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 27

REGULATION AND INVESTIGATION OF THE PACIFIC HALIBUT FISHERY IN 1958

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SEATTLE, WASHINGTON
1959

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-seventh published by the Commission, is the twelfth in a series of annual reports that was begun in 1947 to provide a summary of the Commission's activities and the most 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.

REGULATION AND INVESTIGATION OF THE PACIFIC HALIBUT FISHERY IN 1958

by

INTERNATIONAL PACIFIC HALIBUT COMMISSION

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HISTORICAL BACKGROUND

The commercial fishery for Pacific halibut began in 1888 off Cape Flattery, Washington and from its inception has been a joint adventure by Canadian and United States nationals. After the turn of the century the unregulated fishery expanded rapidly with the catch and in 1915 reached an unprecedented high of 69 million pounds. Thereafter, in spite of increased effort and extension of the fishery to more distant grounds, the annual catches declined. By 1931 the total Pacific Coast catch of halibut was only 44 million pounds.

Control of the fishery was advocated as early as 1915 on the basis of observed declines in yields from the longer-fished grounds. Subsequent declines from other grounds led to the signing in 1923 and the ratification in 1924 of a conservation convention by the United States and Canada.

The Convention of 1923 provided for a three-month closed season during the winter months to prevent the catching of spawning halibut. It also provided for the appointment of the International Fisheries Commission, with two members from each country, to investigate the fishery and to recommend other conservation measures.

The winter closed season failed to halt the decline in yields from the fishery, and intensive investigation by Commission scientists demonstrated that the decline was the result of overfishing. Regulatory authority, recommended by the Commission, was provided by a new convention signed in 1930 and ratified in 1931.

The Convention of 1930 empowered the Commission to change or suspend the closed season; to divide the convention waters into areas and to limit the catch of halibut to be taken from each area during its fishing season; to regulate the licensing and departure of vessels for purposes of the convention; to collect statistics; to fix the type of gear to be used; to close grounds found to be populated by small immature halibut; and to conduct such investigations as were necessary into the life history of the halibut. Enforcement of the regulations was made the responsibility of the individual governments.

A third convention was signed and ratified in 1937. It extended the Commission's authority by providing for control of the capture of halibut caught incidentally to fishing for other species in areas closed to halibut fishing.

Regulation, which effectively began in 1932, has been directed toward holding annual catches from the stocks slightly below the additions being made by growth and new recruits. The success of this policy is shown by the fact that the stocks on some grounds had more than doubled in size by 1940, permitting the taking of larger individual catches with much less fishing effort. As the size of the stocks increased, the Commission increased the annual catches allowed. In 1940 the total coast catch reached 54 million pounds and in 1950 it was about 58 million pounds.

During this 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. In 1946, the Commission recommended to the governments treaty changes that would enable it to broaden the period of the year over which halibut would be caught. Most important of these recommendations was one which would permit more than one fishing season in an area during a single year.

From 1951 to 1953 inclusive, pending action upon the Commission's recommendations, three underfished sections of the coast were closed to fishing during the regular season and opened at a more appropriate time when other sections were closed. A significant increase in the utilization of underfished stocks resulted and the total annual catch reached 60 million pounds.

A fourth halibut convention was signed and ratified late in 1953. Besides changing the name of the Commission to International Pacific Halibut Commission and increasing its membership from four to six commissioners, three from each country, the 1953 Convention gave the Commission certain additional regulatory authority requested in 1946. Chief of these was the authority to establish one or more open or closed seasons each year in any area. Also granted was the authority to apply size limits in addition to catch limits; to regulate the retention of halibut caught incidentally while fishing for other species in areas both open or closed to halibut fishing; and to conduct or authorize fishing operations for investigation purposes at any time. The 1953 Convention also restated the objective of the Commission—the development of the stocks of halibut to levels which will permit maximum sustained yield and maintenance of the stocks at those levels.

The responsibilities of the Commission have been still further augmented indirectly by the International North Pacific Fisheries Convention, signed and ratified in 1953 by the United States, Canada and Japan. This requires 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.

Under authority of the 1953 Convention the period of fishing was extended in 1954 by the use of multiple open seasons with intervening closed periods. The use of multiple open seasons has been continued in some areas. It has been discontinued in other areas where a system of between-trip tie-ups, voluntarily adopted by the fishermen and vessel owners, has extended the period of fishing sufficiently to make additional periods unnecessary.

The multiple-season system of regulation has spread fishing over a longer period of the year. It has increased fishing on underfished grounds and the annual yields therefrom. The average of the 1954 to 1958 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 annual total in 1931, the year preceding regulation. The difference in the average annual catch during the 1954 to 1958 period from the catch of 1931 was worth about $3,800,000 to the fishermen, one and one-half times the funds made available by both countries for the Commission during the 35 years of its existence.

ACTIVITIES OF THE COMMISSION

In 1958 the Commission completed its twenty-seventh year of regulation of the halibut fishery. It also carried forward the intensive program of statistical and biological research which is required to guide regulations designed to attain stock levels that will permit maximum sustainable yield, as required by the Halibut Convention of 1953.

The members of the Commission from the United States in 1958 were: Mr. Seton H. Thompson, Washington, D. C., elected chairman; Mr. Mattias Madsen, Seattle, Washington; Mr. J. W. Mendenhall, Boulder Creek, California; and Mr. William A. Bates, Ketchikan, Alaska who was appointed in March to succeed Mr. Mendenhall on his resignation after four years of service upon the Commission. The Canadian members were: Dr. William M. Sprules, Ottawa, Ontario, elected Vice-Chairman; Mr. Harold S. Helland, Prince Rupert, British Columbia; and Mr. Richard Nelson, Vancouver, British Columbia.

The Commission held its regular annual meeting at its office and laboratory headquarters in Seattle, Washington from January 27 to 31 inclusive, 1958, to scrutinize the results of regulations and investigations in 1957, to consider and approve the research program for 1958, to deal with administrative and budgetary matters, to confer with industry representatives regarding the regulation of the fishery and to adopt regulations for 1958.

On January 27, a joint meeting was held with all branches of the fishing industry to review events in the fishery and the results of investigations in 1957, and to discuss these and suggestions that had been received regarding the regulation of the fishery in 1958. On January 28 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 29 it conferred separately with the dealers and with representatives of the vessel owners' and fishermen's organizations. On January 30 a representative of the Pacific Trollers' Association was heard.

On January 30 the Commission also considered all regulatory proposals in the light of conditions within the stocks and in the industry and adopted regulations for 1958. A summary of the changes 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.

A general report upon the investigation and regulation of the Pacific halibut fishery in 1957 was published. A technical report and several technical memoranda, relative to the utilization of the stocks of halibut, were also prepared for the information of the two governments.

THE REGULATIONS IN 1958

The Pacific Halibut Fishery Regulations adopted by the Commission for 1958 were approved by the President of the United States on March 28 and by the Governor General of Canada on March 29 and became effective on the latter date.

Several changes were made in the regulations. Area 3B, which encompasses all convention waters from Shumagin Islands west including the Bering Sea, was opened one month earlier than in 1957 and approximately

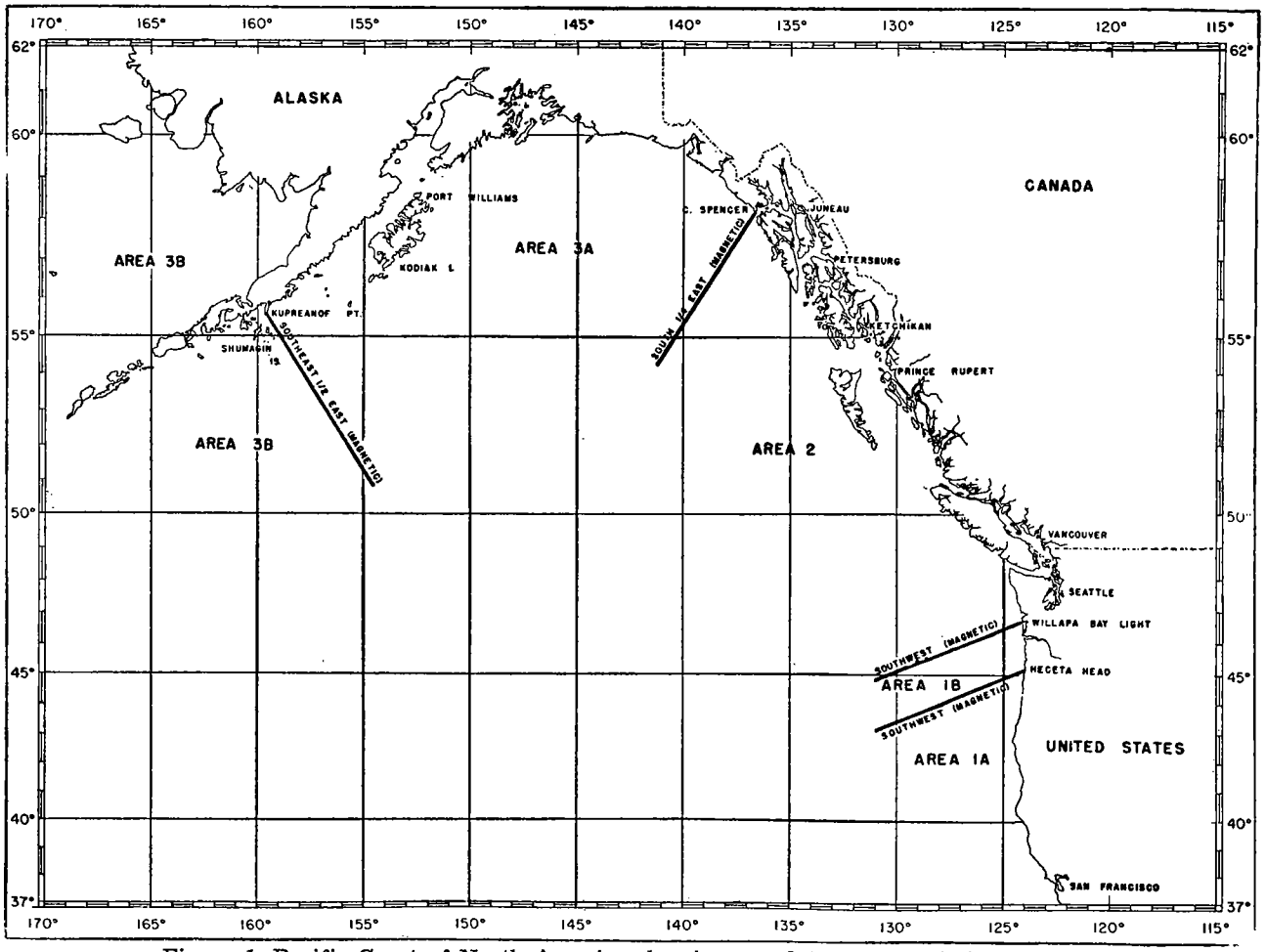

Figure 1. Pacific Coast of North America showing regulatory areas defined by the International Halibut Commission in 1958.

one month before the other areas which were opened three days later than in 1957. The second fishing season was continued in Area 2 except for the Cape Scott and Goose Islands grounds off British Columbia where the fish had become smaller and more scarce since the second-season fishery was inaugurated in 1954. For the first time since 1931 fishing was permitted on the so-called Masset and Timbered Islet "nursery grounds". These grounds, formerly populated by small, immature halibut, were opened to fishing to utilize accumulations of large, old halibut revealed by recent investigations.

The five regulatory areas in 1958, shown in Figure 1, were the same as in 1957: 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 1957. 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 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 4. The first seasons in Areas 1B and 2 were terminated on July 2 and the single season in Area 3A on August 31, 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 31. Areas 1A and 3B were closed to halibut fishing on October 16.

STATISTICS OF THE FISHERY

LANDINGS BY REGULATORY AREAS

Landings for groups of regulatory areas corresponding to the original Area 1, Area 2 and Area 3 are shown in the following table for 1958 together with those for 1954, 1955, 1956 and 1957 and for 1931, the year preceding regulation by the Commission.

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

	Areas 1A and 1B	Area 2			Areas 3A and 3B			All Areas		
Year	U.S.	U.S.	Can.	Total	U.S.	Can.	Total	U.S.	Can.	Total
1931	923	14,609	7,018	21,627	20,907	765	21,672	36,439	7,783	44,222
1954	674	19,165	17,574	36,739	23,841	9,952	33,793	43,680	27,526	71,206
1955	650	15,717	13,027	28,744	20,595	9,121	29,716	36,962	22,148	59,110
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

All poundages are corrected for amounts declared from the wrong areas, and for approximately 500,000 pounds of halibut estimated to have been caught in contravention of the regulations in all areas. Also included are landings of halibut caught incidentally to fishing for other species under permit after closure of the regulatory areas to halibut fishing. In 1958 the latter amounted to 413,000 pounds from Areas 1B and 2.

Landings from Areas 1A and 1B were lower than in 1957 by reason of a reduction in the already small Area 1 fleet.

The total catches from Area 2 were 30.6 million pounds from all sources in 1958 and 1957, somewhat below the annual average for the period since 1954. This is largely accounted for by a decline in second-season landings.

The first-season catch in Area 2 in 1958 amounted to approximately 26.7 million pounds, about 1.0 million pounds above the corresponding catch in 1957 and slightly above the catch limit of 26.5 million pounds.

The catch during the 7-day second season in Area 2 was 3.4 million pounds compared to 4.3 million pounds in 1957, 7.6 million in 1956, 5.4 million in 1955 and 9.4 million in 1954. The smaller second-season catch in 1958 compared to 1957 resulted largely from the closure of the Cape Scott and Goose Islands grounds to fishing during that season.

The overall decline in second-season landings since 1954, the first year of multiple seasons, reflects a reduction in the accumulated stocks that had been built up by relatively light fishing for a number of years prior to 1954. By 1958 reduction of the Cape Scott and Goose Islands stocks had progressed to the point where it was deemed advisable to prohibit fishing on them during the second season.

The catches in 1958 from Areas 3A and 3B, which are combined in the preceding table to make them closely comparable to the catch from the Area 3 of earlier years, amounted to 34.3 million pounds, an all-time high for that region.

The catch in Area 3A during its single season amounted to 29.7 million pounds, about 800,000 pounds above the 1957 catch but 300,000 pounds under the 30.0 million pound catch limit provided in the regulations.

The Area 3B catch in 1958 of 4.6 million pounds was the largest on record. Catches in recent years from Area 3B were 1.4 million pounds in 1957, 0.8 million in 1956 and 1.8 million in 1955. Almost one-half of the Area 3B catch in 1958 was from the Bering Sea, designated as Area 4 prior to 1954. Practically all the Bering Sea catch was from grounds discovered in 1956 by a vessel chartered by the Commission for tagging.

In the following table catches of halibut from Bering Sea are shown for the period 1930 to 1958 inclusive. In recent years this region has become increasingly important to both Canadian and United States fishermen. It holds promise of becoming even more important in the immediate future.

United States and Canadian Catches from Bering Sea in Thousands of Pounds, 1930-1958

Year	U.S	Can.	Total
1930	101	—	101
1931	111	—	111
1945	5	—	5
1950	42	—	42
1951	—	—	—
1952	265	—	265
1953	227	—	227
1954	41	—	41
1955	45	—	45
1956	183	84	267
1957	46	—	46
1958	969	1,211	2,180

United States and Canadian landings from all areas in 1958 amounted to 65.2 million pounds compared to 61.4 million pounds in 1957 and 67.5 million pounds in 1956. The higher amount in 1958 compared to 1957 resulted chiefly from the record-high Area 3B catch in 1958. The fact that the 1958 landings were below those of 1956 despite the large Area 3B production in the former year may be attributed to the reduction in yield from the second fishing 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 1958 in the following table with comparable data for the 1954 to 1957 period and for 1931, the year before regulation.

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

Year	Calif. and Oregon	Washington		Alaska		British Columbia			Total Can. Ports	Total U.S. Ports
		Seattle	Other Ports	S.E. Alaska	Western Alaska	Van-couver	Prince Rupert	Other Ports		
1931	892	15,032	202	8,240	1,482	1,066	16,792	516	18,374	25,848
1954	1,061	16,270	1,510	19,493	3,408	5,892	18,187	5,385	29,464	41,742
1955	737	14,521	1,992	14,233	5,025	5,230	14,626	2,746	22,602	36,508
1956	772	14,238	2,669	20,707	3,200	7,631	15,827	2,461	25,919	41,586
1957	573	15,618	1,124	16,033	3,835	5,651	15,689	2,832	24,172	37,183
1958	732	17,303	583	17,109	5,114	5,610	14,901	3,861	24,372	40,841

The proportion of the 1958 catch landed in Seattle, central Alaska and minor British Columbia ports increased. In Prince Rupert, Vancouver and minor Washington ports the proportion declined. Canadian landings in United States ports were the highest on record, totaling 5.1 million pounds compared to 2.4 million pounds in 1957.

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 then 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 as a whole the catch per unit effort remained at about the same level as in 1957, resulting in cessation of the sharp downward trend observed in recent years. However, some subsections of the area showed increases, others decreases.

There was some increase throughout Hecate Strait where the abundance has been well maintained despite recent large removals of halibut. On Masset and Timbered Islet grounds, opened to fishing for the first time since 1931, the catch per unit compared favorably with Hecate Strait. In the Cape Scott and Goose Islands sections of Area 2, which were closed to fishing during the second season in 1958, the catch per unit effort during the first season was slightly higher than in 1957 but still well below the average of comparable seasons in other recent years. The catch per unit effort in the inside waters of southeastern Alaska, where heavy removals have been made recently, was lower than in 1957 and well below the high point

reached in 1954. The outside waters of southeastern Alaska also showed a decline in catch per unit effort. However, the drop in outside waters is probably a reflection of a temporary decline in availability of halibut there rather than a reduction in abundance. Recent removals from this region do not appear excessive in view of the catches which the region maintained at much lower levels of catch per skate* prior to 1930.

The catch per unit effort in Area 3A at the outset of the 1958 season was about the same as at the start of the 1957 season but did not decline thereafter as much as in 1957. Consequently, the average catch per unit effort for the entire season was considerably above that of 1957. Some of the increase may be attributed to an increasing use of octopus as bait during the season. There is also some evidence that the availability of halibut was higher in 1958. A noticeable exception to the generally favorable situation in Area 3A was Shelikof Strait where the catch per unit effort throughout the year was lower than in 1957, an expected consequence of very heavy removals from that region in 1957.

The catch per unit effort in the Pacific portion of Area 3B in 1958 returned to the high level that prevailed from 1953 to 1955. In the Bering Sea section the catch per unit effort for the entire season was about twice as high as that in the Pacific portion; however, it fell rapidly as the season progressed. How much of this decline should be attributed to a drop in availability of halibut as the season progressed and how much was due to removals by the fishery cannot be determined without at least an additional year of fishing.

COMPOSITION OF THE CATCHES

Scientific studies of the composition of the catches of halibut stocks on important banks are conducted each year to obtain information regarding numbers of spawners and recruits and rates of growth and mortality. A detailed knowledge of the changes in these, both past and present, under different stock and environmental conditions is essential for attainment of maximum justifiable yield now and maximum sustainable yield in the future.

For practical reasons this research is based primarily upon representative samples of length and corresponding samples of otoliths obtained from the commercial catches at the time of landing. However, because sex and maturity are not distinguishable in the halibut as landed, the market samples must be supplemented as frequently as possible with samples taken at sea where sex and stage of maturity can also be determined.

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 a few important banks. It was begun in Prince Rupert in 1949 where landings from additional important banks, not available at Seattle, could be reached. Through a streamlining of procedures, sampling was increased at Seattle and Prince Rupert in 1958 and was extended to Petersburg during the first fishing season in Area 2 and thereafter to Vancouver where landings from still other banks were available. In 1958 market sampling was satisfactorily representative of the geographic and seasonal distribution of market catches. It was facilitated by the seasonal employment of several University of British Columbia students as biological aides.

A total of 189 landings, including 103 from Area 2 and 86 from Areas 3A and 3B, were sampled in the four ports. From them were obtained

*A "standard" skate consists of 300 fathoms of groundline with approximately 120 hooks.

52,000 measurements, plus otoliths and measurements for age and growth studies from an additional 24,000 fish. A further collection of 1700 measurements and 2800 measurements plus otoliths was obtained at sea during tagging operations and viability studies conducted by the Commission.

The following facts regarding changes in size composition in 1958 are noteworthy. In Area 2, the number of chickens (under 10 pounds) on the Goose Islands grounds, where chickens are usually well represented, showed a substantial increase after declining in both the first and second fishing seasons during the preceding three years. There was no significant change from 1957 in the numbers in the three classes of mediums (10 to 20, 20 to 40, and 40 to 60 pounds), but the two classes of large (60 to 80 and over 80 pounds) showed a distinct increase in numbers.

On the important Portlock and Albatross banks in Area 3A, there was a cessation of an irregular decline in the catch of chickens which had continued for several years. The numbers in the three classes of mediums were considerably higher than in 1957, and the large which had declined gradually for four years were twice as numerous. The great increase in the number of large is indicative of an abrupt change in availability.

The age composition of the catches from Hecate Strait in Area 2 showed a continuation of a decline in the numbers of older fish which began in 1954 when fishing was increased by the inauguration of a second fishing season. There was some leveling-off in a parallel decline in the Goose Islands section where it had been most pronounced initially. An unusually high availability of young fish, noted in second-season catches from the grounds between Vancouver Island and Dixon Entrance in 1957, continued throughout 1958 with fish under six years of age more numerous in the landings than at any other time during the years of sampling on these grounds. On the Goose Islands grounds these young fish accounted for over 10 percent of the weight of the season's catch.

Substantial removals from the accumulation of larger and older fish on the Masset and Timbered Islet "nursery areas" were effected through the opening of these grounds to fishing in 1958. The age composition of samples from Masset catches (Figure 2) showed a greater proportion of older fish than the catches from the heavily-fished adjacent grounds in northern Hecate Strait. The percentage of very young (below 6 years of age) taken in the Masset catches was less than one-half of that in the catches from northern Hecate Strait.

The initiation of market sampling at Petersburg in Alaska during 1958 provided information regarding the nature of the stocks in the waters of southeastern Alaska and an accumulation of materials through which future changes in these stocks may be measured. The age and weight compositions of samples taken from catches made throughout southeastern Alaska (Figure 3) indicate considerable differences between the stocks in different sections, particularly between the "inside" and "outside" grounds. Catches from Frederick Sound, Stephens Passage and Chatham Strait, contained many old fish but the relatively young, seven to ten years old, were dominant numberwise. Ten- to fourteen-year-olds dominated in the catches taken from the outside grounds. Older fish averaged as much as 100 percent heavier at the same age on the inside grounds than on the outside grounds, indicating at least a seasonal difference in sex composition.

There was no indication in the samples from any section of southeastern Alaska of the high abundance of young fish that were being taken in the adjacent Hecate Strait section of Area 2.

In Area 3A, particularly on Portlock and Albatross banks where there was a progressive decline in most of the commercially important year classes during 1954, 1955 and 1956, an improved availability was noted for the second successive year. Younger fish of the 1948 through 1951 year classes formed a strong block of entering groups which may further bolster future catches in this region.

Samples taken from catches made throughout the season in the Shumagin Islands-Davidson Bank section of Area 3B showed seasonal changes in availability of the various age groups, similar to those observed in other recent years and suggest seasonal movements of matures on these grounds. Fish over age 11 occurred in increasing abundance to midseason, coinciding with a declining catch of younger fish. From midsummer through October the composition then reverted approximately to the proportions observed

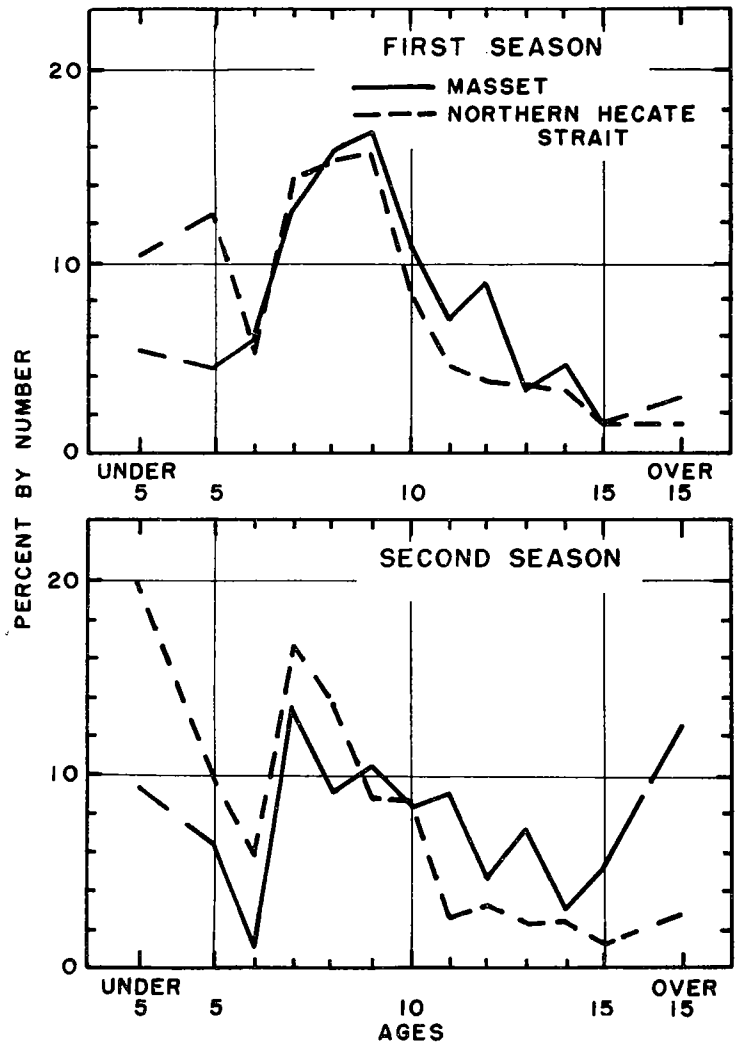

Figure 2. Age composition of catches from Masset and northern Hecate Strait during the first and second seasons, 1958.

at the opening of fishing in the spring, though at a lower level of abundance.

Studies of the populations in the Bering Sea progressed rapidly in 1958 through sampling of the catches from the greatly intensified fishery which developed there as a result of the Commission's discovery of a substantial concentration of halibut upon the edge in 1956 and modification of the regulations in 1958 to encourage its utilization. The existence of a complicated combination of seasonal changes in composition and availability has become apparent.

Except for a temporary greater availability of older fish in June, the abundance of most age groups on the Bering Sea edge appeared to diminish rapidly from the initial high level at the opening of the season in April to a low in July when the last samples were obtained. There was a progressive

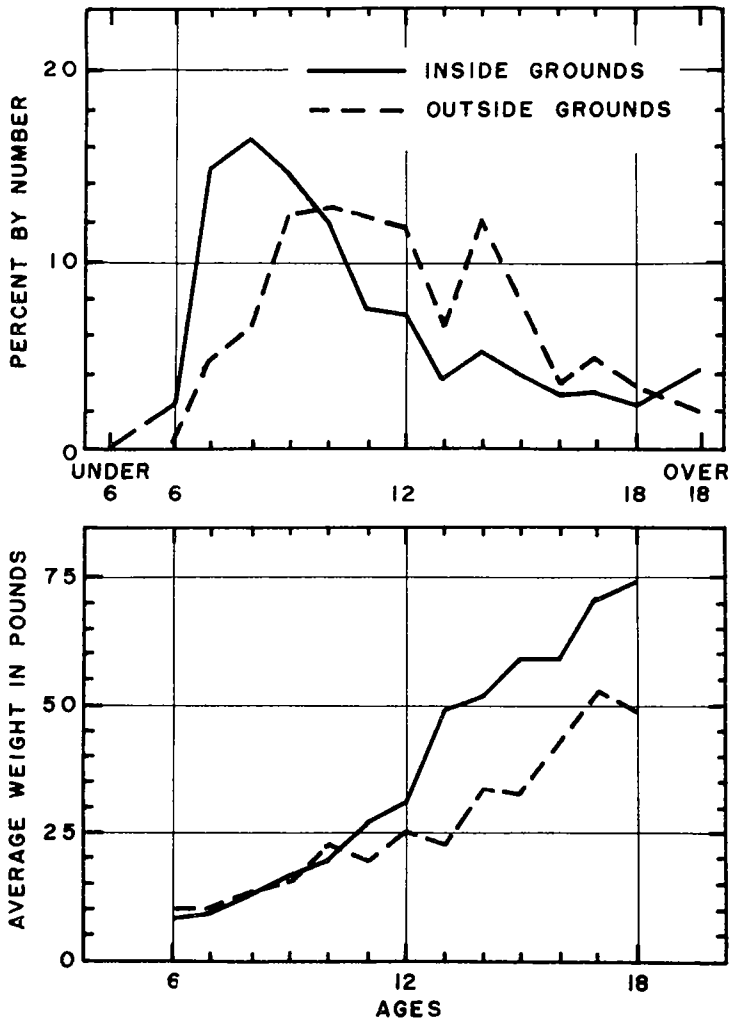

Figure 3. Age compositions and average weight at each age for the grounds inside and outside southeastern Alaska during the May-June season, 1958.

decrease in average weight at each age of the older fish throughout the season. Similar changes were indicated by the limited sampling in 1956 and 1957 and suggest a seasonal dispersion which can be clarified only through marking experiments.

Discovery of the concentration of halibut in Bering Sea was important, entirely aside from its practical value to the industry. As there was no fishing in Bering Sea upon this population prior to its discovery, the total mortality rate indicated by the average decline from one age to the next of fully-recruited age groups in 1956 can be regarded as a measure of the natural mortality rate as well. The estimate thus obtained, about 20 percent per annum, agrees very closely with estimates of natural mortality for other stocks on long-fished grounds. Moreover, since tagging has shown some emigration from the Bering Sea into fisheries on grounds outside Bering Sea, this estimate can be regarded as a maximum for natural mortality.

That substantial use of this stock is occurring is indicated by comparing the relative abundance of the fully-recruited year classes in 1958, after the removal of over 2.5 million pounds, with the initial condition of the same age classes in June 1956. The decline of these year classes from 1956 to 1958 provides an average estimate of total annual mortality of 50 percent which is higher than estimates for adjacent grounds outside Bering Sea and as high as estimates for very heavily-fished stocks in Hecate Strait in Area 2.

GROWTH STUDIES

Studies of the growth of the halibut from measurements of the growth zones on the otoliths were continued. This method has been proven practical and permits the processing of large volumes of material relatively quickly. In a long-lived species such as the halibut it has the special merit of providing growth data to fill gaps which result from inability to obtain samples from all banks every year.

In 1958 these studies were extended from the Portlock-Albatross grounds in Area 3 to the Goose Islands grounds and the northern Hecate Strait regions of Area 2. In addition, samples of halibut taken incidentally to the king crab investigations in the Bering Sea were obtained from the United States Fish and Wildlife Service and processed. Also included in the year's work were halibut caught by the Commission during its investigations of halibut below commercial size. These small-halibut materials provided valuable data for comparison with samples to be obtained in the future when the same year classes are of commercial size.

Measurements of approximately 4000 otoliths were made. Of these, about 2700 were from the Goose Islands grounds, 1000 from northern Hecate Strait and 300 from halibut of sub-commercial size taken off British Columbia, the Pacific Coast of Alaska and in Bering Sea. The Goose Islands materials consisted of samples collected during one tagging trip in 1926 and one market-measurement trip each year from 1935 to 1958 inclusive. The northern Hecate Strait samples consisted of one market-measurement trip each year from 1950 to 1958. The measurements permitted reconstruction of the growth patterns of each year class from 1921 to 1952 on the Goose Islands grounds, and from 1936 to 1952 on the grounds of northern Hecate Strait.

In contrast to the pronounced changes in growth observed in halibut from the Portlock-Albatross grounds the data from the Goose Islands grounds indicate little or no change in average weight for each age since 1921.

These growth studies are fulfilling their objectives of providing information as to when and where changes in growth rate have occurred and providing data for study of the possible causes of these changes. While these studies are being extended to different regions and times, results of the reconstructed growth patterns of each year class obtained to date from important fishing grounds in Areas 2 and 3A will be useful in preliminary investigations into the interrelationships of the factors that determine stock size and yield.

TAGGING EXPERIMENTS

The tagging program which provides information regarding the relationships, the availability and the utilization of the stocks upon the various fishing grounds was modified in 1958 to include preliminary studies of the effect of tagging upon the survival of halibut. Two vessels were chartered, one for conventional tagging operations, the other for the viability studies.

The halibut vessel ARLICE was operated in the inside waters of southeastern Alaska for a period of 45 days in March and April. Tagging was done during two trips in Frederick Sound and the adjacent sections of Chatham Strait and Stephens Passage, where tagging had not been done previously. Objectives were to study the migrations of the halibut in this region and to measure the extent to which they are exploited by the commercial fishery in that and other regions. A total of 1530 halibut, 52 percent of the number caught, were tagged.

The University of Washington's research vessel COMMANDO was operated for a period of 57 days in May and June to catch and transport live halibut and to act as a tender during viability experiments which were undertaken with a view to improving the quantitative value of tag-recovery data. Kitoi Bay on Afognak Island, Alaska was chosen as a base of operations as it offered a sheltered harbor with a good bottom and was close to halibut fishing grounds. In the course of this work 222 halibut were tagged and released.

The time and location, the amount of fishing and catch, and the numbers and weights of halibut tagged in 1958 are summarized in the following table.

Summary of 1958 Tagging Experiments

Trip	Locality	Month	Skates Fished	No. Tagged	Pounds Tagged	Total Catch
ARLICE						
1	Frederick Sd. and Lower Chatham Strait	March	338	818	32,999	64,038
2	Frederick Sd., Chatham Strait and Stephens Passage	March-April	377	712	23,962	44,864
	Sub-Total		715	1,530	56,961	108,902
COMMANDO						
1	Marmot Bay	May-June	310	222	5,339	15,298
	TOTAL		1,025	1,752	62,300	124,200

The recoveries were expected to be lower than in 1957, as all tagging in 1956 and 1957 had been done in Area 3. However, a very strong recovery of tags from the Bering Sea due to an early season and greatly increased fishing pressure, an increase in recoveries from the 1955 Masset and Timbered Islet grounds due to the opening of these former nursery grounds to fishing, plus a strong 0-year return from 1958 tagging in southeastern Alaska, caused a two percent increase in returns over 1957. A total of 1,198 recoveries were made as compared to 1,175 in 1957. Recovery information

obtained with these returns was very good, 80 percent being accompanied by otoliths and 32 percent with sex information.

A summary of recoveries in 1958 from the 1955, 1956 and 1957 tagging experiments is given on the following page in comparison with recoveries from the same experiments in 1957. Data for the year after tagging are omitted because they are not comparable with recoveries in subsequent years. The "other" recoveries were made outside the fishing seasons and by trawlers throughout the year.

Summary of 1957 and 1958 Tag Recoveries from 1955 to 1957 Tagging Experiments

Year and Location	Month	No. Tagged	Number of Recoveries*							
			1957				1958			
			1st**	2nd**	Other	Total	1st**	2nd**	Other	Total
SOUTH OF CAPE SPENCER										
1955 Experiments										
Goose Is.	July	1,963	130	23	31	184	103	—	7	110
Goose Is.	Oct.	900	63	7	23	93	41	—	2	43
Lower Hecate Strait	Sept.	392	32	—	2	34	18	3	2	23
Upper Hecate Strait	Aug.	1,337	84	27	9	120	45	7	8	60
Masset Nursery	Aug.-Sept.	2,535	206	14	9	229	229	4	30	263
Timbered I. Nursery	Aug.	1,400	30	10	4	44	48	7	2	57
WEST OF CAPE SPENCER										
1955 Experiments										
Yakutat and "W" Ground	Nov.-Dec.	1,242	24	1	—	25	25	—	—	25
1956 Experiments										
Shumagin Gully	May	527	4	—	1	5	4	—	1	5
Shumagin Is.	July	704	7	2	1	10	12	—	—	12
Shumagin Is.	Sept.	163	1	—	—	1	2	—	—	2
Bering Sea	June	1,715	4	—	—	4	69	—	1	70
Bering Sea	Aug.	790	5	—	—	5	54	—	—	54
Makushin-Akun	May-June	182	—	—	—	—	3	—	—	3
Makushin-Akun	July-Aug.	496	1	—	—	1	2	—	—	2
Yakutat and "W" Ground	Nov.-Dec.	588	35	—	1	36	21	—	1	22
Trinity Is.	Sept.	97	—	—	—	—	—	—	—	—
1957 Experiments										
Yakutat and "W" Ground	Jan.	504	—	—	—	—	16	—	—	16
Seward Gully	Apr.-May	588	—	—	—	—	19	—	1	20
Cape Cleare	May	275	—	—	—	—	21	—	—	21
Cape Cleare	Aug.-Sept.	94	—	—	—	—	7	—	—	7
Shelikof Strait	May	1,089	—	—	—	—	15	—	1	16
Foggy Cape	June	506	—	—	—	—	3	—	—	3
Foggy Cape	July-Aug.	539	—	—	—	—	4	—	—	4
Cook Inlet	June	748	—	—	—	—	10	—	—	10
Albatross Bank	Aug.	328	—	—	—	—	5	—	—	5

*Recoveries during the year of tagging are omitted because they are not comparable.
**Fishing seasons.

The patterns of tag recoveries in 1958 were generally along expected lines, but those of a few experiments are of particular interest.

The two 1956 experiments on the edge in Bering Sea produced 124 recoveries, a marked increase over the number returned in 1957. Most of the increase occurred in Bering Sea and is attributable to the development of a fishery there as a result of the earlier opening of the fishing season in Area 3B. However, the number of Bering Sea tags recovered in Areas 3A and 2 also increased, as was predicted in 1957, and corroborated the results of a 1930 experiment in Bering Sea which indicated an increase in the migration of Bering Sea halibut into the fishery south and east of the Alaska Peninsula with time. There was a significant difference in the percentage of the June and August tags recovered, but no logical explanation of this difference is yet apparent.

Returns from tagging in the vicinity of Kodiak Island during the summer of 1957 showed the customary moderate migrations. The fish tagged in Shelikof Strait were not appreciably available elsewhere in 1958, indicating that the change from good to poor fishing in Shelikof Strait from 1957 to 1958 was not caused by a movement of fish out of the region.

Recoveries from the November and December experiments on the "W" and Yakutat grounds in 1956 showed a marked westward migration as did halibut tagged on the same grounds in the winters of 1926 and 1927. However, the fish tagged in the recent experiments were much more available in the area of tagging than were those in the earlier experiments. No satisfactory explanation of this difference has been found.

Ten percent of the tags released in Frederick Sound and vicinity in March and April of 1958 were recovered, which was quite high for the year of tagging and indicative of an intense fishery upon those stocks. The numbers of tags recovered during the first and second fishing seasons were nearly proportional to the amount of gear fished in the two seasons, indicating a relatively uniform availability.

During the viability experiments halibut were captured and tagged in the usual way. They were then held under observation in floating live boxes in Kitoi Bay for periods up to two weeks. No mortalities occurred prior to the sixth day. Thereafter deaths increased to the end of the holding period. From observations and examination of the fish it appeared that the halibut were not critically injured by the tagging operation. However, decision as to whether the deaths after the first week were a delayed result of the capture and tagging processes or were caused by the unnatural conditions under which the fish were held must await more detailed experiments in which fish are held under more natural conditions.

Studies of tag losses were intensified in 1958 to obtain quantitative information regarding the loss of tags from the fish and the proportion of recovered tags that are overlooked or lost by the fishermen and by the fish-handlers onshore. The results of tagging experiments in which halibut had been marked with two tags were analyzed and showed that tags were lost from the fish.

Examination of the tags in position on recaptured tagged fish indicated that some tags were sloughed off and that the sloughing was a continuing process. The tagging of dead fish in the holds of vessels about to unload their catches showed that a considerable proportion of the tags which had been overlooked by the fishermen at the time of capture would also be overlooked at the time of unloading and thereby lost. However, the results of these preliminary and limited experiments and observations indicated that the total loss of tags as a percentage of the number released was not high.

STUDIES OF HALIBUT BELOW COMMERCIAL SIZE

Investigations of the life of the halibut in the years before they enter the fishery were begun in 1955. First objectives were to learn where and how the young fish live and how fast they grow, to locate places where they occur consistently in relatively large numbers and to develop efficient gear and methods of sampling which can be used in these locations to measure the strength of the age groups of young in different years. Later objectives were, and are, to measure the strength of the year classes and the differences that occur, to find out whether these are related to the abundance of parent spawners and resultant recruits and, if they are not related, to ascertain the causes therefor. The ultimate aim is to determine

the stock and environmental conditions required for optimum recruitment.

Good progress has been made upon the first of the above-mentioned objectives. The effectiveness of a variety of types of gear has been tested. The area explored during the invstigations has been extended gradually from Hecate Strait and Dixon Entrance in 1955 to the waters of southeastern Alaska in 1956, the Gulf of Alaska and Kodiak region in 1957 and the Shumagin Islands in 1958.

For field studies in 1958 the University of Washington's research vessel COMMANDO was chartered from mid-July to mid-September. Sampling was repeated at the locations off British Columbia, southeastern Alaska and central Alaska where some small halibut had been found in previous years. The main fishing locations were McIntyre Bay in Dixon Entrance, Shelikof Bay near Sitka, off Yakutat Bay, the approaches to Prince William Sound, Kachemak Bay in Cook Inlet, off Kodiak Island near Karluk and in Alitak Bay. Exploratory fishing was also done off Koniuji and Unga Islands in the Shumagin Islands group.

The types of gear used in 1958 included otter trawls with cod-end meshes of 1¼ and 2½ inches, a lightweight beam trawl with small-meshed webbing, a gill net with a variety of meshes, ring nets of a trap-like type, and light setline gear. On the basis of prior experience, fishing was done principally with otter trawls having wings of 2½ inch mesh and body and cod-end of 1¼ inch mesh. The number of sets, the depth ranges fished, the average duration of set and the catch for each type of gear are shown below.

Type of Gear	Number of Sets	Depth Range	Average Duration	Number Caught
Otter trawl	50	10-33 fathoms	23 min.	4,659
Otter trawl	5	35-51 fathoms	20 min.	4
Otter trawl	1	107-113 fathoms	40 min.	0
Beam trawl	3	3-15 fathoms	15 min.	0
Ring nets	4	11-17 fathoms	17 hrs.	0
Setline	11	1-14 fathoms	1 hr.	0
Gill net	1	16 fathoms	2 hrs.	0

Otter trawl drags are separated into three groups to show six hauls of a purely exploratory nature that were made beyond the depths where small halibut had been found previously. Five of the latter were made on the shallowest trawlable spots found on Goose Islands grounds in depths ranging from 35 to 51 fathoms. The sixth was made in relatively deep water in Marmot Bay, Alaska. A total of 4663 small halibut were taken, all with otter-trawl nets.

On the basis of experience in 1958 and in prior years it is evident that otter trawls are most effective and should be adopted as the standard type of gear for sampling small halibut. Although the beam trawl failed to catch any halibut in 1958, it caught some in 1957 and seems worthy of further trial as a qualitative exploratory tool in areas where it is impossible to use the otter trawl. The ring nets and gill net have been completely ineffective and the light setline gear almost so, even in areas with known concentrations of small halibut. Further attempts to use these seem pointless.

The majority of small halibut taken in 1958 were caught in depths of from 10 to 25 fathoms; they ranged in length from 2 to 25 inches and in age from less than one to seven years. Occasional halibut of commercial size were also caught. A summary of the catches according to locality, date, depth and age is given in the following table.

Catches of Halibut of Sub-Commercial Size During Investigations in 1958

Location	Date	Fathoms	Number of Halibut by Age *0	1	2	3	4	5	6	7	?	Total
British Columbia												
Queen Charlotte Sound	July 25	47-49	—	—	—	—	2	—	1	1	—	4
Northern Hecate Strait	July 26	14-23	—	1	2	1	3	3	3	3	—	16
	Sept. 9	11-18	1	2	—	—	—	—	—	—	—	3
McIntyre Bay	July 29	12-20	—	2	—	—	—	—	1	—	—	3
	Sept. 8	11-16	38	5	—	1	2	1	—	—	1**	48
Southeastern Alaska												
Shelikof Bay	Aug. 1-2	10-20	37	113	10	3	1	—	—	—	—	164
	Sept. 2	14-23	226	26	1	—	1	—	—	—	1**	255
Central Alaska												
Yakutat	Aug. 3	11-22	—	1	4	2	3	3	—	2	—	15
	Aug. 31	20-21	—	—	1	—	—	—	—	—	—	1
Prince William Sound	Aug. 6-7	15-24	—	—	3	1	4	2	—	—	—	10
	Aug. 29-30	13-22	12	49	33	13	3	3	—	—	—	113
Cook Inlet	Aug. 9-12	18-29	—	253	21	8	3	1	—	—	—	286
Afognak Island	Aug. 27	26-32	—	6	6	—	—	—	—	—	—	12
Kodiak Island	Aug. 15-25	13-24	309	2547	300	130	63	18	1	—	—	3368
Shelikof Strait	Aug. 16	13-14	—	79	8	—	1	—	—	—	—	88
Western Alaska												
Shumagin Islands	Aug. 19-20	14-20	—	272	4	1	—	—	—	—	—	277
TOTAL			623	3356	393	160	86	31	6	6	2	4663

*Less than one year old.
**Otolith illegible (probably 2 or 3 years old).

The 1958 data, when compared with those of 1957, were found to be similar in some respects and quite different in others. The Kodiak-Cook Inlet region yielded the highest catches per unit effort in both years. Shelikof Bay in southeastern Alaska was second in production and the Yakutat-Prince William Sound region third. The catches taken off British Columbia were much below those of the above regions in the two years and insufficient for comparative purposes.

In both 1958 and 1957 the catch in each region was about equally divided as to males and females. No consistent differences in the average size of the sexes at the same age was apparent. Also, halibut taken later in the season off central Alaska were smaller at the same age than were those caught off southeastern Alaska.

Catches showed consistent differences in numbers taken and in age composition between sections of Area 3A. Fewer halibut and a higher proportion of larger and older fish were caught per haul at Yakutat and Prince William Sound than at Cook Inlet and Kodiak Island.

There was a striking difference in the strength of age groups in all productive regions in the two years. In 1957, 3-year olds were generally most numerous in the catches. In 1958, 1-year olds tended to be dominant. As a result of the high abundance of 1-year olds in the 1958 catches there was a threefold increase in the average number caught per standard haul.

The stomach contents of more than 2000 small halibut taken between 1955 and 1958 have been examined. More than 1500 of the stomachs contained identifiable food. Halibut less than 4 inches long, less than 1-year old, have been found to feed mainly upon small crustaceans. In halibut over 4 inches long—the largest of the 0-year group and older groups—fish, shrimp and crabs have been predominant in the diet. In halibut over 12 inches long, fish became the principal item of food except in Cook Inlet where halibut up to 16 inches were still feeding largely upon shrimp.