	13,032	3,692
Cook Inlet-Shelikof St.	2	—	—	2	1,000	280
Portlock-Albatross Banks	5	4	1	10	3,884	1,342
Trinity Is.-Chirikof I.	4	—	—	4	2,031	561
Shumagin Is. and west	18	2	—	20	8,080	2,838
Totals Areas 3A and 3B	36	24	3	63	28,027	8,713
Totals Areas 2, 3A, 3B	66	51	55	172	70,843	20,149

Rupert in 1949 where landings from additional fishing grounds, not available at Seattle, could be sampled. In 1958 sampling was increased at Seattle and Prince Rupert and was extended to Petersburg, where landings from still other banks were available, to make it more representative of the geographic and seasonal distribution of commercial catches.

The number of trips sampled in 1959 and the numbers of measurements and otoliths obtained are shown in the preceding table according to the area of origin of the catches.

Additional measurements and otoliths were obtained at sea during tagging operations conducted by the Commission. Sex and maturity data were also secured.

Critical mathematical studies of the adequacy of market samples were made during the year. These showed that samples from Area 2 landings were satisfactorily representative of the individual fares, but that those from Area 3A and Area 3B landings could be improved by moderate increases in size. They indicated a need for a further extension of sampling to provide explanations for observed geographical differences and seasonal changes within the regulatory areas.

Analysis of the 1959 samples showed some noteworthy changes in size composition. In Area 2 the number of "chickens", 5-10 pounds, on the Goose Islands grounds increased, continuing the promising rise of 1958. The three classes of "mediums", 10-20 pounds, 20-40 pounds and 40-60 pounds, and the trade categories of "large", 60-80 pounds and over 80 pounds, showed a slight decline in 1959 but were not below the trend of the preceding three years.

In upper Hecate Strait, all sizes of fish were more available during the second season as in each other year since the institution of a second season in 1954. However, the changes in the strengths of the size categories in the first and second seasons from 1958 to 1959 were not uniform. Fish of the three smaller commercial categories, 5-40 pounds, were less numerous in 1959 during the first season, but larger fish, over 40 pounds, remained at the same level. In the second season, fish of the two smaller categories, 5-20 pounds, were substantially more numerous, whereas those in the four categories over 20 pounds showed declines that were especially pronounced in the two categories over 60 pounds.

Samples from the inside waters of southeastern Alaska showed all sizes of fish more numerous than in 1958.

On the important Portlock-Albatross banks in Area 3A, all trade categories in 1959 remained at their 1958 levels or increased, the latter being clearly the case in the 10-20 and 20-40 pound groups.

In the Bering Sea, fish in the 5-10 and 10-20 pound categories were more than twice as numerous as in 1958. The number of fish in the 20-40 pound group was unchanged. The three larger categories of fish, over 40 pounds, showed a marked decline from 1958. An increase of the smaller sizes and a decline in the larger fish are normal consequences of increased utilization.

In Area 2, the age composition of the stock on the Goose Islands grounds showed an increase in numbers of the young fish from 1958 to 1959, particularly the 1951 and 1954 year classes, but a slight decrease in the older fish. These changes were in accord with the trend of the preceding three years. On the grounds of upper Hecate Strait the young fish declined slightly in availability during the first season, whereas the older fish remained at about the same level throughout the season. During the second season the young fish were substantially more numerous, the old fish pronouncedly less so than in 1958. All age groups were more numerous during the second season than during the first season in both years.

The differences in size and age composition of the stocks between the first and second season again showed the need for continuing multiple seasons in Area 2 to assure full utilization of all component elements of the stocks.

In 1959 samples from the Masset and Timbered Islet grounds, closed as nurseries prior to 1958, were very limited. Although field observations were made aboard

vessels and at a camp in the Masset area at the beginning of the season, only a few small samples were obtained due to the sharply-reduced fishery there. The age composition continued to be similar to that on nearby grounds in northern Hecate Strait. However, substantial utilization of the accumulation of old and large fish in the formerly-closed area appears to have been accomplished by the fishery in 1958 and 1959. The samples from the Timbered Islet grounds indicated that substantial numbers of relatively large fish were still available in that area.

The studies of stock composition on both the Masset and Timbered Islet grounds indicate that these areas do not currently qualify for closure as nursery grounds under the provisions of the convention.

In southeastern Alaska, the 1959 catches continued to contain a good proportion of older fish without the apparent dependence on very young observed in Hecate Strait. The 1954 year class, so dominant in Hecate Strait, had not yet made a significant appearance in the catches except at Timbered Islet, the formerly closed "nursery" ground. On the other hand, the 1951 year class, also strong in Hecate Strait, was the major contributor to the catches on both inside and outside grounds. Most inside grounds in southeastern Alaska contained the same age groups of fish as the outside grounds but had a greater proportion of young.

In Area 3A, samples from the Portlock and Albatross banks indicated that most age groups were at the same general level of abundance as in 1958 or had increased. There was clearly an increase of young fish. The availability of older fish, which contribute most to the weight of the catch, declined slightly as the season progressed, as it had for several years.

On the Area 3B grounds south of the Alaska Peninsula, the number of older fish in the catches decreased typically as the season progressed. Some reduction in the general level of abundance of most of the important weight-producing older age groups was apparent. In Bering Sea, small young fish were more than twice as numerous as in 1958, while the large fish showed a marked decrease. Samples from the Bering Sea edge, taken throughout the season from one year to the next, confirmed previous indications that the accumulation of old fish found in 1956 had been substantially reduced by the subsequent fishery.

GROWTH STUDIES

The yield in weight resulting from a recruitment depends upon the number of young produced, their rate of growth and their mortality rate. At an early age the growth rate exceeds the mortality rate; subsequently, the growth rate is equalled by the mortality rate; and later, the mortality rate exceeds the growth rate. Capture before the time when growth and mortality rates are equal results in loss of potential poundage. Thus, management on a maximum sustained yield basis, such as is required of the Commission, necessitates accurate knowledge of growth and mortality rates at different ages and of the relationship of one to the other in the various components of the stock.

Recognizing these facts, an intensive study of growth of halibut was begun in 1956. A method, which uses measurements of the widths of the annual growth zones in the otoliths to estimate the lengths of fish at each earlier age, is being used. This method makes possible the reconstruction of the pattern of growth of individual year classes of fish covered by past and current age materials.

During 1959, measurements were completed upon approximately 2200 otoliths from 16 of the late-summer-trip samples collected from the Portlock-Albatross region between 1935 and 1958 to obtain data required to reconstruct the growth patterns of each year class between 1920 and 1951. The late-summer growth patterns of the year classes were compared with May-June growth patterns of the year classes reconstructed earlier and yielded essentially the same results.

Approximately 150 otoliths of halibut below five pounds were also measured from two samples taken on the Bering Sea flats incidentally to king crab investigations by the United States Fish and Wildlife Service. Valuable information regarding the growth of young halibut in Bering Sea was obtained.

Body-length as a relationship of otolith-radius was studied mathematically for different combinations of capture periods, fishing grounds and sexes of the halibut. It was found that these groupings of the data are better described individually for each sex, area and time of capture than in combination. However, the differences are small and body-length may be estimated from otolith measurements, with sufficient accuracy for practical management purposes, by a combination of the data.

In view of the importance of being able to identify the sex of each fish in the landed catches which are eviscerated at sea, studies were undertaken to ascertain whether relationships between total body length, head length and various otolith measurements in conjunction with the age of the fish would identify the sex. Preliminary findings show that the method can correctly identify the sex of a high proportion of the individuals and warrant an expansion of the studies.

The possibility of using calculated lengths of fish based on measurements of otoliths, instead of actually measuring the fish, to estimate the average weight at each age and the age composition of the catch was examined and found to be practicable. The overall utility and cost of the method as a means of determining the composition of commercial catches are being compared with those of the currently-used method with a view to its possible adoption in the future.

TAGGING EXPERIMENTS

Tagging experiments are used to determine the migrations and relative utilization of halibut in different regions and on different banks, information that plays an important role in the Commission's management program. Tagging also provides measures of both fishing and natural mortality which are required for management of the stocks.

A total of 569 tags were recovered in 1959, a marked drop from the 1202 recovered in 1958. At least three factors contributed to this drop: the increased age of the Area 2 experiments which usually produce a large portion of the total recoveries; an unusually strong appearance of young untagged fish in Area 2 producing an apparent decrease in availability of tagged fish; and, the virtual absence of a fishery on the Masset grounds which produced 263 recoveries in 1958 and only 20 in 1959.

Five tagging trips were made inside the Bering Sea using the vessel ALLAVERDY, which was chartered for a 117-day period beginning May 1. Information regarding the operations is given below.

Summary of 1959 Tagging Experiments

Trip	Locality	Month	Skates Fished	Number Tagged	Pounds Tagged	Total Catch
I	Bering Sea edge (Clipper Spot)	May	222	1,270	27,505	124,610
II	Makushin Bay-Bering Sea edge (Polaris Spot)	June	250	512	15,100	47,866
III	Slime Bank	June-July	358	1,932	32,400	68,078
IV	Bering Sea edge and Slime Bank	July	292	1,045	17,700	58,968
V	Makushin Bay	August	218	389	11,456	50,263
TOTAL			1,340	5,148	104,161	349,785

To test for loss of strap tags, which have been used almost exclusively heretofore, most of the 5148 fish tagged in 1959 were also marked with a plastic dart tag attached on the white side. The effectiveness of these experiments depends upon the continuance of the commercial fishery in the Bering Sea.

The year 1959 was the third full recovery year for the Bering Sea tagging that was done in 1956. Thus far 258 tagged fish have been recovered from the 3183 releases (8.1%), indicating that these fish are being utilized to a considerable extent. Of these recoveries, 58 are known to have been retaken outside Bering Sea, the longest migration being to Goose Islands grounds in Area 2, approximately 1650 miles from the point of release. Out of 195 recoveries known to have been made inside Bering Sea six made migrations of particular interest. Three of these were tagged on the "edge" outside the 100-fathom line between Unimak Pass and the Pribilof Islands. Two were recovered off the north shore of Unalaska Island and one was retaken on the "flats", the large shallow portion of eastern Bering Sea lying inside the 100-fathom line and south of Nunivak Island. Three others tagged off the north shore of the Aleutian Islands were recovered on the edge.

These preliminary returns indicate that there is a significant migration of Bering Sea fish into Areas 3A and 2, and suggest that there is some movement of fish inside Bering Sea between the edge, flats and Aleutian Islands. Although the number of recoveries from a statistical standpoint is small, the returns take on added significance when the opportunity for recapture is considered.

An analysis of all tagging experiments on Goose Islands grounds since 1925 has provided useful information regarding the utilization of these stocks. When the amount of gear fished on Goose Islands grounds each year since 1927 is plotted, a definite downward trend is apparent. A similar downward trend is apparent when the percent recovery from Goose Islands experiments conducted between 1925 and 1951 are plotted by years. However, the percent recovery for fish tagged on Goose Islands grounds in 1953 and 1955 is well above the trend line. This is strong evidence that the marked increase in the catch of Goose Islands grounds fish in the years 1953 through 1956 resulted in a level of utilization much higher than has been experienced since the early days of the fishery. Since this catch was taken without an equivalent increase in fishing effort it must be attributed to an unusual availability of these fish, particularly in 1953 and 1954.

The returns of double-tagged fish from experiments in 1955 on Goose Islands grounds were used to compute tag losses. The results indicated that tag losses do occur but not at an alarming level.

Experiments involving the tagging of fish in the holds of vessels that are about to unload their fish were initiated in 1958 and continued in 1959. This was done to obtain an estimate of the proportion of tags that may be overlooked during the unloading procedure and thereafter. These experiments have provided evidence that some strap tags are lost during and following the unloading process, and indicated a need for increased stimulation of the interest of fishermen and dockside workers.

STUDIES OF HALIBUT BELOW COMMERCIAL SIZE

Management and development of the halibut fishery requires a knowledge of the abundance of young and of their recruitment to the fishable stocks. Because of the years that elapse between spawning and full recruitment, a knowledge of the relationships between the number of spawners, number of young and the resultant recruits, and an understanding of the factors that affect them is also essential. To obtain such knowledge and understanding, which may provide a means of predicting the recruitment that can be expected from each spawning, investigations of the small halibut are conducted each year.

The small-halibut investigations fall into four general categories: studies of the early life of the species including distribution, habitat, food and growth; systematic sampling of the young fish to develop quantitative measures of their relative abundance; comparison of the abundance of young with the abundance of spawners that produced them and with the abundance of recruits that results from them; and, study of the environmental factors which may limit the survival of young to fishable size.

Field investigations were initiated in 1955 with exploratory fishing in Hecate Strait and Dixon Entrance off British Columbia. The range of sampling was extended gradually to include the waters of southeastern Alaska in 1956, the Gulf of Alaska and Kodiak regions in 1957 and the Shumagin Islands in 1958.

In 1959 most of the field work was directed to sampling in Shelikof Bay near Sitka, in Kachemak Bay in Cook Inlet, off Karluk in Shelikof Strait, and in Alitak Bay at the south end of Kodiak Island. Sampling in these locations in previous years had suggested that sufficient numbers of small halibut could be obtained for annual quantitative estimates of relative abundance. Also included in 1959 were explorations off the west coast of Vancouver Island and of Graham Island and resampling in locations in northern Hecate Strait and Dixon Entrance where some halibut had been found in previous years.

The field operations in 1959 were conducted aboard the COMMANDO, a fishery research vessel, which was chartered from the University of Washington for a two-month period from mid-July to mid-September. Otter trawls with cod ends of 1 $\frac{1}{4}$ -inch and 2 $\frac{1}{2}$ -inch stretched mesh and a lightweight beam trawl of 1 $\frac{1}{4}$ -inch mesh, the types of gear which were most effective in 1957 and 1958, were again used.

A total of 5604 small halibut ranging from 2 to 25 inches in length and from less than one to eight years of age were caught in 1959. Of these, 5525 were taken in 76 drags using trawls with cod ends of 1 $\frac{1}{4}$ -inch mesh and 76 fish in three drags with a trawl with cod ends of 2 $\frac{1}{2}$ -inch mesh. Three halibut were taken in two drags with the beam trawl. The catches are summarized in the table below, according to locality of fishing, depth of haul and age.

Catches of Halibut of Sub-Commercial Size during Investigations in 1959

Location	Date	Fathoms	Age										Total		
			*0	1	2	3	4	5	6	7	8	?			
British Columbia															
Masset	July 26-28	13-15	—	3	7	1	—	1	—	—	—	—	1**		13
McIntyre Bay	July 28	6-22	—	—	—	—	—	1	2	—	—	—	—		3
	Sept. 12-13	8-21	9	—	—	3	—	1	—	—	—	—	—		13
Northern Hecate Strait	July 29	12-23	—	4	1	—	—	—	—	—	—	—	—		5
Southeastern Alaska															
Shelikof Bay	Aug. 1-2	11-24	123	280	17	18	15	18	7	3	—	—	—		481
	Sept. 4-6	9-37	378	444	20	11	13	15	2	3	1	—	—		887
Central Alaska															
Cook Inlet	Aug. 17	16-20	3	110	166	25	3	2	—	—	—	—	—		309
Kodiak I.	Aug. 8-14	6-24	13	2322	357	93	103	42	10	1	1	—	—		2942
	Aug. 21-27	8-25	25	757	100	33	25	6	2	3	—	—	—		951
TOTAL			551	3920	668	184	159	86	23	10	2	1			5604

* Less than 1-year old.

** Otolith illegible (probably 4-6 years old).

All halibut caught were measured, the sex of 4650 fish was identified, and 389 were weighed. Representative samples of otoliths were collected from 1974 individuals and 938 stomachs were examined for content. The ages of the fish were determined in the laboratory by examination of the otoliths.

Several similarities have been noted in the catches taken in 1959 and those taken in 1957 and 1958. The sex ratio of the catches in each region each year has been about equal. The average size of one-year-old and older females has been generally greater than that of males at the same age and time. Halibut taken off central Alaska have been smaller at the same age than were those caught off southeastern Alaska. Also, the 0-year fish have been relatively scarce in the catches from the Kodiak Island and Cook Inlet section of Area 3A until late August, whereas they have been taken in large numbers in early August and even late July on the grounds near Sitka in Area 2.

Whether the later appearance of the 0-year fish in the Kodiak Island-Cook Inlet region is a result of later settling to the bottom as is suggested by the smaller size of the fish there, or is due to an escapement of the smaller fish through the cod-end mesh is still uncertain.

The results obtained to date indicate that 0-year and 1-year-old halibut are not uniformly distributed over the grounds sampled. Differences are found in the numbers caught per unit effort between sub-regions and within the sub-regions off Kodiak Island, in Cook Inlet and in Shelikof Bay. Fishing off Kodiak in 1959 was conducted in 6 to 25 fathoms, and the larger catches were generally taken in depths less than 15 fathoms. In the Cook Inlet region in depths from 16 to 29 fathoms, no distinct change in abundance with depth was apparent. However, in Shelikof Bay where fishing was done in 9 to 37 fathoms, the numbers per unit effort were generally greater in depths between 15 and 25 fathoms.

The catches of 2-year-old and older halibut of sub-commercial size indicate that the distribution of these age groups is different than the 1-year-olds and suggest that they may not be adequately represented in past catches. An increase in the numbers of older fish and a decrease in the numbers of 1-year-olds as a depth of fishing exceeds 25 fathoms suggest that the older groups may frequent deeper water. More extensive sampling of the grounds and in deeper water appears necessary to improve the measure of abundance of these older ages. Also, further experimentation is desirable to establish whether large-meshed otter trawls would be more effective in sampling the older sub-commercial sizes.

In no year have the catches of small halibut off British Columbia been sufficiently large to provide quantitative estimates of abundance. Further exploration of the grounds is required, and sampling at other seasons may be necessary in this region.

The stomach contents of over 3,000 small halibut have been examined. More than 2,000 of the stomachs contained identifiable food. Halibut less than 4 inches long, not yet one year old, feed mainly upon small crustaceans. Fish, shrimp and crabs predominate in the diet of individuals over 4 inches long. Fish, mainly sand lance, become increasingly important in the diet as halibut increase in size, and is the principal food of those over 10 inches long. The occurrence of flatfish in halibut stomachs is extremely low. There is no evidence that the halibut below commercial size feed upon the younger age groups or of extensive predation upon small halibut by commercial-sized halibut or large fish of other species.

In all areas sampled, associated flatfish have been found to feed primarily upon the same organisms—shrimp and small crabs—as do halibut less than 6 inches long. Only the largest of associated flatfish—over 16 inches long—feed upon the same species of fish as are eaten by the 6-inch and larger halibut.

Through the cooperation of the United States Fish and Wildlife Service, the Commission secured a sample of 1270 length measurements of Bering Sea halibut, 374 of which were accompanied by otoliths. These fish were part of a catch of over 1500 halibut taken incidentally during king crab investigations in Bering Sea. They were caught during May and August in 100 one-hour hauls with otter trawl, distributed over a wide area between Unimak Pass and Cape Newenham in depths ranging from 14 to 71 fathoms. Halibut were taken in 77 percent of the hauls, and about 89 percent of those caught were below the minimum legal size of 26 inches. The halibut of sub-commercial size ranged from 7.5 to 25.5 inches in length and from 2 to 6 years of age. Of 318 stomachs examined, 60 percent were empty. Shrimp was the only item in most of the stomachs that contained food.