The Pacific Halibut: Biology, Fishery, and Management

by

The International Pacific Halibut Commission

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FOREWORD

This report provides a general review of the biology of the Pacific halibut, its fishery, and management. It is designed to answer questions frequently asked by fishermen, students, and the general public. The report is an update and expansion of Technical Report No. 6, which was published in 1970, and Technical Report No. 16, which was published in 1978. The information has been excerpted from the Commission's publications that are listed at the end of this report.

On the cover, a crewman on the vessel LINN J, out of Kodiak, Alaska, gaffs a halibut to bring on board. The picture was taken by David G. Gordon in May, 1986, on a fishing trip led by Captain Blake Kinnear, Jr.

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Biology

DESCRIPTION AND SCIENTIFIC NAME

Halibut belong to a family of flounders called Pleuronectidae. Most fishes are torpedo-shaped and symmetrical, often with heavily pigmented backs and light, white bellies. Flounders are compressed laterally and, except in the larval stages, have both eyes on one side of the head; the eyed side is pigmented and the underside is white. Halibut usually are dextral, that is, both eyes are on the right side. Pigmentation varies from olive to dark brown or black with lighter, irregular blotches that often are similar to the color pattern of the ocean floor. This protective coloration makes the fish less conspicuous to predators and prey. The left or blind side faces the ocean bottom and usually is white.

Halibut are more elongate than most other flatfishes. The average width of the body is about one-third its length. The mouth is relatively large, extending to below the lower eye, and nearly symmetrical. The small, smooth scales are well buried in the skin and the lateral line has a pronounced arch above the pectoral fin. The tail or caudal fin is crescent-shaped or lunate (Figure 1).

The scientific name for Pacific halibut is *Hippoglossus stenolepis*, a name derived from the Greek *hippos* (horse), *glossa* (tongue), *steno* (narrow), and *lepis* (scale). The

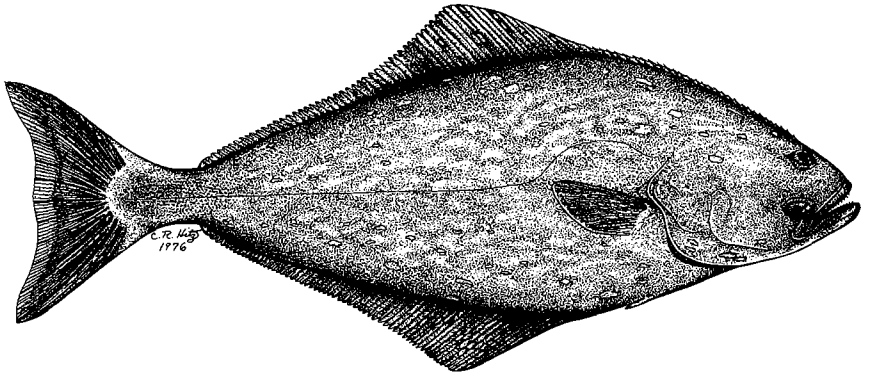


Figure 1. Adult Pacific Halibut, *Hippoglossus stenolepis*. (Drawing by Charles R. Hitz).

name was proposed by a Russian scientist, P. J. Schmidt, in 1904, who distinguishes the Pacific halibut from the Atlantic halibut *(Hippoglossus hippoglossus)* by anatomical differences such as the shape of the scales, length of the pectoral fin, and the shape of the body. In 1936, another Russian, M. F. Vernidub, claimed that the differences between the Atlantic and Pacific halibut did not warrant the designation of separate species and suggested the name *Hippoglossus hippoglossus stenolepis* for Pacific halibut. However, North American scientists have detected some serological and other morphological differences between halibut from the Pacific and those from the Atlantic and the name suggested by Schmidt is the one most commonly accepted.

DISTRIBUTION AND MIGRATION

Pacific halibut are found on the continental shelf of the North Pacific Ocean. They have been recorded along the North American coast (Figure 2) from Santa Barbara, California to Nome, Alaska and also occur along the Asiatic Coast from the Gulf of Anadyr, U.S.S.R. to Hokkaido, Japan. Halibut are demersal, living on or near the bottom, and prefer water temperatures ranging from 3 degrees to 8 degrees C. Although halibut have been taken as deep as 3600 feet, most of them are caught during the summer when they are at depths from 90 to 900 feet. Halibut move from deep water along the edge of the continental shelf to shallower banks and coastal waters during the summer and most return to deep water in the winter. This seasonal movement also is associated with winter spawning and summer feeding. Halibut also undergo coastwide migration that may involve distances of hundreds of miles. These movements have been documented by tagging experiments.

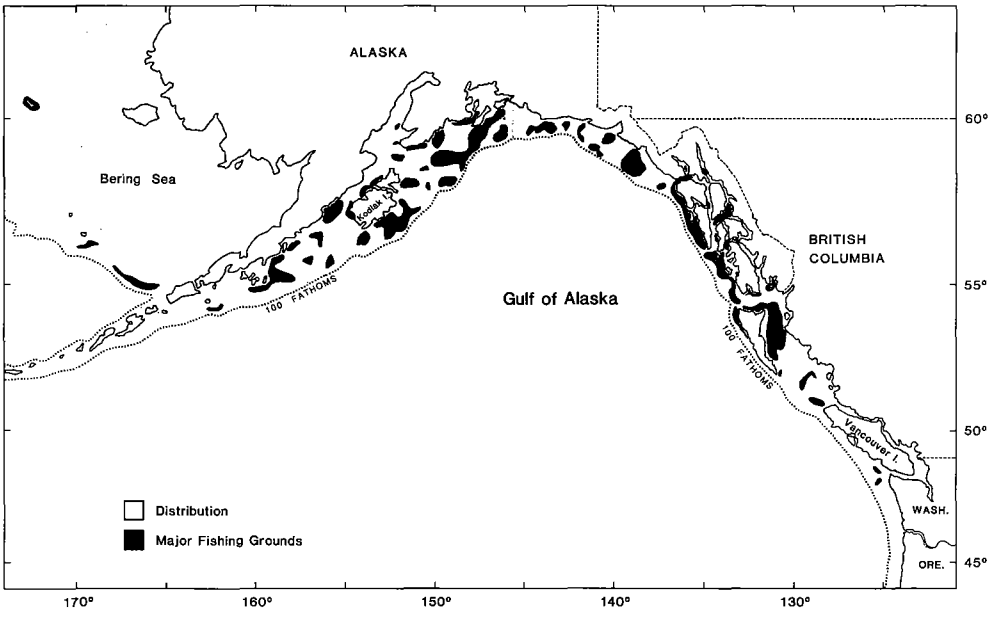


Figure 2. North American distribution of Pacific halibut and major fishing grounds.

The International Pacific Halibut Commission (IPHC) has tagged over 350,000 halibut since 1925 and over 35,000 tagged fish have been recovered. A reward is paid for tags that are returned to IPHC (see reward poster, inside back cover). Most of

the tagging experiments have been conducted in the summer and most of the recoveries occur during the summer when fishing is usually permitted. Although extensive summer to summer movements have been recorded, most of the recoveries take place within 60 miles of the release area. Data from tagging experiments in which halibut were tagged or recovered in the winter are limited, but the results show that summer-winter movements are more extensive than those between summers and that the predominant direction of movement may differ substantially between the two seasons.

The distance and direction of the migrations also may differ with the size and age of the fish. Emigration has been observed from all regions, but few recoveries of adult halibut released in the Gulf of Alaska have been made in the Bering Sea. An example of the distribution of tag recoveries from a Bering Sea experiment in 1959 is shown in Figure 3. Halibut occasionally migrate great distances and several tags have been recovered over 2,000 miles from their point of release. These fish were tagged in the Bering Sea or near the Aleutian Islands and recovered at points from Cape Flattery, Washington to Cape Mendocino, California. One of the fish was recovered two years after being released; the others were recovered in five or six years. The longest migration was from Atka Island in the Aleutian Islands to Coos Bay, Oregon, a distance of 2,500 miles. Another halibut released southeast of Cape Navarin, U.S.S.R. during a joint Soviet-IPHC experiment in 1975 was recovered in 1977 near the Shumagin Islands in Alaska, a distance of 1,000 miles.

Juvenile halibut, those under 7 years old, also migrate long distances, apparently counterbalancing the northwesterly drift of the eggs and larvae as described in the next section. These juvenile and adult movements result in net migrations of an easterly and southerly direction in the Gulf of Alaska. This complex pattern of movements indicates that the halibut stocks are interrelated and that intermingling is extensive, a factor that must be considered in the management of the fishery.

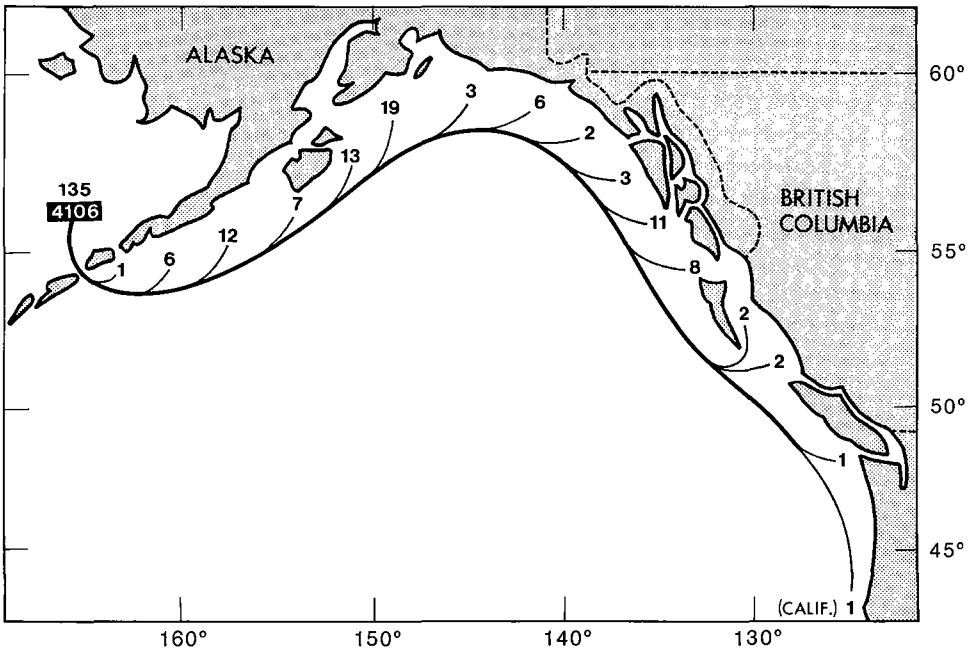


Figure 3. Recoveries of halibut tagged in the Bering Sea during 1959. The number of fish tagged is shown in the black box.

Throughout this report the terms stock and stocks are used in discussing the halibut resource. Although the Pacific halibut population is considered to be one stock biologically, certain components of the population may be discussed and identified by the area in which they reside, such as the Bering Sea stock, or by characteristics which may set them apart from the rest of the population, such as the stock of 15 year old halibut. These references do not imply the existence of separate stocks, but only serve to identify certain sub-stocks within the halibut population.

REPRODUCTION AND DEVELOPMENT

Maturity varies with sex, age, and size of the fish. Females grow faster but mature slower than males. Most males are mature by the time they are 8 years old, whereas the average age of maturity for females is about 12 years. From November to March, mature halibut concentrate on spawning grounds along the edge of the continental shelf at depths from 600 to 1,500 feet. Spawning occurs annually. The major spawning sites include Cape St. James, Langara Island (Whaleback), and Frederick Island in British Columbia, and Yakutat, Cape Suckling- Yakataga ("W" Grounds), Portlock Bank, and Chirikof Island in Alaska. Other reported spawning locations include Goose Islands, Hecate Strait, and Rose Spit in British Columbia and Cape Ommaney, Cape Spencer, and Cape St. Elias in Alaska. Spawning concentrations also occur in the Bering Sea. In addition to these major grounds, there is reason to conclude that spawning is widespread and occurs in many areas, although not in as dense concentrations as those mentioned above. Evidence to support this conclusion is based on the widespread distribution of sexually mature halibut during the winter months as indicated by research and commercial fishing.

The number of eggs produced by a female is related to its size. A 50-pound female will produce about 500,000 eggs, whereas a female over 250 pounds may produce 4 million eggs. The free-floating eggs are about three mm in diameter when released and fertilization takes place externally. Developing ova generally are found at depths of 300 to 600 feet, but occur as deep as 1,500 feet. The eggs hatch after about 15 days, depending upon water temperature. The eggs and larvae are heavier than the surface sea water and drift passively in deep ocean currents. As the larvae grow, their specific gravity decreases and they gradually move towards the surface and drift to shallower waters on the continental shelf. The life cycle of halibut is depicted in Figure 4. Postlarvae may be transported many hundreds of miles by the Alaskan Stream which flows counter-clockwise in the Gulf of Alaska and westward along the Alaska Peninsula and Aleutian Islands. Some of the larvae are carried into the Bering Sea. The velocity of this current may exceed a mile per hour in certain coastal areas, but overall speeds of 3 to 5 miles per day are more typical.

Halibut larvae begin life in an upright position with an eye on each side of the head. Nutrition is derived from a prominent yolk sac until it is absorbed during the early postlarval stage; then the young fish must begin feeding on small planktonic organisms. When the larvae are an inch long, an extraordinary transformation or metamorphosis occurs: the left eye moves over the snout to the right side of the head and pigmentation on the left side fades. When the young fish are about 6 months old, they have the characteristic adult form and settle to the bottom in shallow inshore areas. Detailed drawings of these early life history stages are depicted in Figure 5.

The survival of young halibut is affected by the environment and the abundance of the year classes varies accordingly. Juveniles from 1 to 3 years old generally remain in

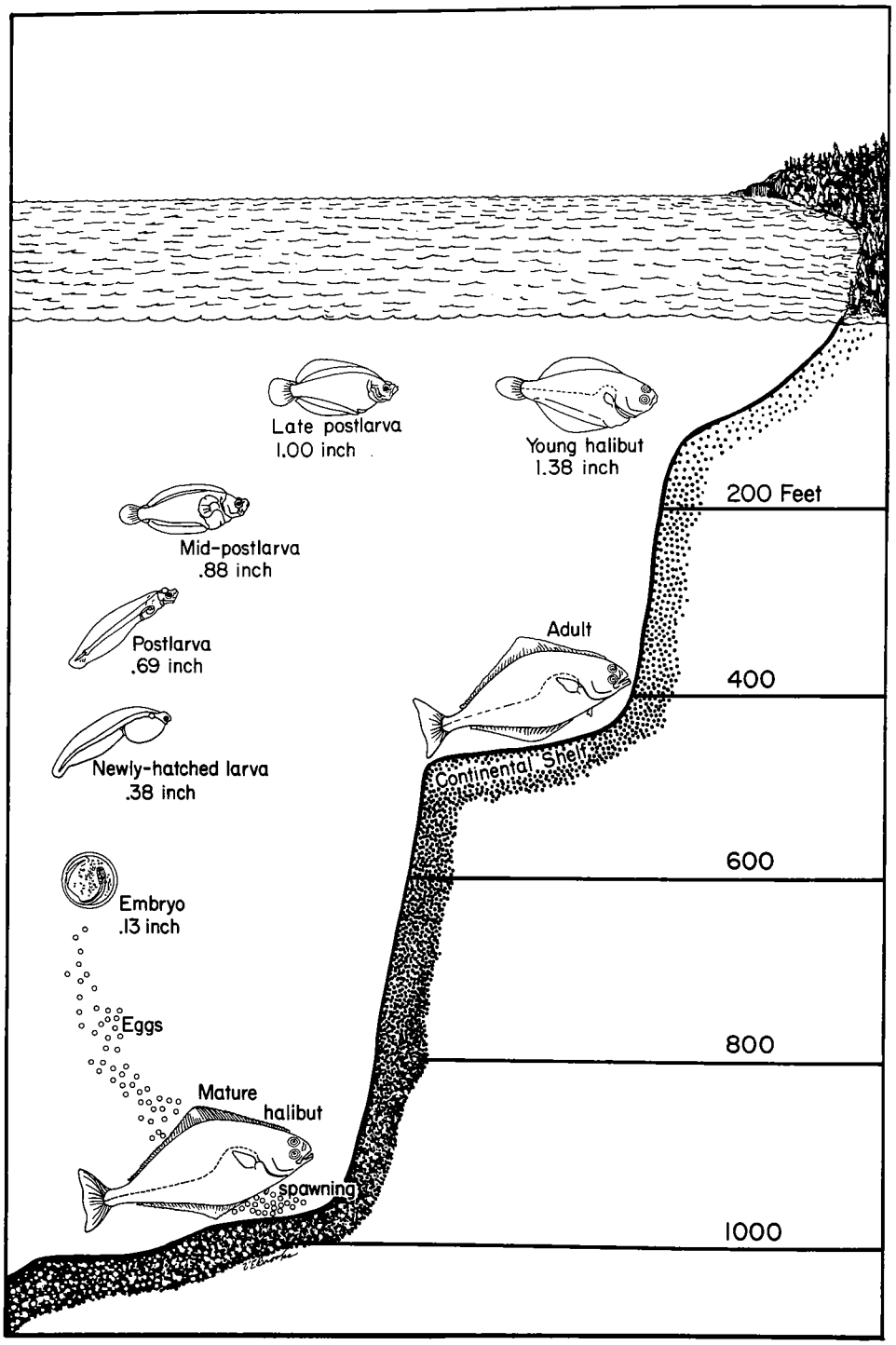
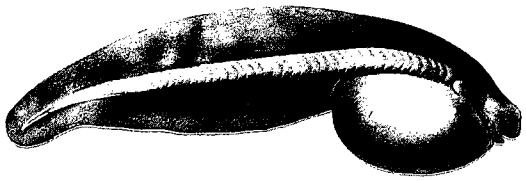


Figure 4. Life cycle of Pacific halibut.

NEWLY-HATCHED LARVA (Stage 1)

Showing prominent yolk sac.



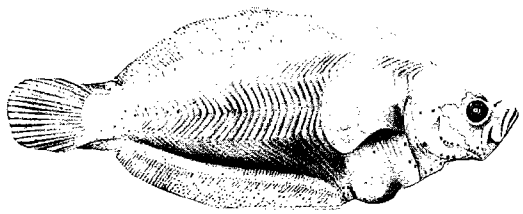
Approximately 9 mm in length.

POSTLARVA (Stage 3)

Yolk sac has been absorbed.

Approximately 16 mm in length.

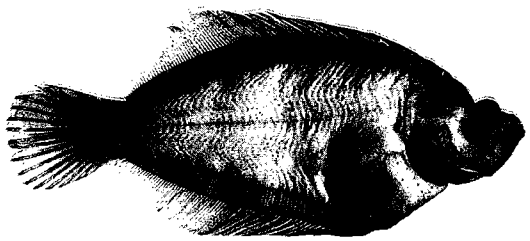
POSTLARVA (Stage 7)



Approximately 21 mm in length.

POSTLARVA (Stage 9)

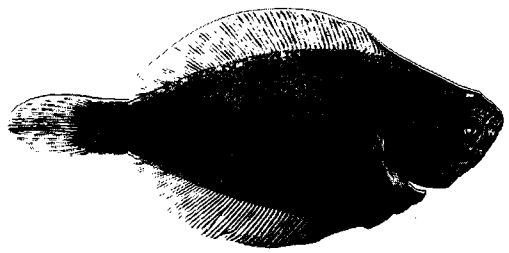
Showing the beginning of eye migration.



Approximately 25 mm in length.

YOUNG HALIBUT

Adapted to bottom life.



Approximately 35 mm in length.

Figure 5. Growth and early development of halibut.

relatively shallow inshore waters and usually are not caught by the commercial setline fishery. With increasing age, many juveniles move to deeper waters and migrate in an easterly and southerly direction, reciprocal to the passive movement of eggs and larvae. Juveniles tagged in the Bering Sea and the western Gulf of Alaska have migrated as far south as British Columbia, Washington, and Oregon, suggesting they may have been spawned in this general area. During the migratory phase, many of the young halibut are taken as incidental catch in trawls that are used to catch other species of groundfish.

FOOD AND FEEDING

Halibut are strong swimmers and carnivorous feeders, eating almost any animal they can catch. Larval halibut feed on plankton. Halibut 1 to 3 years old are usually less than 12 inches (30 cm) in length and feed on small shrimp-like organisms and small fish. As halibut increase in size, fish become a more important part of the diet. The species of fish frequently observed in stomachs of large halibut include cod, sablefish, pollock, rockfish, sculpins, turbot, and other flatfish. Halibut often leave the bottom to feed on pelagic fish such as sand lance and herring. Octopus, crabs, and clams, as well as an occasional smaller halibut, also contribute to their diet. Crabs with a carapace width of seven inches have been found in the stomachs of halibut, although halibut do not appear to be a primary predator of crab.

AGE AND GROWTH

Halibut are the largest of all flatfish and are among the larger species of fish in the sea. The largest specimens in the Atlantic and Pacific are over 9 feet long and have been reported to weigh 700 pounds; these weights have not been thoroughly documented. An 8-foot long, 33-year-old Pacific halibut female that weighed 375 pounds with its head and viscera removed, or 500 pounds live weight, is shown in Figure 6. This fish was caught in the Bering Sea in 1974 by the vessel THOR. At $.80 per pound, the gigantic halibut was worth $300 to Captain Ralph Lund and his crew; at 1986 prices, the fish would be worth almost $550. Two other specimens weighing 500 pounds have been authenticated, one from Petersburg, Alaska and the other from Sakhalin Island, U.S.S.R. The North American catch of Pacific halibut, caught mostly by longline gear, consists of individuals chiefly from 10 to 200 pounds. The average size in the commercial catch is between 30 and 40 pounds. Few males reach 80 pounds and nearly all halibut over 100 pounds are females.

IPHC studies have shown that female halibut grow faster and live longer than males and that both males and females grow faster now than they did many years ago. For example, in the 1970-1980 period, 10-year-old male and female halibut in the Gulf of Alaska were on the average 38 and 46 inches long and weighed 20 and 37 pounds, respectively. In the 1920's, the same fish would have averaged 29 and 32 inches long and weighed 8 and 10 pounds, respectively. This increase in the growth rate since the 1920's is assumed to be the result of changes in population density and/or environmental conditions. The increased growth has important biological and management implications because stock biomass and fecundity are related to the growth rate.

The age of halibut is determined from the otolith, a calcareous or stone-like body in each internal ear, that serves as a hydrostatic or balancing organ (Figure 7). As the fish grows, the otoliths also grow and the size of halibut can be estimated from the otolith's length or weight. Each year, alternating opaque (summer) and translucent

Figure 6. Female halibut 33 years old, 8 feet long, and 500 pounds before the head and viscera were removed.

(winter) rings are deposited on the otolith. The annual growth rings are called annuli and are counted to determine the age of the fish. The oldest age recorded for a halibut is 42 years for females and 27 years for males. Most halibut in the North American setline catch are 8 to 15 years old.

IPHC biologists sample the commercial catch and obtain age and length information from about 40,000 halibut each year. This information is used to assess the condition of the resource. For example, the number of fish at each age in the catch indicates the relative strength of individual year classes. Over a succession of years,

Figure 7. Otolith from a halibut in its ninth year. Photographed on a dark background, the wide, white bands are the opaque summer zones; the dark rings are the translucent winter zones.

individual year classes can be traced throughout their life and the rate at which their numbers decrease is an indication of their mortality rate. The increase in length with successive age provides a measure of the growth rate of the fish. Strength of year classes, mortality rates, and growth are essential items of information for determining stock condition and necessary conservation measures.

The Fishery

THE INDIAN FISHERY

Halibut and other marine animals were a part of the folklore of coastal Indian tribes and were commemorated in carvings on totem poles or painted on the fronts of community houses (see back cover of this report). The following excerpt is from a Tsimshian myth[1] that mentions a supernatural halibut:

> "On the following day three of their young people went out in a canoe across the inlet; and when they reached the foot of a steep cliff, behold! a large halibut came up, opened its mouth, and swallowed the canoe with the three persons — two princesses and one prince. The people on the other side saw it. Therefore two of their brave men went to kill the monster who had devoured their prince and their princesses. They crossed the inlet in their canoe, having their large knives tied to the right wrist. As soon as they reached the foot of the steep rock, a halibut came up, opened its mouth, and swallowed the canoe with the two brave men; but as soon as the halibut had swallowed them, they cut it inside with their knives. They cut up its intestines until it died. Then the supernatural halibut felt the pains in its stomach, jumped out of the water, and struck the water with its tail. It swam around the inlet, and finally ran ashore and died there. Then those who had remained alive went down to the beach, and saw that the great supernatural halibut was dead. They cut it open, and saw the two canoes and five persons. Then they sang their mourning-song."

Halibut was included in the diet of several tribes and their hook and line fishery was conducted from large canoes (Figure 8) which ventured as far as 20 miles from shore. The technique of these fishermen was well developed and very efficient:[1]

> "Halibut are caught with hooks made of crooked branches of red or yellow cedar, attached to fishing-lines made of red-cedar bark sixty fathoms long. The halibut hook is tied to the fishing-line with split spruceroots. Devilfish (octopus) is used as bait. The fishing-lines are taken out by the fishermen in their canoes and thrown overboard. After a while they are pulled up again. After the halibut hooks have been taken up, the fish are killed by clubbing. Then hooks are thrown back into the water. At this place it is said that there were two fishermen in the canoe, who distinguished the halibut they had caught by placing them with the head toward the owner. The fishermen had his knees covered with a mat."

[1]Tsimshian Mythology by F. Boas, Bureau of American Ethnology. Annual Report 1909-1910, U.S. Government Printing Office, Washington, D.C., pp. 27-1037.

Figure 8. Indian catch of halibut at Neah Bay, Washington (circa 1910). Photographed by A. H. Barnes. Hillary Irving of the Makah Tribe identified the location.

The hooks often were elaborately carved (see below) and were selective for large fish suitable for drying and smoking. Drucker provided a detailed description of the hooks that were used by various tribes:[2]

> "Halibut were taken by bottom-fishing, also, from the Olympic Penninsula north, but special hooks were used. The Tlingit, Haida, Tsimshian, and the Northern Kwakiutl groups, Haisla, and Xaihais, made halibut hooks of hardwood, shaped like a V with one short arm, with a bone barb fastened into the short side. The shanks of these hooks were often elaborately carved with crests or figures intended to have magical potency... Two of these hooks were attached by short leaders to the ends of a cross-pole, to the middle of which a stone sinker was attached. The cross-pole held the bouyant wooden hooks clear of the line so as not to foul it. Large hooks of similar form, but undecorated, were used by the Chinook for the huge Columbia River sturgeon. The other Kwakiutl-speaking tribes, the Nootka, the Coast Salish of the Gulf of Georgia and Puget Sound, and the groups of northwestern Washington, made halibut hooks of spruce withes, steamed into U shape, and fitted with a sharp stone barb ... The springy arms of the hook spread to permit the halibut to insert his snout to take the bait, then helped set the barb. These hooks were attached to one end of a short rod, the other end of which was made fast to the line, and also supported a stone weight just heavy enough to hold the rod horizontally, and keep the hook clear of the line. Lines were commonly made of the long thin stems of giant kelp."

The annual consumption of halibut by Indians in British Columbia was estimated at three million pounds in 1884, whereas the catch by commercial fishermen was only 150,000 pounds. The catch by the Makah Indians at Neah Bay, Washington during the late 1880's was reported at 600,000 pounds annually and the commercial fishermen landed 740,000 pounds in Washington ports in 1890. Today, many Indians in Washington, British Columbia, and Alaska participate in the commercial and sport fisheries. Because of treaty rights, several Indian tribes which fish off the northwest coast of Washington were given a special allocation of halibut by the U.S. government in 1986. Additional allocations were granted in 1987 to tribes with treaty rights within Puget Sound, Washington.

THE COMMERCIAL FISHERY

The Fleet

The initial impetus for expansion of the commercial fishery for halibut occurred in 1888 when three sailing vessels from New England began fishing off Cape Flattery, Washington. The catch was shipped from Tacoma to Boston on the newly-completed transcontinental railroad. By 1892, following completion of the trans-Canada railroad,

[2]Indians of the Northwest Coast by Philip Drucker, The American Museum of Science, Books Edition, 1963, 224 p.

Vancouver, British Columbia became the major center for the fishery. At the outset, fishing was conducted from two-man dories that were carried to the fishing grounds by relatively small sailing vessels. Larger sailing schooners and sloops joined the fishery during the next decade; however, by the late 1890's, the fishery was dominated by large company-owned steam-powered vessels that carried 10 to 12 dories. Over the years, these steamers declined in number because of their high operating costs, labor problems, and a reduction in the stocks of halibut. At the same time, smaller independently-owned vessels powered by gasoline engines began entering the fishery and several of these were two-masted schooners carrying from five to seven dories.

During the 1920's, the rising economy, the development of diesel engines, and the expansion of the fishery across the Gulf of Alaska as far west as Unimak Pass led to a sharp increase in the number of owner-operated schooners. These diesel-powered schooners were designed to mechanically haul longline gear directly from the deck (Figure 9). This innovation quickly phased out the hand operations from dories. Most of the halibut schooners were built prior to 1930 and few have been built since that time. They ranged in size from 50 to 80 feet and were between 25 and 60 net tons. Most schooners still operating in the halibut fishery have been completely renovated. New propulsion systems, advanced navigation devices, communication equipment, hydraulic power and deck controls, cargo-hold modifications, refrigeration, new types of gear and bait, and other technological advances reduced the necessary manpower per vessel by 30 percent.

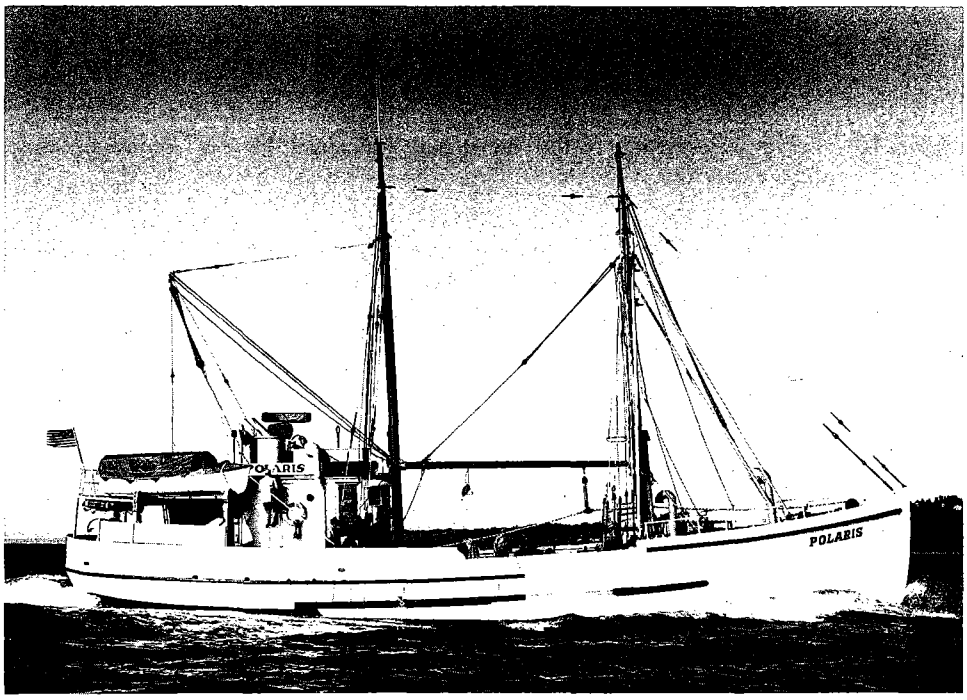


Figure 9. Halibut schooner *Polaris*, home port Seattle. Note pilothouse aft.

After 1930, most of the additions to the fleet were more versatile; the vessels could be used for trawling and purse seining in other fisheries as well as for longlining halibut (Figure 10). Small vessels, particularly salmon trollers and gillnetters, gradually entered the fishery during the 1930's and 1940's.

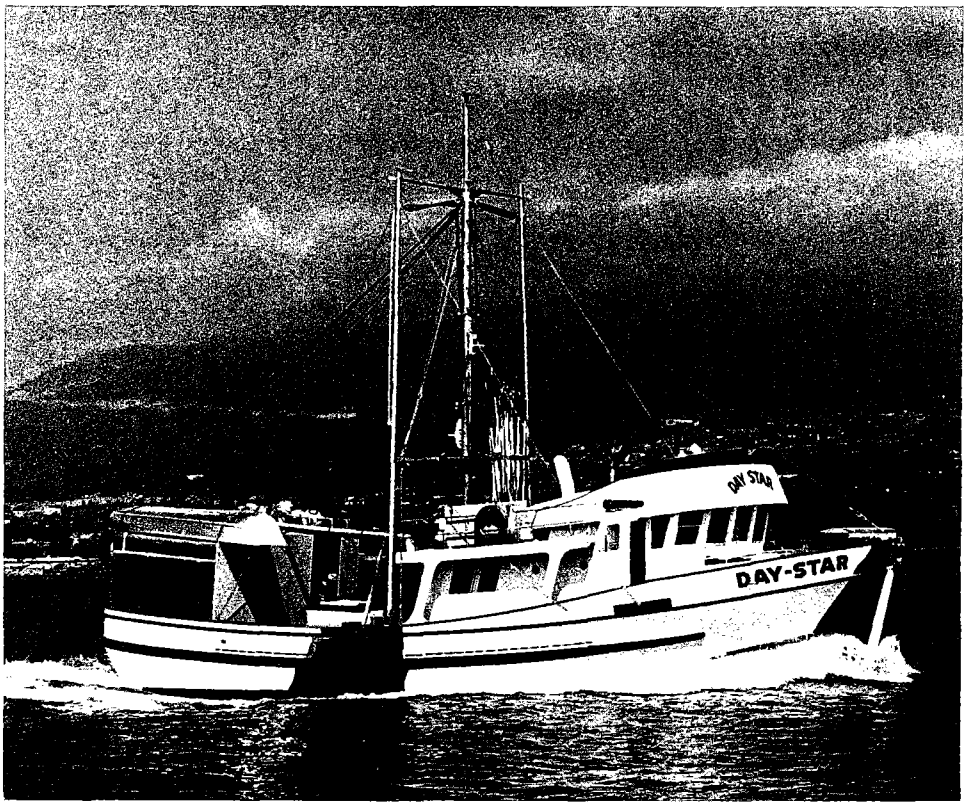


Figure 10. Seine-type vessel *Day Star*, home port Vancouver. Note pilothouse forward. (Photo courtesy of the Pacific Coast Fishing Vessel Owners' Guild.)

The composition of the fleet was relatively stable from 1950 through the 1960's. During the 1970's, there was a further influx of smaller vessels fishing relatively close to port and making short trips. In part, this influx was caused by a marked increase in the price of halibut, but also many fishermen entered the halibut fishery because they were not eligible to fish salmon under the several limited entry programs. Most of these small vessels are under 5 net tons. Many originally were designed for the salmon gillnet fishery and are equipped with a power-driven wheel for the storage of the gillnet. The gillnet can readily be replaced with halibut gear. During the 1980's, the number of large vessels increased sharply. Many of these vessels had previously been used in the crab fishery, but switched to halibut in response to declining crab stocks and increasing halibut stocks. Most of these ex-crab vessels are over 40 net tons and have proven very efficient at catching halibut. The number of vessels in the 1985 halibut fleet is shown in Table 1. Although the number of vessels less than 20 net tons (2,137 boats) far outnumbers the fleet of larger vessels (625 vessels), they land only about 31 percent of the catch because most of them are not able to fish as much gear as the larger vessels and may not be able to venture offshore to the more productive halibut grounds. Currently, all vessels fishing commercially for halibut, including chartered vessels carrying recreational fishermen, are required to possess a license issued by the Halibut Commission.

Table 1. Number of licensed and unlicensed vessels by area and nationality, 1985.

Vessel Category	Number of Vessels						
	Area 2		Area 3		Total		Grand
	Canada	U.S.	Canada	U.S.	Canada	U.S.	Total
Unlicensed Vessels							
Trollers	—	31	—	—	—	31	31
Setliners	58	73	—	153	58	226	284
Total	58	104	—	153	58	257	315
Licensed Vessels							
Unknown tons	10	68	—	41	10	109	119
1-4 tons	8	381	—	392	8	773	781
5-19 tons	258	569	—	529	258	1,098	1,356
20-39 tons	43	156	—	235	43	391	434
40-59 tons	9	21	—	73	9	94	103
60+ tons	6	4	—	78	6	82	88
Total	334	1,199	—	1,348	334	2,547	2,881
Grand Total	392	1,303	—	1,501	392	2,804	3,196

Fishermen

The commercial halibut fishery was pioneered by fishermen of Norwegian ancestry. Many of the original immigrants had fished halibut in Norway and came to North America intent on earning their living in the Pacific halibut fishery. Once established in the fishery, relatives followed and now there are many second and third generation Norwegians in the Canadian and United States fishery. Many Nova Scotians and Newfoundlanders also have participated in the West Coast fishery.

Crew size on today's halibut vessels ranges from 1 to 8 men, depending on the size of the vessel and type of gear used. Fishing crews on many of the larger vessels operate under closed-shop contracts between the various vessel owners associations and fishermen's unions on the Pacific Coast. These contracts specify the responsibilities of each party and establish the distribution of the gross proceeds from the trip between the vessel owner and the crew. Fishermen on smaller vessels usually do not belong to halibut unions.

Compensation is on a share basis and varies greatly among vessels. Typically, on larger vessels about one-fourth of the gross proceeds from the sale of the catch is the "boat share" which goes to the owner of the vessel. Lost gear, insurance, and other items also are deducted from the gross. From the remainder, the trip expenses (such as food, bait, fuel, and worn gear) are deducted. The net balance, or "crew share", is divided equally among all members, including the captain. If the captain is not the vessel owner, he usually receives an additional one-tenth of the boat share. Apprentice fishermen, or "in-breakers", are paid a part share until they can earn a full share. On most vessels, the cook also works on deck except when meals are being prepared.

Halibut fishermen work hard, often for 18 to 20 hours each day. In recent years when fishing periods have been short (1 or 2 days), fishermen work the entire fishing period without sleep. During bad weather, fishing stops only when handling the gear

becomes dangerous or the captain can no longer keep the vessel "on the gear". Prior to the 1980's when the commercial fleet was smaller, the larger vessels usually completed their trips in less than 15 days, but trips of 20 days or more were not uncommon during the 1970's.

At the beginning of each trip, the vessel takes on several tons of crushed ice so that the catch can be chilled near, but usually not below, the freezing point. Halibut are dressed by removing the viscera and gills soon after they are brought aboard. The body cavity, or "poke", is scraped, washed, and filled with ice. The head is not removed until the catch is delivered at dockside. The fish are stored in the hold in layers separated with crushed ice. Many vessels now have refrigeration that reduces the amount of ice needed and maintains a lower and more uniform temperature in the hold. Some vessels have experimented with keeping fish in the hold in refrigerated sea water or an ice/sea water mixture. This type of system saves time and may be more efficient during short seasons, but requires proper refrigeration and circulation to insure that the fish do not spoil.

Fishing Grounds

Most fishing occurs in specific areas or grounds where halibut tend to concentrate because of favorable conditions such as abundant food supply or preferred bottom type. These fishing grounds are located throughout the entire range of the species from northern California to the central Bering Sea (Figure 2). The relative importance of particular regions along the coast is evident in Figure 11 which shows the average catch by decades.

In general, halibut are found at depths less than 900 feet during the summer and greater than 900 feet in the winter. The fish move into the shallower waters in the late

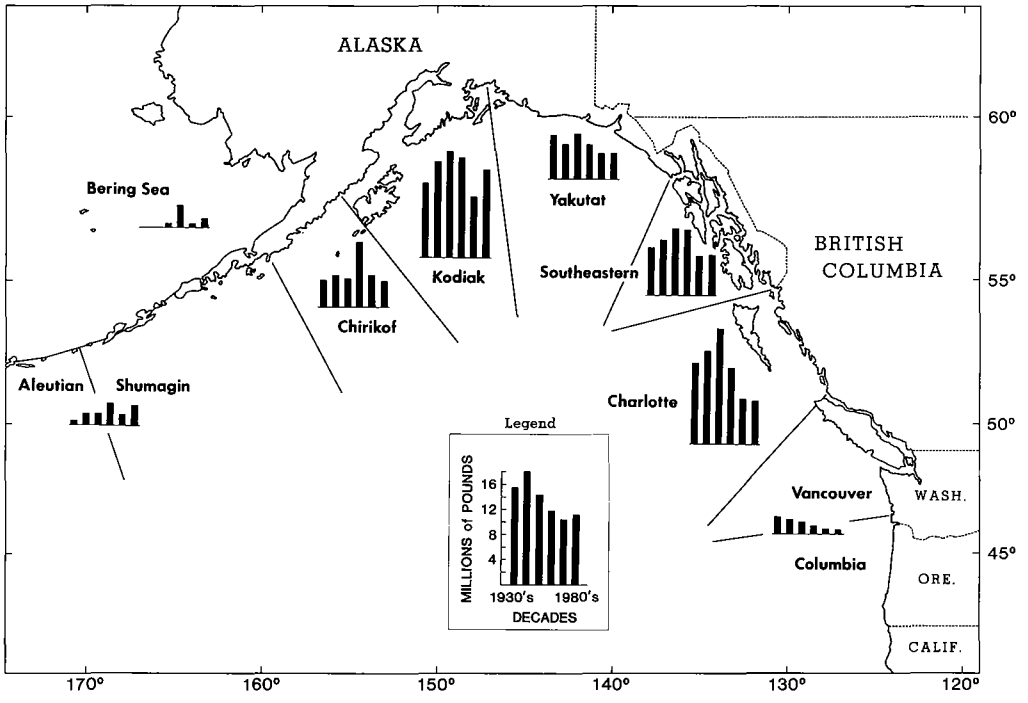


Figure 11. Distribution of the catch by coastal regions by decades from the 1930's to 1980's.

spring as the water temperatures begin to rise. However, some halibut remain in the shallower waters year-round.

Successful fishing depends on an intimate knowledge of the distribution of the species and the technique of setting gear with bait that will attract the fish. Experienced fishermen often prefer to set their gear on hard bottom (rock or gravel). Electronic depth sounders and navigation devices (loran, plotters) assist the captain in locating the fishing grounds. Some grounds cannot be fished when tidal currents are strong; others are difficult to fish because rock outcrops tend to snag the gear and chafe the groundline.

Fishing Gear

The gear, setting and hauling equipment, and deck arrangement for conventional longline gear are depicted in Figures 12 and 13 and are discussed in the following paragraphs. Another type of longline gear called "snap-on" is discussed later in this section. Halibut also are caught on salmon troll gear. Most of the troll catch is incidental to the salmon troll fishery, but trollers sometime seek halibut when salmon fishing is poor or if the price of halibut is relatively high. A few small boats still use handlines.

Traditionally, a unit of setline gear or "skate" consists of groundline, gangions, and hooks. In the early years, a number of lines, each 300 feet in length, were spliced end to end to form the groundline. The number of lines varied considerably, but the 6-line skate (1,800 feet) eventually was adopted by most of the fishermen. Now, groundline is sold in 1,800-foot coils. Loops of light twine (beckets) are attached at regular intervals to the groundline. Short branch lines (gangions) 4 to 5 feet long are attached to the beckets and a hook is attached to the end of each gangion. Years ago, hooks were bound or "ganged" to the end of the gangion with linen thread treated with pine-tar; now, eyed-hooks are attached to a loop in the gangion. The interval between hooks or "rig" of the gear has varied from 9 feet to as much as 42 feet. The most common rigs have been 9, 13, 18, 21, 24, and 26 feet, as these intervals facilitate baiting the hooks and coiling the lines. Today, most of the gear is rigged at 18, 21, and 26 feet. The lines of conventional setline gear originally were made of natural fibers such as hemp, cotton, manila, or sisal, depending on their availability, quality, and cost. These natural fibers now have largely been replaced with man-made materials, mainly nylon.

Halibut fishermen have recently converted to circle-shaped hooks from the traditional J-shaped hooks (Figure 14). The conversion began in the early 1980's, but became wide-spread in 1983. IPHC conducted studies during 1983 and 1984 to provide information on the relative efficiency of circle hooks. The results clearly indicated that circle hooks caught approximately two times more fish than the traditional J-hooks. The reason for the greater efficiency of circle hooks is not fully understood, but appears to be related to both better hooking qualities as well as to lower escape rates once the fish are on the hooks.

The traditional gear usually is tied together and set in strings of 4 to 12 skates each. The number of skates per string depends on factors such as the size of the fishing ground and the likelihood of snagging on the bottom. Each end of the string is attached to an anchor and buoy line and marked at the surface with a buoy, flagpole, and flag. When fishing at night or in heavy fog, lights or radar reflectors are used on each flagpole to aid in locating the gear.

Most of the fishing is conducted in depths between 90 and 900 feet. The skates with baited hooks are set over a chute at the stern of the vessel. Depending upon the grounds,

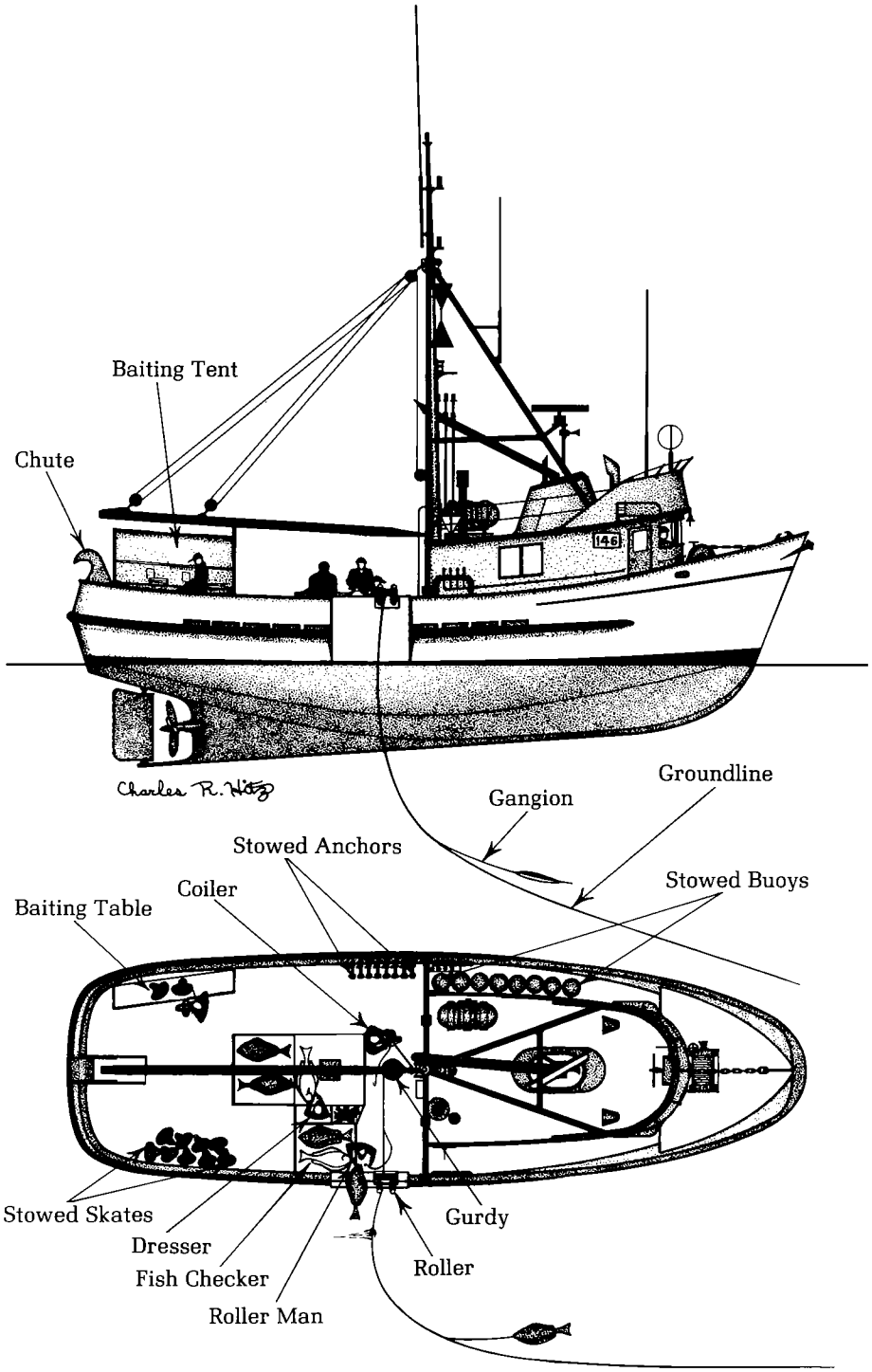


Figure 12. Deck layout and fishing arrangement. (Drawings by Charles R. Hitz)

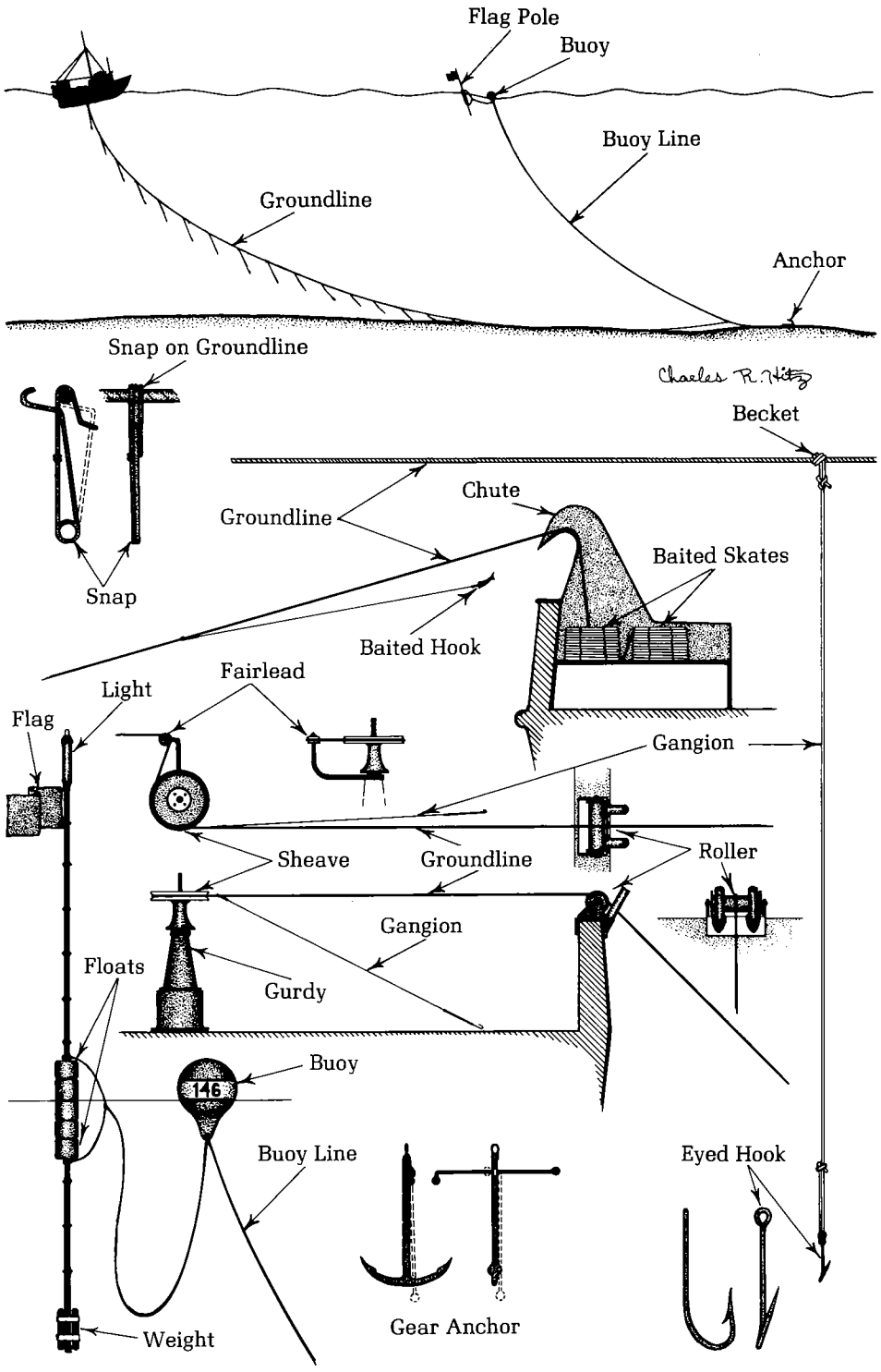


Figure 13. Halibut fishing gear and deck equipment. (Drawings by Charles R. Hitz)

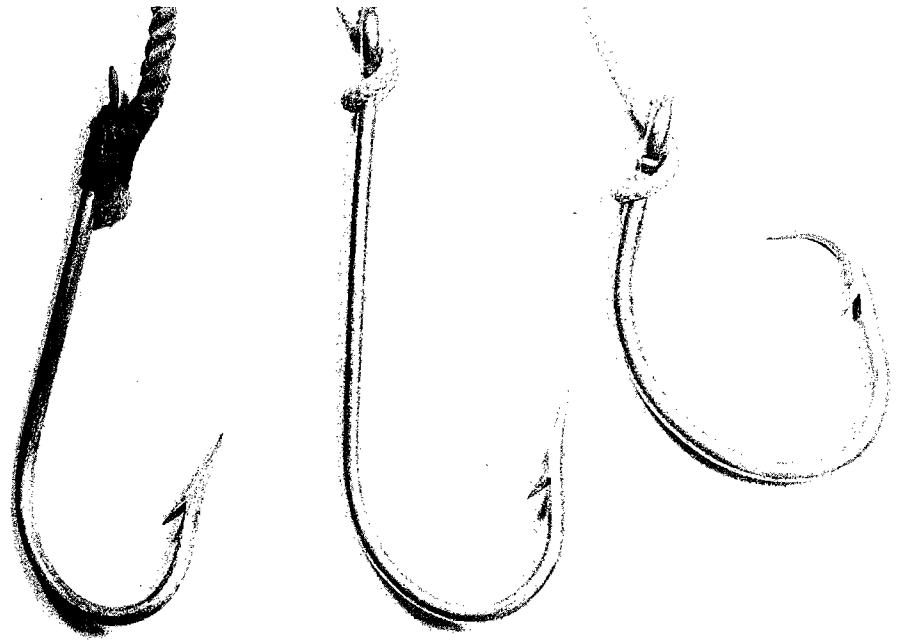


Figure 14. Hooks used over the years by the halibut fishery. Left, the flattened off-set hook, common in the fishery for over 60 years. Much of the fishermen's time running to the grounds was spent seizing the hooks to the gangions with ganging twine. The eyed off-set hook (center) replaced the ganged hook in the late 1960's. On the right, the modern circle hook, introduced in 1982-83.

time of year, and bait used, most of the gear is left in the water, or is "soaked", for 4 to 48 hours, but the average soak for each skate is about 12 hours. Long soaks require durable bait and cannot be made when other organisms are likely to eat the bait or the halibut caught on the gear. The gear is hauled on a power-driven wheel, the gurdy, controlled by a fisherman who lands the fish, clears snarled lines, and stops the gurdy if the gear is snagged or if other problems occur (Figure 15). On traditional longline gear, another man coils the line after it passes the gurdy. The gear is then inspected for necessary repairs, baited, and recoiled in preparation for the next set. Baits used in the halibut fishery are either fresh or frozen and include herring, octopus, salmon, and "shack" or "gurdy" bait such as Pacific cod, sablefish, or other species caught incidentally on the halibut gear.

Snap-on gear was introduced into the halibut fishery about 30 years ago; it differs from traditional setline gear in that the branch lines (gangions) are attached to the groundline with metal snaps rather than being tied to the groundline with twine. Further, the groundline used for snap-on gear is one continuous line that is simply stored on a drum after the gangions are removed, instead of being coiled. The method of attaching the hooks to the gangions is the same for snap-on and traditional gear. When snap-on gear is set, the hooks are baited and the gangions are attached to the groundline as it unwinds from the drum. Hook intervals can be changed with each set. When the gear is retrieved, the hooks are unsnapped and stored on racks and the groundline is rewound on the drum. The snap-on gear is most prevalent on small boats.

For small boats with only two or three fishermen, snap-on gear has several advantages over traditional gear. First, storing the groundline on a drum eliminates the

Figure 15. Hauling gear with power gurdy (left) and coiling a skate (right).

need for a man to coil gear and reduces the amount of storage space required. The amount of gear set and the catch of snap-on vessels is generally much less than that of larger vessels using traditional gear, but two men usually can set and haul more snap-on gear than they could using the traditional coiled skates. Another advantage is that the hooks can be widely spaced when prospecting for fish and more closely spaced when a concentration of fish is located. For these reasons and the relatively low capital investment for small boats, hundreds of new fishermen have entered the halibut fishery in recent years. Snap-on gear is particularly attractive for boats that use a gillnet drum for salmon fishing because the gillnet can be readily replaced with halibut groundline when the vessel switches from salmon to halibut fishing.

Statistics of the Catch

The catch of halibut by Canadian and United States fishermen from 1930 to 1985 is shown in Figure 16. The total catch first peaked at 69 million pounds in 1915 and fell to 44 million pounds in 1931; thereafter, the catch generally increased and exceeded 70 million pounds in 1962 but fell below 25 million pounds in 1974-1979. Since then, catches have increased steadily and totalled 56 million pounds in 1985. (Detailed catch data by country, region, and by statistical and regulatory areas, from California to the Bering Sea, are available in the Commission's Technical Report 14 for 1929 through 1975 and in subsequent annual reports for later years.)

When the fishery first began, U.S. vessels fished extensively in waters off British Columbia, but this effort decreased, and, since 1979, U.S. vessels have been prohibited from fishing in Canadian waters under terms of the 1979 Protocol to the 1953 Halibut Treaty. Off Alaska, the situation is just the reverse. The Canadian catch was very low in

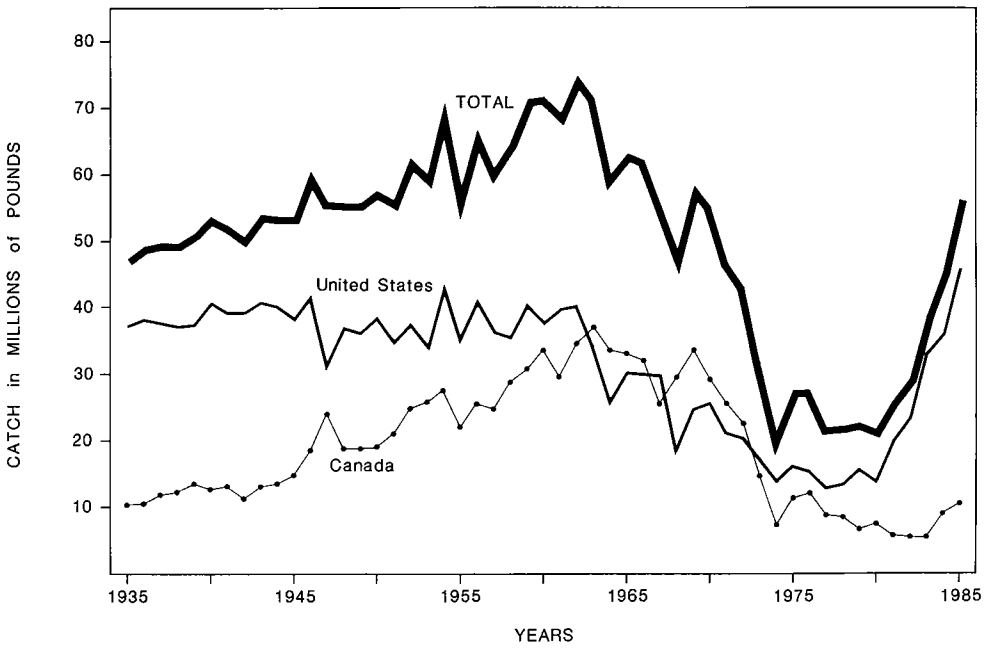


Figure 16. Total Canadian and United States catch of Pacific halibut, 1930-1985 (heads-off, eviscerated weight).

the early days of the fishery off Alaska and increased to 50 percent of the total from Alaska during the 1960's, but was only about 30 percent in the 1970's. Canadian fishing in U.S. waters has not been allowed since 1981, also under terms of the 1979 Protocol. Since 1926, nearly three billion pounds of halibut have been caught by the North American longline fleet; Canadian fishermen have taken 35 percent of this total and U.S. fishermen have taken 65 percent.

The two countries have a reciprocal landing agreement, permitting fishermen of one nation to land halibut at ports in the other country (see section on Halibut Conventions). In the early years of the fishery, United States fishermen landed over 20 million pounds of halibut in Canada, but they now land mostly in U.S. ports. Canadian landings in United States ports were less than 5 million pounds before 1958, averaged about 7 million pounds during the 1970's, and are now less than 3 million pounds annually.

The six major ports of landing in 1985 were Prince Rupert, B.C., Kodiak, Seward, Homer, and Sitka, Alaska, and Seattle, Washington. Prince Rupert long held the distinction of being the "Halibut Capital of the World", but has been replaced in recent years by Kodiak. Seward, Sitka, and Homer have also gained in importance in recent years, whereas ports such as Ketchikan have declined. In deciding where to sell fish, fishermen must balance the higher prices usually prevailing in more southern ports against the fuel costs in running to these ports. In recent years, buyers in northern ports have been offering more competitive prices and fewer vessels are running to southern ports. The relative importance of the ports is shown in Table 2 giving the percentage of the total landings at the major ports at 10-year intervals since 1935.

Table 2. Percentage of total landings by ports at 10-year intervals, 1935-1985.

Port of Landing	Year					
	1935	1945	1955	1965	1975	1985
	%	%	%	%	%	%
Kodiak	—	—	—	6.9	15.2	28.5
Prince Rupert	27.4	28.6	25.3	32.3	18.8	7.3
Seward	—	—	—	1.0	14.2	7.3
Sitka	1.6	5.2	1.7	1.7	2.2	7.3
Homer	—	0.2	—	0.1	1.5	6.4
Seattle	47.1	22.5	24.5	9.7	2.2	5.9
Vancouver	4.7	3.5	9.0	6.3	6.8	5.4
Petersburg	1.0	3.7	5.8	8.0	11.5	3.8
Bellingham	—	—	0.7	3.7	2.2	2.8
Pelican	—	3.5	4.4	2.4	5.9	1.8
Sand Point	—	—	3.4	4.9	1.0	1.6
Ketchikan	8.0	17.0	6.5	13.8	1.5	1.1
Wrangell	0.2	1.1	0.5	0.6	1.6	1.0
Juneau	3.0	3.7	4.5	2.9	3.2	0.9
Port Williams	—	3.5	3.0	2.0	1.0	—
Other	7.0	7.7	10.7	3.8	12.7	25.3
Total Catch (000's of pounds)	47,343	53,395	57,521	63,176	27,616	56,113

Value and Marketing

The Pacific halibut fishery is one of the more valuable fisheries in North America. The landed value of the catch usually is among the top five foodfish species. The average annual catch and value by 5-year periods are shown by country in Table 3. The value to the fishermen has increased overall since the 1930's, in spite of fluctuations in price and total catch. Ex-vessel value reached an all-time high of $49.9 million in 1985. Prices paid to the fishermen vary according to market conditions. Before 1940, the average annual price per pound usually was less than $.10. During the 1940's and 1950's, the price varied from $.10 to $.23 per pound and was $.16 to $.35 during the 1960's. The greatest change occurred during the 1970's when the price increased from $.58 in 1972 to $2.13 in 1979. During the 1980-1985 period, the average price ranged from $.89 to $1.13 per pound. The average retail price is two to three times greater than the landed price.

The system of distributing halibut to the consumer has changed. In the early years, most of the fish were shipped in ice and sold fresh, but today, a higher proportion of the catch is landed at Alaskan ports, and over 90 percent of the catch is frozen. Before freezing, the head is removed (Figure 17) and, after the initial freezing, the fish is dipped into water several times to "glaze" or coat the body to prevent dehydration in storage.

In the past, most vessels sold their halibut catch to the highest bidder at public auctions called the Fish Exchange. Now, vessels usually sell directly to the processors, frequently after calling buyers by radio-telephone from the fishing grounds to obtain the best possible price. After the sale, the halibut are unloaded from the vessel, beheaded, and graded into trade categories according to weight (Figure 18). Halibut up

Table 3. Average annual halibut catch (heads off, eviscerated) and landed value by 5-year periods.

Years	Average Annual Catch (in thousands of pounds)			Average Annual Value	
	Canada	United States	Total	Total	Price Per Pound
1930-1934	7,965	38,537	46,502	$ 3,097,000	$ .07
1935-1939	11,650	37,602	49,252	3,645,000	.07
1940-1944	12,608	40,019	52,627	7,161,000	.14
1945-1949	18,962	37,028	55,990	9,305,000	.17
1950-1954	23,565	37,627	61,192	11,099,000	.18
1955-1959	26,346	37,789	64,135	12,025,000	.19
1960-1964	33,645	35,707	69,352	15,435,000	.22
1965-1969	30,650	26,806	57,456	17,562,000	.31
1970-1974	19,789	19,706	39,505	19,723,000	.50
1975-1979	9,477	14,830	24,307	34,659,000	1.46
1980-1984	6,657	25,335	31,992	31,337,000	1.00
1985	10,389	45,724	56,113	49,884,000	.89

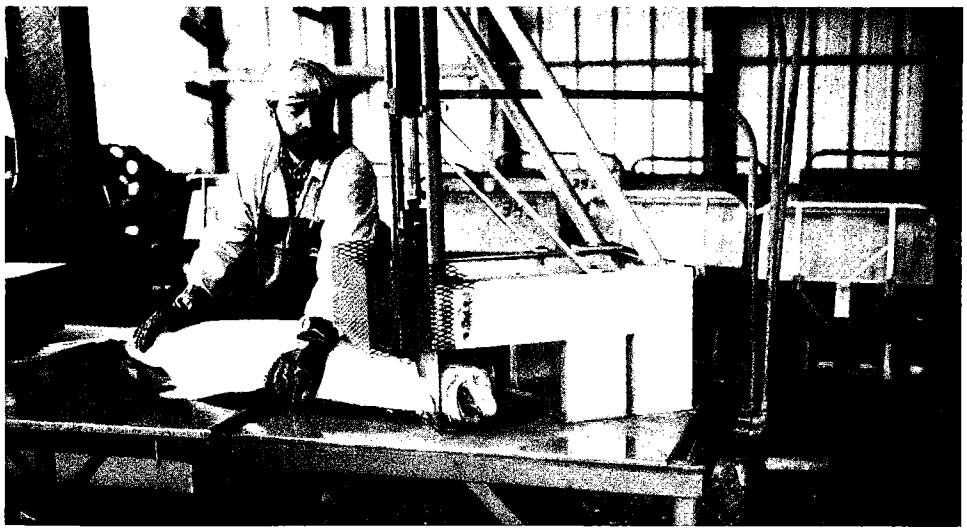


Figure 17. Beheading a halibut with a guillotine.

to 60 pounds are called "mediums" and those over 60 pounds are called "large". Formerly, there was a third grade, called "chickens", of fish from 5 to 10 pounds; but in 1973 the legal size limit was increased and few fish under 10 pounds are now landed.

Halibut is a versatile species for marketing and is sold as steaks, fillets, or roasts. Its preparation for the table is varied — poaching, frying, baking, steaming, barbecuing, etc. Recipes are available from federal agencies such as the Canadian Department of Fisheries and Oceans and the U.S. National Marine Fisheries Service. Industry

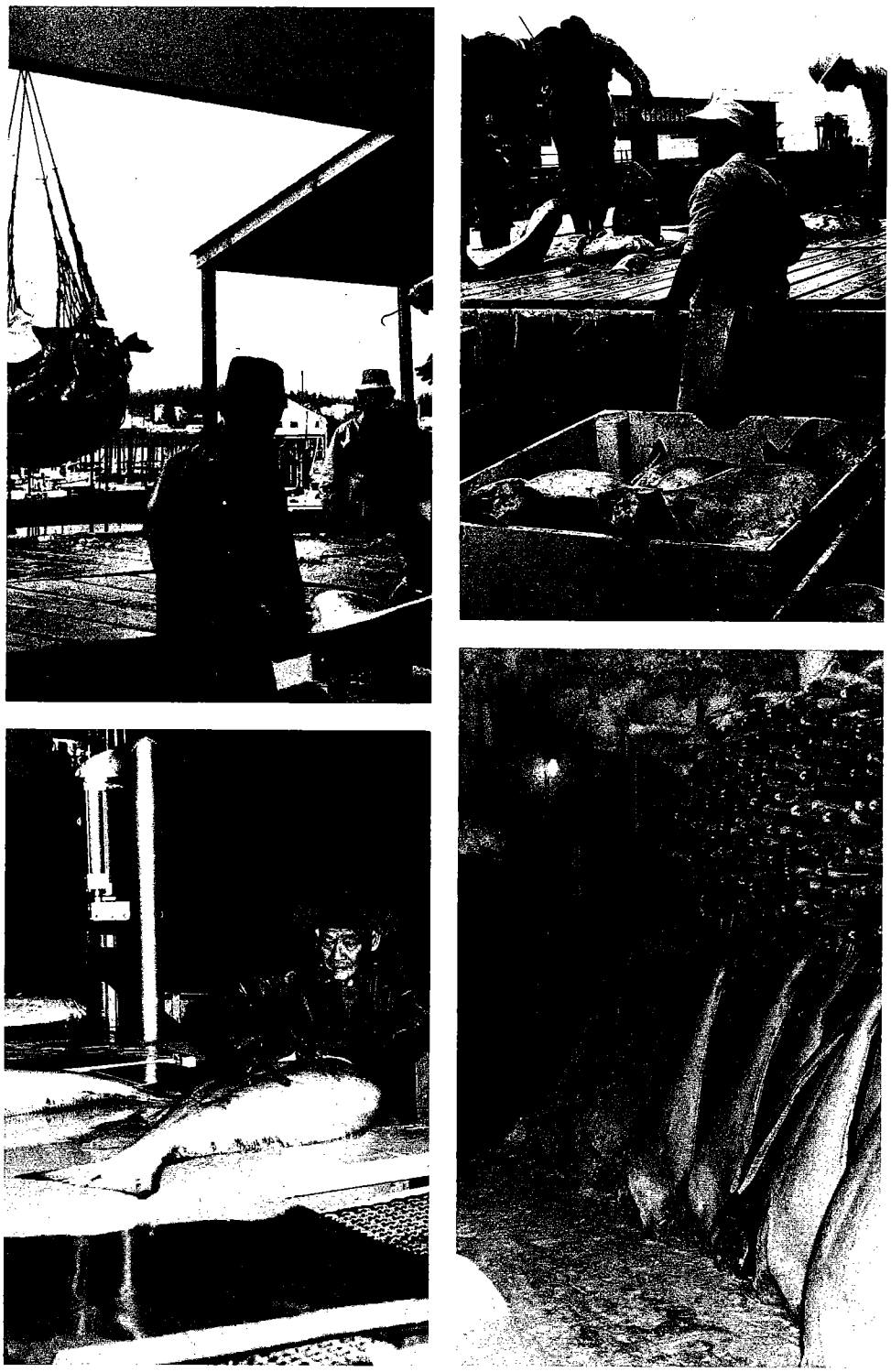


Figure 18. Unloading, sorting, beheading, and storage of halibut. (Photo credits Canadian Department of Fisheries and Oceans and U.S. National Marine Fisheries Service.)

organizations such as the Halibut Association of North America (HANA) also provide recipes and tips on preparation. A recipe we have not seen in publication that is popular among halibut gourmets is presented below:

PELICAN COLD STORAGE COMPANY'S
FAVORITE HALIBUT RECIPE
(Sour Cream Halibut Recipe)

1 cup white wine or sauterne	1 cup mayonnaise
1 teaspoon salt	1/2 cup sour cream
1 pound halibut fillet	1/4 cup chopped onion
Fine bread crumbs	Paprika

Mix wine and salt and marinate halibut for at least 1 hour (best if marinated most of the day). Drain fish on paper towel, dip both sides in bread crumbs, place in greased baking dish. Mix together mayonnaise, sour cream, and onions, spread over fish and sprinkle top with remaining bread crumbs and paprika. Bake at 500 degrees for approximately 20 minutes or until fish flakes with a fork.

THE SPORT FISHERY

Before 1973, all fishing for halibut, including recreational and personal-use fishing, was governed by the commercial fishing regulations. Catching halibut during the closed commercial season was illegal, but sport-caught halibut frequently were taken out of season. Because the sport catch was not large and because the number of fish taken illegally by sportsmen was small compared with the commercial catch, IPHC concluded that the problem was not a serious concern in the management of the fishery.

As the sport catch increased, federal and state agencies urged IPHC to officially recognize the sport fishery. Legal interpretations by the two federal governments indicated that the Halibut Convention provided the authority to regulate the sport fishery. After consultation with the Canadian Department of Fisheries and Oceans, the U.S. National Marine Fisheries Service, and the appropriate state agencies in Alaska, California, Oregon, and Washington, the Commission adopted sport regulations in 1973.

Sport fishing seasons vary in different regions. In 1987 sport fishing was permitted from February 1 to September 30 in California, Oregon, and Washington. In Alaska and British Columbia sport fishing was permitted from February 1 to December 31. Traditionally, there has been no minimum size limit on sport-caught halibut, but in 1987 a 30-inch minimum size limit was placed on halibut caught by sports fishermen in California, Oregon, and Washington to prevent overfishing and help rebuild stocks in Area 2A. Studies on the impact of placing a size limit on sport-caught halibut in Alaska and British Columbia are currently underway. The regulations set a two-fish bag and possession limit.

Taking of halibut by sport fishermen was usually incidental to saltwater fishing for salmon. As recreational opportunities for salmon diminished between 1976-1985, the popularity for bottomfish surged. Directed sportfishing for halibut now occurs from Oregon to Alaska and the recreational harvest has increased from 176,000 pounds in 1976 to over 3.3 million pounds in 1985. The large size of halibut makes it a prestige or trophy fish. A 450 pound halibut caught on a rod and reel in 1984 holds the Alaska state record. The record in the state of Washington is 240 pounds and was also caught in 1984. Several large fish were caught on the sport fishing trip depicted in Figure 19.

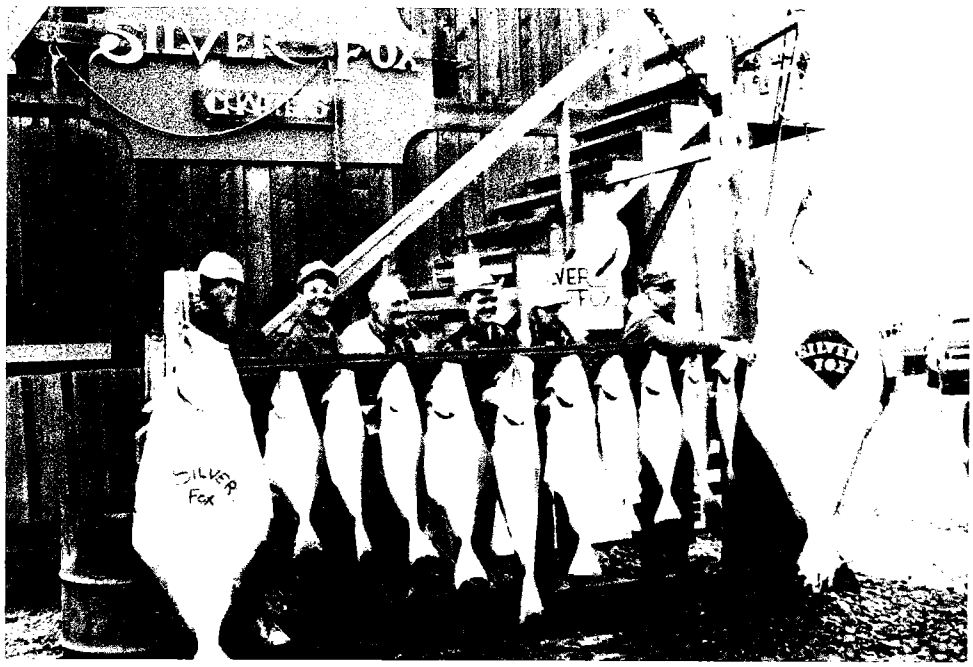


Figure 19. The results of a successful sport fishing trip for halibut out of Homer, Alaska.

Sportsmen have individual preferences for their halibut gear. Lines usually test from 40 to 80 pounds and circle or treble hooks, either 6/0 or 8/0 are used. Light or poorly-made hooks can be straightened out or bent by large halibut. A 10- to 32-ounce sinker is used with baited hooks and spreader bars when fishing with rod and reel, whereas metal lures weighing from 17 to 28 ounces are used with jigs. Rods generally are heavy and stiff to handle the heavy sinkers and the potentially large halibut. Reels should have a high gear ratio to reduce the effort in retrieving the gear from depths as great as 300 feet. Jigging gear is used extensively in British Columbia and Alaska.

All sportsmen should be aware of the dangers in handling a large halibut in a small boat. Halibut are powerful and have been known to smash objects with their tails. The tragic story related below is from the *Alaska Empire*, Juneau, Alaska in August 1973:

"FISHERMAN KILLED BY HALIBUT"

"A man killed by halibut!

Alaska State Troopers investigated one of the most unusual deaths to occur in Alaska this year.

The body of Joseph T. Cash, 67, of Petersburg was found lashed to the winch of his troller after a 150 pound halibut had apparently broken his leg and severed an artery when he hoisted it aboard his boat while fishing alone in the vicinity of Eagle Point on Kupreanof Island.

Cash's customary way of landing a large halibut was . . . to gaff the fish with a shark hook attached to a ten foot length of half inch thick rope.

From evidence gathered at the scene, Cash . . . hauled it aboard (and) it apparently flopped and in so doing crippled the elderly man.

When falling to the deck, Cash cracked three ribs on his left side. Based on information obtained from friends, Cash had a horror of being injured or killed and being washed overboard to become "crab bait". Consequently, he crawled to the winch and tied himself to it.

After his death the trolling boat washed ashore and was found partially sunk by men on another fishing boat. Crewmen of the boat found the old fisherman as indomitable in death as he was in life. His head and chest were still above water with the gaffed halibut at his feet."

INCIDENTAL CATCH

Pacific halibut are inadvertently captured by other gear types in fisheries targeting on other species. These include the foreign trawl and setline fisheries, the joint venture fisheries, and the domestic crab pot, trawl, and setline fisheries. The precise amount of halibut incidentally caught by these fisheries is unknown, but can be estimated from observations made at sea during the various fishing operations. The most complete set of data has been collected from the foreign and joint venture fisheries operating off the U.S. coast, where an observer program is conducted under the auspices of the U.S. National Marine Fisheries Service. Observers monitor and sample the groundfish catch as well as incidentally-caught species such as halibut, salmon, and king and Tanner crab. Observer data from the other fisheries are extremely limited, so data from research surveys are usually used to provide estimates of incidental catch. These estimates are considered less reliable than those from the foreign fisheries and are used mainly as an indication of the relative magnitude of the incidental catch.

Historically, incidental catches of halibut were relatively small until the early 1960's, when they increased rapidly due to the sudden influx of foreign fishing vessels targeting on groundfish (Figure 20). The total incidental catch peaked in 1965 at about 28 million pounds. Catches fluctuated slightly below that level throughout the late 1960's and early 1970's, and then dropped to a 15 million pound level during the late 1970's and early 1980's. By 1985, incidental catches had dropped to the lowest level in many years, totalling slightly less than 10 million pounds.

Not all halibut that are incidentally captured die from the injuries received, so incidental mortality is less than the incidental catch. Past studies conducted by IPHC indicate that 25 percent of the fish caught on setlines die. Mortality of halibut caught in

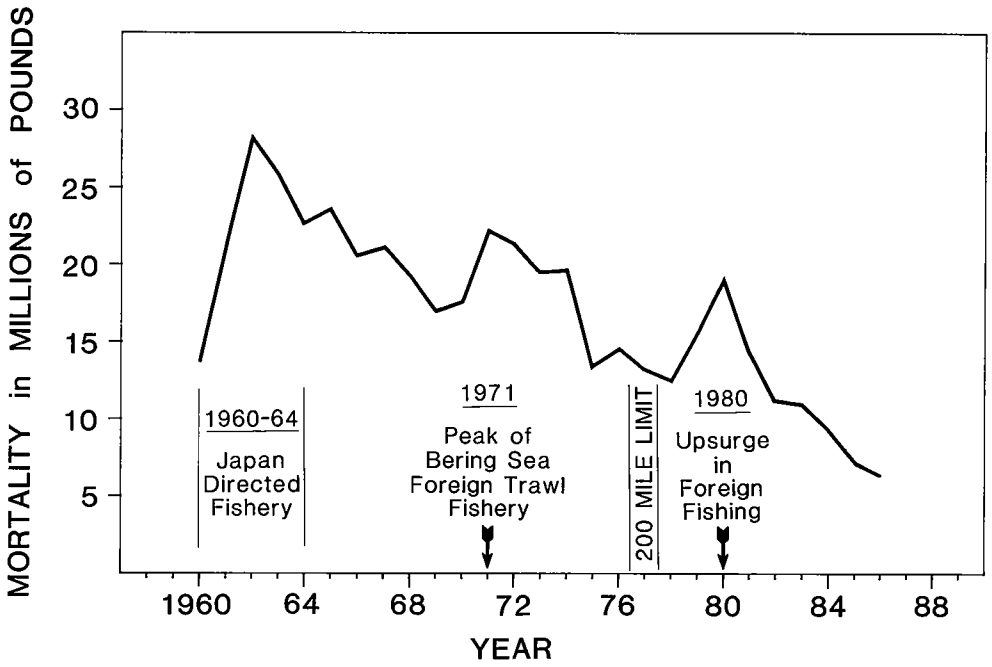


Figure 20. Historical trend in incidental mortality of Pacific halibut.

trawls is dependent upon the length of tow and the speed at which the catch is sorted. For trawl operations making short tows and with rapid sorting, mortality is estimated at 50 percent. When cod-end transfers, tows of several hours in length, or slow sorting of the catch is involved, halibut mortality is estimated at 100 percent. The former case is typical in U.S. and Canadian groundfish trawl fisheries, whereas the latter situation occurs primarily during shrimp trawling and in joint venture fisheries. Mortality of halibut caught in large pots used in the king and Tanner crab fisheries is estimated at 100 percent. More recent studies have indicated that mortality may not be as high in some fisheries as previously believed. However, in order not to underestimate the potential loss, the former assumptions about mortality are used. The total incidental mortality dropped below 10 million pounds in 1984 for the first time in many years and declined in 1985 to 8.7 million pounds.

Regulating the incidental catch of halibut in foreign, joint venture, and domestic fisheries off Alaska is the responsibility of the U.S. North Pacific Fishery Management Council (NPFMC). Over the years, the NPFMC has used various combinations of time and area closures, incidental catch ceilings, incidence rate limits, and gear restrictions to restrict the incidental catch of halibut. IPHC is working closely with the NPFMC to develop a comprehensive management plan for the incidental catch of halibut.

Conventions and Treaties

The International Pacific Halibut Commission, originally called the International Fisheries Commission, was established in 1923 by a Convention between Canada and the United States. The abundance of halibut had been declining and industry representatives had requested international control. The Convention was the first international agreement for joint management of a marine fishery and has been revised several times to extend the Commission's authority and to meet new conditions in the fishery.

This section presents a brief review of the several revisions of the Halibut Convention (Treaty) and other treaties relating to halibut.

THE HALIBUT CONVENTION OF 1923

Efforts to consummate a treaty in 1919 were unsuccessful, but the halibut industry persisted in advocating international control. In 1922, another convention was drafted that excluded the sensitive provisions of port-use and tariffs, and Canada and the United States signed the Convention for the Preservation of the Halibut Fishery of the Northern Pacific Ocean on March 2, 1923. In the past, Canada and Great Britain both signed treaties that involved Canada, but Canada contended that it alone should sign the Halibut Convention since it dealt with domestic matters. Great Britain preferred to retain this right but finally agreed that the Dominion of Canada could sign on behalf of His Majesty. This symbolic act was a first for Canada as a member of the British Commonwealth and for other Commonwealth nations of the British Empire.

The Convention went into effect on exchange of ratifications on October 23, 1924. It provided for a 3-month closed season during the winter and for regulations concerning halibut caught incidentally during the closed season. The Convention also created an International Fisheries Commission of four members. Each country was to pay the expenses of its two Commissioners, but expenses of the Commission and its staff were to be shared equally by the contracting parties. The Commission was charged with studying the life history of halibut and with recommending regulations for the preservation and development of the fishery.

THE HALIBUT CONVENTION OF 1930

In 1928, the Commission reported that the closed season alone could not protect the resource and requested authority to institute other conservation measures. A new Convention was signed in 1930 and ratified on May 9, 1931. The 1930 Convention empowered the Commission to establish regulatory areas, to limit the halibut catch from each area, to regulate the licensing and departure of vessels for halibut fishing, to collect statistics, to regulate the type of gear, and to prohibit fishing on nursery grounds wehre young fish are concentrated. Annual regulations were subject to the approval of the Governor General of Canada and the President of the United States. Enforcement of regulations was the responsibility of the individual governments. To provide an industry forum for the discussion of regulatory proposals, the Commission established a Conference Board of fishermen and vessel owners on May 27, 1931.

THE HALIBUT CONVENTION OF 1937

As the catch increased, more vessels entered the fishery and the catch limits were taken more rapidly. The 1937 Convention permitted more effective control of vessels catching halibut incidentally while fishing for other species during the closed season. The United States Act (implementing the 1937 Convention stated that it was unlawful "... to bring to any place within the jurisdiction of the United States any halibut caught in Convention waters by the use of any vessel of a nation not a party to the Convention ...", but this stipulation has not been applied.

THE HALIBUT CONVENTION OF 1953

The trend toward shorter fishing seasons continued and, by the end of World War II, fishing was concentrated on certain segments of the stock. Treaty changes were recommended by IPHC in 1946 to permit multiple seasons within a fishing area, but the new Convention was not signed until March 2, 1953, on the 30th anniversary of the signing of the first Halibut Convention. On exchange of ratifications, the new Convention became effective on October 28, 1953.

The 1953 Convention contained several important changes. Multiple seasons were permitted to distribute fishing effort in accordance with seasonal availability of different stocks, the number of Commissioners was increased from four to six, three from each country, and the International Fisheries Commission was renamed the International Pacific Halibut Commission. In addition, the Commission was charged with developing and maintaining halibut stocks at a level which would permit the maximum sustainable yield. This directive was implied in earlier conventions but had not been explicitly stated.

In 1969, to expedite the approval of regulations in the United States, the Presidential authority was delegated to the Secretary of State who was to consult with the Secretary of the Interior (now the Secretary of Commerce).

THE 1979 PROTOCOL TO THE HALIBUT CONVENTION OF 1953

The U.S. Magnuson Fisheries Conservation and Management Act (MFCMA) of 1976 required renegotiation of all international fisheries treaties. As a result, Canada and the United States negotiated an amendment to the 1953 Halibut Convention during 1978 and early 1979. The amendment, termed a "protocol", was signed by both countries on March 29, 1979. The Commission's mandate was altered somewhat from managing on the basis of maximum sustained yield to that of optimum yield. The Protocol called for a two-year phase-out of reciprocal fishing privileges between the two countries and also required that 60 percent of the catch in Area 2 be taken in Canadian waters (Area 2B) and 40 percent in U.S. waters until 1981.

The amendment further stated that

> "By January 1, 1981, and thereafter as it considers appropriate, the Commission shall, on the basis of a review of pertinent information, recommend for the approval of the Parties any appropriate changes in the division of the annual total allowable catch set forth in paragraph 3 of this Annex. No such changes may take effect before April 1, 1981."

The required 60/40 division of the Area 2 catch had as its basis the average long term productivity of the stocks in the two areas. However, a fixed harvest ratio between areas presented management problems. Since the signing of the amendment in 1979, the distribution of the stocks in Area 2 has departed from the long term average. Southeast Alaska stocks have become disproportionately more abundant than those in British Columbia. In 1985, the Commission recommended to the governments of both countries a departure from the 60/40 requirement and adopted a harvest strategy which takes a constant proportion of the exploitable biomass in each region. The following resolution was adopted:

"WHEREAS, the Commission acknowledges the historic spirit and intent of the Protocol, specifically as it related to the 60/40 division of the catch in area 2; and

WHEREAS, the Commission is desirous of optimizing production from all parts of Area 2 based upon careful consideration of scientific data provided by Commission staff and other sources; and

WHEREAS, the Commission is informed by the Commission staff that the current distribution of stocks represents a departure from the long-term condition in this area;

Based on these unusual conditions, the Commission recommends that a departure from the 60/40 catch division is appropriate in 1985. In future years, departures from the 60/40 catch division will be considered based on stock conditions at that time."

By adopting this strategy, the catch will be optimized and the ratio will return to 60/40 when the Area 2 stock distribution returns to its long term average condition.

NORTHERN PACIFIC HALIBUT ACT OF 1982

In the spring of 1982, the United States passed the necessary legislation to give effect to the 1979 protocol and to repeal the previous enabling legislation; the amended Northern Pacific Halibut Act of 1937. The Act provided for representation on the Commission, for funding and enforcement and discussed the role of the regional fishery management councils. The councils were granted the authority to develop limited access regulations. The Act also stated, "That the Regional Management Council may provide for the rural coastal villages of Alaska the opportunity to establish a commercial halibut fishery in areas of the Bering Sea to the north of 56 degrees north latitude during a three-year development period." As of 1987, no effort limitation scheme has been adopted by the U.S. government.

RECIPROCAL PORT PRIVILEGES

In 1897, Canada granted special port privileges to a United States firm, the New England Fish Company, that had established an office in Vancouver, British Columbia. Vessels owned by the company were permitted to land halibut and take on supplies in Vancouver. These privileges were renewed in subsequent years and in 1915 were extended to all United States flag vessels and included the port of Prince Rupert. This unilateral action was renewed each year by an Order-in-Council in Canada. In

1918, the United States reciprocated and permitted Canadian vessels to land and outfit in the United States.

In 1950, Canada and the United States signed a Convention for the Extension of Port Privileges to Halibut Fishing Vessels on the Pacific Coasts of the United States of America and Canada. The express purpose of this Convention was "to further the well-being" of halibut fishermen and to permit landings without payment of duty other than that required by the customs agency. Fishermen could trans-ship or sell their catch in bond for export and could obtain supplies, repairs, and equipment. The Convention specifies that vessels of one country landing in a port of the other country shall comply "with applicable customs, navigation, and fisheries laws" of the host country. The agreement includes sablefish as well as halibut.

INTERNATIONAL NORTH PACIFIC FISHERIES COMMISSION

An account of the several halibut conventions would not be complete without mention of the Convention by Canada, Japan, and the United States which established the International North Pacific Fisheries Commission (INPFC). This Convention, like that for the preservation of halibut, was to "ensure the maximum sustained productivity of the fishery resources of the North Pacific". The Convention was signed in 1952 and entered into force on June 12, 1953.

Included in the Annex of the Convention is the abstention provision under which member countries agreed to abstain from fishing specific stocks of fish. Japan agreed to abstain from fishing halibut along the coast of North America and the fishery east of 175 degrees W longitude remained under the jurisdiction of the Canadian and United States Halibut Commission. In 1962, INPFC decided that the halibut in the Bering Sea east of 175 degrees W longitude no longer qualified for abstention, thereby allowing Japan to begin a directed fishery for halibut in 1963. This change was an unpopular decision among North American halibut fishermen and was labeled "the Bering Sea halibut giveaway" by critics. After this decision, the condition of the halibut stocks in the eastern Bering Sea was reviewed and conservation measures were recommended annually by both IPHC and INPFC for adoption by the respective governments. Although Japan discontinued fishing after 1967, this procedure was followed until 1977 when Canada and the United States extended their fisheries jurisdiction, obviating the authority of INPFC relative to halibut.

Management of the Resource

Under the current Halibut Treaty, IPHC has jurisdiction over the Canadian and United States setline fishery for halibut and can prohibit retention of incidentally-caught halibut in other Canadian and U.S. fisheries, but has no jurisdiction over foreign or domestic fisheries to limit the incidental catch of halibut. Conservation measures to protect halibut in foreign fisheries were initially instituted through the International North Pacific Fisheries Commission and in bilateral arrangements with Japan and the U.S.S.R. prior to extended jurisdiction. Canada and the United States now have control of both foreign and domestic trawl fisheries within 200 miles of their respective coasts. In the United States, regional fishery management councils are responsible for management of these fisheries.

REGULATIONS AND ENFORCEMENT

Authority for the Commission to regulate the halibut fishery is incorporated in the Halibut Convention and the Enabling Acts passed by the two countries to carry out the terms of the Convention. The following text from the 1953 Convention described the various regulations the Commission can recommend:

"(a) divide the convention waters into areas;

(b) establish one or more open or closed seasons, as to each area;

(c) limit the size of the fish and the quantity of the catch to be taken from each area within any season during which fishing is allowed;

(d) during both open and closed seasons, permit, limit, regulate, or prohibit, the incidental catch of halibut that may be taken, retained, possessed, or landed from each area or portion of an area, by vessels fishing for other species of fish;

(e) prohibit departure of vessels from any port or place, or from any receiving vessel or station, to any area for halibut fishing, after any date when in the judgment of the International Pacific Halibut Commission the vessels which have departed for that area prior to that date or which are known to be fishing in that area shall suffice to catch the limit which shall have been set for that area under section (c) of this paragraph;

(f) fix the size and character of halibut fishing appliances to be used in any area;

(g) make such regulations for the licensing and departure of vessels and for the collection of statistics of the catch of halibut as it shall find necessary to determine the condition and trend of the halibut fishery and to carry out the other provisions of this Convention;

(h) close to all taking of halibut such portion or portions of an area or areas as the International Pacific Halibut Commission finds to be populated by small, immature halibut and designates as nursery grounds."

Each year, the Commission holds an annual meeting, usually in January, to determine the regulations that will prevail for halibut fishing during the year. At the annual meeting, the scientific staff reports on the condition of the halibut stocks and recommends regulations for the next halibut season. The Conference Board, whose members represent vessel owners and fishermen from the various halibut ports, presents its recommendations for regulations. At this time, the Commission also receives recommendations from other groups and individuals. Since 1974, all proposals are reviewed with an industry Advisory Group, whose members are selected by the Conference Board and the Halibut Association of North America (HANA). Regulations are adopted by the Commission in the presence of the Advisory Group and submitted to the two governments for approval. The first halibut fishery restriction was a three-month winter closure established by the 1923 Halibut Convention to protect spawning concentrations of halibut and began in the winter of 1923-1924. The first regulations enacted by the Halibut Commission went into effect in 1932. At that time, Commission research indicated that the halibut stocks were depleted by excessive fishing in earlier years, and the regulations were designed to reduce the intensity of fishing and to allow the stocks to rebuild (Commission Report 1). During the next 30 years, the halibut stock conditions improved as indicated by increasing abundance, larger average size, and older average age. As the stocks improved, the regulations permitted larger catch limits. By 1960, the Commission believed that the halibut stocks had reached their maximum sustained yield level. However, at about the same time, domestic and foreign trawl fisheries expanded on the halibut grounds, and large numbers of halibut were taken as incidental catch by these fisheries. Most of the halibut taken by these trawlers were smaller and younger than those taken by the commercial halibut fishery. Information on the magnitude of the incidental catch was unavailable so IPHC was not able to account for the full impact of the incidental catch on the halibut resource. By the late 1960's, the halibut stocks showed clear signs of declining abundance and more restrictive regulations were adopted for the halibut fishery. Furthermore, alarm over the magnitude of the incidental halibut catch prompted the Commission to urge the governments of Canada and the United States to reduce the foreign incidental catch because the Commission lacked authority to impose regulations on the other fisheries. The first regulation imposed to reduce the incidental catch was a time-area closure during January-March 1974 in the southeastern Bering Sea. In subsequent years, this closure was expanded in time and space and additional closures were adopted in the Gulf of Alaska. At the same time, estimates of the source and magnitude of the incidental catch were improving. In the United States, passage of the MFCMA of 1976 established fishery management councils for the purpose of regulating fisheries other than halibut and established the U.S. conservation zone. At the same time, Canada extended its conservation zone and assumed authority for management of fisheries other than halibut therein. Ongoing research has indicated that, while foreign trawlers are still the major source of the incidental catch of halibut, the domestic trawl, crab, and shrimp fisheries are also significant contributors. The Commission has repeatedly advised the governments and other fishery management agencies of the significance and impact of the incidental halibut catch and has worked cooperatively with governments and agencies to reduce waste of the valuable halibut resource.

During the late 1960's and the 1970's, the Commission adopted regulations that severely limited the catch of halibut by the commercial fishery. The Commission's objective was to set annual catch limits below the estimated surplus production to allow stocks to rebuild. The minimum size limit was also increased in 1973 to reduce

the mortality of young fish and make better use of their high growth potential. In recent years, the stocks have responded to these regulations, and stock abundance is now back to historical peak levels in most areas.

The Halibut Commission has no enforcement authority. This authority is vested in the Treaty to enforcement branches of the two federal governments. In the United States, when the states adopt the Commission regulations as part of their state codes, they can enforce the regulations and try violators in state courts. When questions arise as to the legality or enforceability of tentative regulations, the Commission consults with legal or enforcement authorities of the federal fishery agencies before making a decision and enforcement personnel usually attend IPHC's annual meeting to advise the Commission on these matters.

In Canada, most the enforcement is executed by Fishery Officers of the Department of Fisheries and Oceans. Customs officials also participate in enforcement, but are mainly concerned with the issuance of licenses. The enabling legislation also specifies that "Protection Officers" include members of the Royal Canadian Mounted Police and commissioned officers of the Royal Canadian Navy, but neither of these groups have an active enforcement role at the present time.

The U.S. enabling legislation specifies that enforcement shall be conducted by the Coast Guard, Customs Service, and the Bureau of Fisheries (now the National Marine Fisheries Service [NMFS]). The role of the Coast Guard, for the most part, has been limited to providing aircraft or vessels for surveillance by fisheries personnel, but more active participation has resulted with the passage of the MFCMA of 1976. Customs officers have mainly been concerned with licensing requirements. Most of the enforcement in the United States is conducted by NMFS. State agencies, particularly in Alaska, also participate in the enforcement of the fishery.

The penalties for violations of the regulations are specified in each country's enabling legislation. The penalties differ in several respects, but the fines are similar and the vessels, cargo, gear, and fishing license can be seized and forfeited for major or successive offenses.

EFFECTIVENESS OF MANAGEMENT

IPHC's management goal is to maintain the halibut population at levels which produce the optimum yield. The Commission also strives to maintain high, stable yields with a low risk of stock collapse. IPHC uses information from several sources to determine the condition of the resource. Statistics on the catch, effort, and age composition in the fishery as well as the results from tagging programs and research surveys are analyzed to provide estimates of vital parameters such as stock size, mortality rates, growth, production of young, and potential yields. IPHC also studies the life history of the species, the seasonal distribution of the fish, age of entry into the fishery, and the effect of other fisheries on the resource. The influence of environmental factors also is considered in evaluating changes in stock abundance. The data base probably is more extensive than for any other North American fishery and is indispensable for assessing stock condition.

In the early management of the fishery, regulations were based primarily on an empirical approach which related levels of catch to catch per unit of effort (CPUE) in the fishery. If CPUE increased, this was interpreted as an increase in stock size and the catch was allowed to increase. Changes in the age composition of the catch also were examined. If there was a balance between old and young halibut in the catch, stocks

were concluded to be in satisfactory condition. IPHC still relies heavily on changes in CPUE and age composition to manage the fishery but, since the 1950's also has used theoretical models and analyses to estimate parameters such as mortality rates and to determine harvesting levels. The results from these models, coupled with trends in the fishery and data from research surveys, provide for a better understanding of the factors affecing stock abundance and, in turn, improve the management of the resource.

IPHC regulations require that each vessel keep a log of each day's fishing operation giving the location, the amount of gear fished, the estimated catch of halibut, and the depth fished. Information on the amount of gear lost while fishing also is requested. These records are copied by employees of the Halibut Commission at the landing ports. The information from individuals is held confidential and is analyzed collectively to assess stock condition and to make management decisions. Data from the logs are used to calculate CPUE, a measure of the relative abundance of halibut on the grounds. Factors such as length of groundline and number of hooks used also affect the CPUE and are accounted for in analysis of the data.

All phases of the life history of the halibut have been studied: spawning, recruitment, growth, fishing and natural mortalities, parent-progeny relationships, and the identification of stocks. Several investigations initiated by the Commission have become standards for fishery research which not only set a pattern for subsequent biological studies but fathered oceanographic studies in the North Pacific. These early studies indicated that the halibut stocks had declined as a result of fishing and established the basis for IPHC's management program. Under the 1930 Convention, the Commission was granted the authority to regulate the time and area of fishing and to restrict gear, catch, and fish size. These measures, coupled with effective enforcement by the two member countries and with the cooperation of fishermen, gave IPHC the control necessary to manage the resource.

Based on tagging experiments and other biological studies, the Commission concluded that regulatory areas were required so fishing could be adjusted to obtain optimum harvest rates on individual stock components. Boundaries for these areas were defined and have been maintained with periodic adjustments since the 1930's. The major regulatory areas are depicted in Figure 21. Specific seasons and catch limits are assigned for each regulatory area in accordance with the assessment of stock abundance, but this does not imply that the stock units are separate and distinct. Tagging studies have shown that halibut regularly migrate across the boundaries of these regulatory areas. However, variations in abundance, age composition, and growth, as well as geographic boundaries and fleet distribution, warranted the establishment of management units with which to control fishing mortality and to obtain an appropriate distribution of fishing.

Prior to 1923, there were no restrictions on the fishery and the vessels were able to operate throughout the year, although most of the catch was taken between March and October. In 1923-1924, a three-month winter closure was instituted, one of the provisions in the first Halibut Convention. Under authority of the 1930 Convention, catch limits were established in 1932. The season closed when the catch limit was attained or on a fixed statutory closing date. Continued improvement in the stocks attracted many vessels to the halibut fishery. These vessels came from the salmon fleet and primarily fished during May and June. As fishing effort increased during these months, the fishing season for halibut became shorter; in 1953, the season lasted 52 days in the Gulf of Alaska and by 1954 the season was open for 21 days in British Columbia and southeastern Alaska.

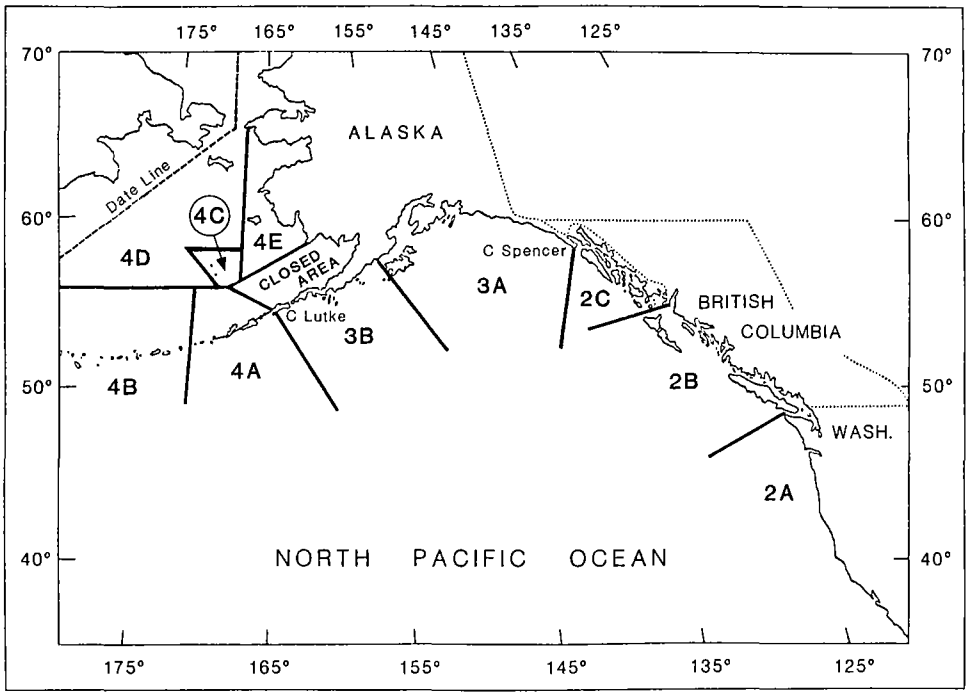


Figure 21. Regulatory areas for the Pacific halibut fishery, 1986.

This resulted in overfishing some segments of the stocks and underfishing others. The 1953 Convention was modified to permit more than one fishing season during any one year and enabled the Commission to spread fishing over a longer period of the year. This, along with a voluntary program of the fleet requiring vessels to lay up eight days between trips, again extended the fishing seasons. During the 1960's, the fishing seasons often were six months long. Since the late 1970's, seasons have become increasingly shorter again as a result of increasing fishing effort, higher catch rates, and a breakdown in the eight day layup program. Season length declined to only a few days in some areas of the Gulf of Alaska by 1983. The short, intense seasons resulted in overruns of the catch limit. The quality of the landings declined because some fishermen did not take the time to properly care for their catch, and landings in some ports were greater than processors could quickly handle.

The problem was less severe in Canada because of a limited entry program instituted by the Canadian government and because catch rates in Canadian waters were lower than in U.S. waters. The U.S. government considered recommendations by the North Pacific Fishery Management Council for a moratorium on fishing effort, but did not approve the recommendation. Because the Commission does not have the authority to limit fishing effort, it responded by instituting a series of one- or two-day seasons in critical areas to try to spread landings over a longer time period and keep catches within the catch limit. This strategy worked reasonably well and the distribution and quality of landings has improved markedly. Catch limits are now approaching historical levels, the resource is in good condition, and the quality and value of the catch is excellent.

A few scientists have disagreed as to the role of the Commission in revitalizing the halibut stock, i.e., whether the increase in abundance in the earlier years resulted from

the restrictions of effort, from improved environmental conditions, or both. Economists contend that because there is restriction on entry, IPHC's regulations have reduced the efficiency of fishing and marketing. Granting that early conservation measures may not have been as effective as initially purported and that economic inefficiencies exist, the maintenance of a viable fishery under intense exploitation for the 50-year period certainly speaks for the Commission's contribution. Many scientists have recognized IPHC's role as a classic example of successful fishery management based on scientific information, but they attributed the success to different causes. Some credited organization structure, i.e., IPHC has its own research staff, in contrast to other international groups that function through an Executive Secretary and draw on research agencies of member countries. Other scientists concluded that IPHC simply had the good fortune to work on a long-lived species with an uncomplicated life history and a one-gear fishery. Still others contend that success was achieved because the two member nations of IPHC have similar cultures and interests. Each of these views has some basis in fact, but no single explanation can account for the accomplishments, and one of the more important aspects has been virtually ignored — that is, control of the fishery. Adequate scientific data were essential but beyond that, to effect the management program, IPHC had the authority to introduce the necessary conservation measures. The cooperation of industry also was needed and IPHC helped to engender this support by convincing the industry of the benefits to be derived from curtailing fishing.

VOLUNTARY CONTROLS BY THE INDUSTRY

In addition to IPHC's regulations, the industry has periodically introduced controls that affected the length of the fishing season and the distribution of the landings. During the 1930's, for example, the fishing fleet introduced a program that required each vessel to lay up for 10 days between trips and the catch of each vessel was limited on the basis of the number of its crew. This program was discontinued during World War II.

During the early 1950's, the catch limit was taken in less than two months and the processors had difficulty handling the volume of the catch in so short a period (Figure 22). In 1956, organized fishermen in Canada and the United States reinstituted a voluntary lay-up program "... to extend the fishing season, establish rest periods for the fishermen, attain a more orderly delivery of the catch, and aid in conservation of the resource". The program was supported by as many as 18 organizations (unions and vessel owner associations) whose representatives met annually to establish the lay-up rules. The larger vessels with three or more men were required to take an 8-day lay-up between trips. Smaller vessels had the option of the same schedule or taking a one-half day lay-up for each day fished.

Support for the voluntary program was strong among the full-time halibut fishermen, but during the 1970's many new and part-time fishermen, who either were unaware of the objective of the plan or disagreed with the rules, did not follow the lay-up system. As a result, more and more of the full-time fishermen, who had supported the program, began to drop out and the lay-up system was in jeopardy for several years. The Commission was asked to incorporate the lay-up program in its regulations but questions were raised concerning the legal authority for the Commission to do so under the existing Convention.

At IPHC's 1977 Annual Meeting, the fishermen announced that the lay-up program was being discontinued because it lacked the needed support. The Commis-

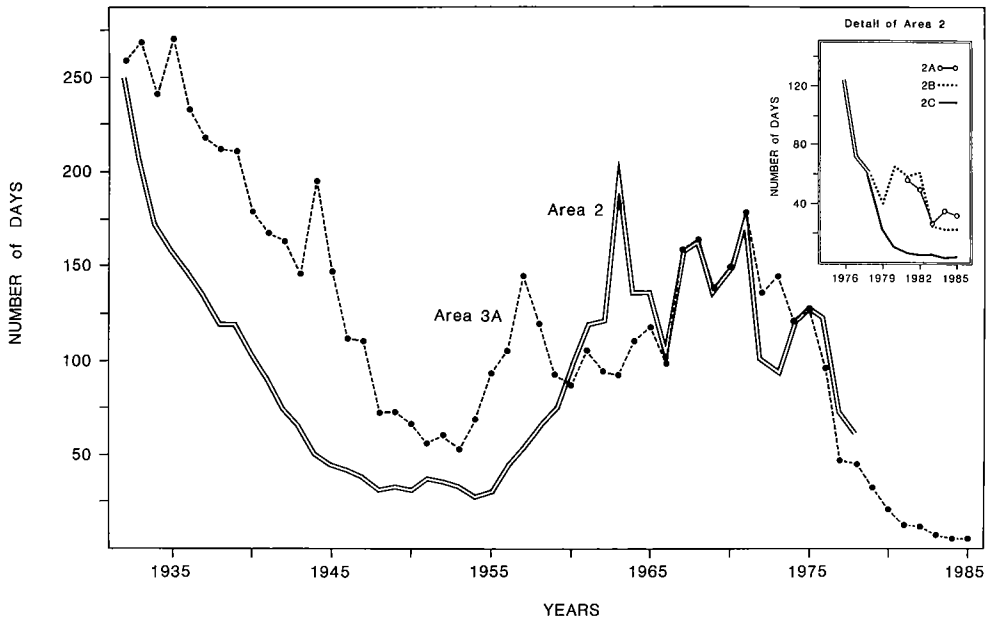


Figure 22. Length of fishing seasons in Areas 2 and 3A, 1932-1986.

sion had the option of letting the fishing season run its natural course in less than 50 days or splitting the season so that fishing would be extended over a longer period of time. A short, single season would have concentrated the fishing effort and resulted in excessive mortality on certain components of the stock. The Commission decided that the fishing season should be divided into a succession of open and closed periods to extend the fishing time and spread the fishing mortality between early and late components of the stock. In adopting the split-season plan, the Commission attempted to provide for a fishing season similar to 1976, with respect to overall length and timing, and scheduled four fishing periods from May to September. Each period was 18 or 19 days and the closed period was 15 days. As in the past, the season in each area would be closed when the catch limit was attained regardless of the designated fishing periods. This method of setting several fishing periods throughout the summer months has continued through 1986.

U.S. FISHERY MANAGEMENT COUNCILS

The MFCMA of 1976 established a United States Fisheries Conservation Zone from 3 to 200 miles and created regional fishery management councils to prepare management plans which guide U.S. management decisions. The Pacific Council (Washington, Oregon, California waters) and the North Pacific Council (Alaskan waters) are involved in the management of fisheries in areas inhabited by Pacific halibut.

The Commission has worked cooperatively with the Councils to develop management regimes for other fisheries, such as for groundfish, to minimize the impact on the halibut resource. These regimes include closing areas where incidental halibut catches are high, gear restrictions, and limits on the incidental catch of halibut.

The Commission staff participates directly in the Council process and has members on multi-agency Plan Teams which review and draft groundfish fishery management plans for the North Pacific Council.

The Halibut Act of 1982 granted authority to the Pacific and North Pacific Councils to develop U.S. regulations, including limited entry, which augment and do not conflict with regulations adopted by the Commission. The North Pacific Council extensively studied limited entry during the early 1980's and recommended a license moratorium for the halibut fishery in 1984. However, this recommendation was rejected by the U.S. government.

HISTORICAL TRENDS IN POPULATION LEVELS

Annual surplus production (ASP) is a basic measure of stock productivity and is defined as the excess of biomass (growth) above what is needed to replenish the population each year. Thus, ASP defines an amount of biomass that can be removed by fishing without causing the population abundance to decline (on an annual scale of reference). The estimated surplus production in 1985 was 75 million pounds.

In Figure 23, the current estimates of commercial ASP are placed in historical perspective. Commercial catch and setline annual surplus production are given in millions of pounds for the years 1935 through 1985. The portion of ASP taken as by-catch in incidental fisheries is not included in the setline ASP total, but it was substantial during the 1960's and early 1970's, exceeding 20 million pounds annually. The ASP estimate for 1985 of 75 million pounds is the highest value for the last fifty

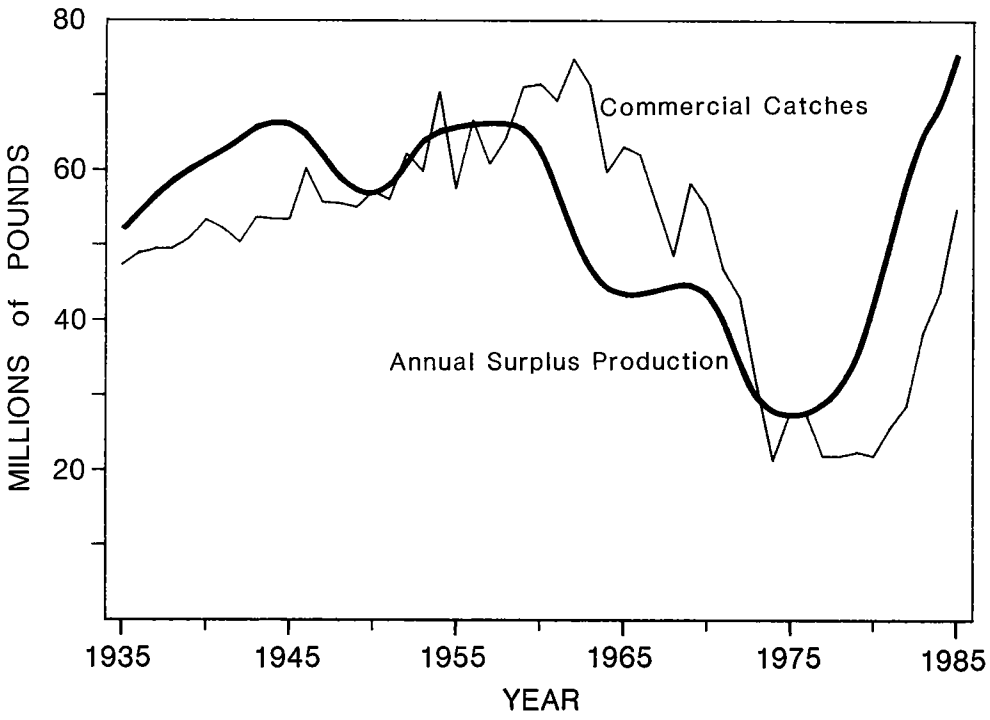


Figure 23. Annual surplus production and commercial catches of halibut for all regulatory areas.

years and exceeds the previous cyclical high point of 66 million pounds which occurred in 1958. The current up cycle began around 1978 when ASP was 31 million pounds. This upward trend has lasted seven years, although there have been signs that it is now leveling off at the current high level. The previous ASP plateau of at least 60 million pounds lasted for 22 years, from 1939 to 1960.

The driving force behind the recovery of the Pacific halibut resource is the recent high rate of production of juvenile halibut by the spawning adults. Figure 24 shows the historical trends in juvenile survival, juvenile production rate, and an index of spawning (mature stock biomass). Each of those trends is given by year of spawning. There is a pronounced cycle in juvenile survival and production rate. The production rate of juvenile halibut during the last fifty years exhibits a periodic pattern with high points occurring around 1937 and again in 1976, and a low point occurring around 1956. This pattern of juvenile production rate is essentially opposite to the time trend for adult spawning biomass. For example, the current high recruitment of young adult halibut in the fishable stock was produced in the early 1970's by the lowest spawning stocks in the fifty-year data series, while the dismal natural survival of juveniles in the late 1950's occurred when spawning biomass was very high.

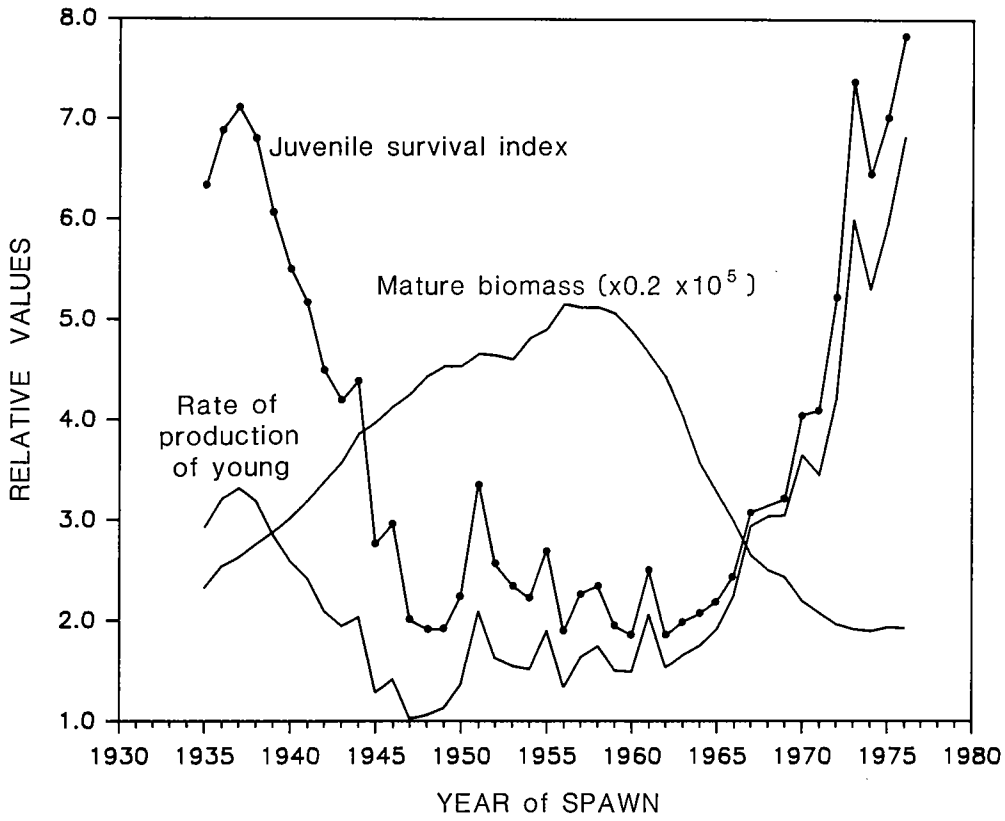


Figure 24. Juvenile survival index and rate of production of young are given by year of birth for each year class. Mature biomass is an index of spawning for each year class. Units are metric tons for mature biomass, number of eight-year-olds per 100 pounds of mature biomass for juvenile survival index, and 2.2x biomass of eight-year-olds per unit mature biomass for the rate of production of young.

One hypothesis for the observed cyclic pattern in juvenile production rate is that high densities of adults reduce juvenile survival and growth through some type of density-dependent population regulatory mechanism, such as competition for food and space. Weighing against this hypothesis is an equally plausible explanation that the cycle of juvenile production is due to cyclical environmental or ecological factors wholly independent of adult halibut biomass. Under this scenario, a long-term cycle in juvenile production is natural and unavoidable.

Environmental vs. Fishery Effects

The Commission has been continually faced with questions concerning the reasons for changes in halibut productivity. The historic Thompson-Burkenroad debate, described in Commission Scientific Report 56, involved the question of whether declines in halibut stocks prior to 1930 were related to fishing or other factors and whether the increase in stocks from 1930 to 1940 was the result of management. Burkenroad claimed that stock changes could not be attributed primarily to the effects of fishing as concluded by Thompson. Thompson rejected Burkenroad's arguments and maintained that the fishery was the dominant factor. Scientific Report 56 presented revised estimates of abundance and concluded that Burkenroad rightly questioned Thompson's interpretations of the early data, but that the revised estimates gave credibility to the thesis that fishing mortality was the major cause of the decline in stock abundance.

Recent studies show that even after another 40 years of data it is still unknown whether exogenous environmental factors are the primary cause of changes in natural production rates of the young, as suggested by Burkenroad. The additional hypothesis of density- dependent production is also consistent with current estimates. Faced with these alternative hypotheses, a form of decision analysis is used to provide guidance in IPHC's management. In essence, a series of halibut populations are simulated on a computer where each simulation was governed by a given hypothesis about juvenile production rate and an assumed fishing mortality rate. It was found that the level of fishing mortality had a substantial effect on long-term yield, as argued by Thompson, irrespective of whether a cycle in juvenile production is due to a density-dependent population mechanism or a long-term environmental cycle. Indeed, it was the environmental scenario, similar to Burkenroad's hypothesis, where the amount of fishing mortality had the most effect on stock changes and long-term yields. By looking at the risks and rewards associated with each fishing mortality, an exploitation rate was found that produces high catches under either hypothesis.

CONSIDERATIONS IN DETERMINING CATCH LIMITS

Halibut stocks declined from the early 1960's to the mid-1970's and the Commission responded by reducing catch limits throughout that period. Since then, the Commission has attempted to rebuild stocks by setting catch quotas below the annual surplus production (ASP), as described earlier. ASP has usually been expressed in terms of setline production, although incidental catches in other fisheries reduce setline ASP and are accounted for in the estimation of setline ASP.

Catch limits set by the Commission during 1980-1983 were based at 75 percent of the estimated ASP. Stocks increased sharply during this period, and catch limits in 1984 were based on 90 percent of ASP in areas where stocks appeared to be approaching maximum sustained yield (MSY) levels. IPHC's policy of setting catch limits below

ASP appears to have been successful in rebuilding stocks. However, ASP may no longer be an appropriate concept once stocks have been rebuilt.

MSY estimates are difficult to use in actual management of the halibut stock. MSY may reliably indicate the long-term goals of management for maximum yield. However, to set annual catch limits at a fixed amount corresponding to MSY and leave them there independent of stock abundance changes can easily cause over-exploitation. Catches that rise and fall with the abundance of the stock are optimal when natural fluctuations occur in the recruitment of young. One such policy is to take a fixed percentage of the stock each year.

The constant exploitation yield (CEY) is the amount of yield obtained by taking catches proportional to stock abundance where the proportionality constant is determined so that MSY is taken when the stock is at the level of abundance that produces MSY. There are several advantages of managing on a CEY concept: (1) catches rise and fall smoothly with the changes in abundance of the stock, (2) each component of the stock is fished with an equal exploitation fraction, and (3) subarea estimates can be made without MSY being separately estimated for each subarea. Disadvantages of CEY include: (1) needing to know how much incidental mortality occurs before being able to establish setline catch limits, and (2) if sub-stocks exist and they exhibit differential productivity, then this will not be properly utilized.

Setting catch limits slightly below estimates of CEY may result in achieving both high and stable yields over time, which should be advantageous both to the harvesting and marketing sectors of the industry. Since the 1920's, annual halibut yields to the setline industry have ranged from slightly over 20 million pounds to over 70 million pounds. Although some variability due to factors such as incidental catch may be unavoidable, management practices which stress taking maximum yield at all times contribute to the extreme variability in annual harvest. By fishing stocks at slightly below maximum levels, more fish will be available during periods of low productivity. Also, factors such as catchability, which are difficult to assess, would be less critical in setting catch limits. For example, it may be possible to keep annual setline harvest at 50 to 60 million pounds even though ASP and CEY will vary over time.

Effects of Migration and Incidental Catch

Halibut are migratory, and catches in one area will reduce the yield available in other areas. To examine the effect of migration, tag release and recovery data were analyzed by area. The analysis was based on the distribution of tag recoveries and assumes constant exploitation and tag reporting among areas. The effect of migration into Area 2B may be somewhat exaggerated because evidence supports a higher recovery rate for tags in Area 2B compared to other areas.

Halibut migration rates are higher for small halibut than large halibut and setline-caught halibut tend to be larger than trawl-caught halibut. The effect of setline catches was estimated using tagging data for fish over 80 cm long. In general, the results suggest relatively little impact on yield. For example, the 23 million pound catch quota for Area 3A in 1985 results in a yield loss of less than 0.5 million pounds in each of Area 2B, 2C, and 3B (Figure 25).

The effect of incidental catches was examined using levels of catch-mortality typical of those estimated for the 1960's and 1970's, and tagging data for fish less than 80 cm long. Also, a 50 percent increase in yield loss due to growth was assumed. Figure 26 illustrates the effect of a five million pound incidental catch in Area 4. Because of the small size and higher migration rates, halibut caught incidentally in the trawl fisheries

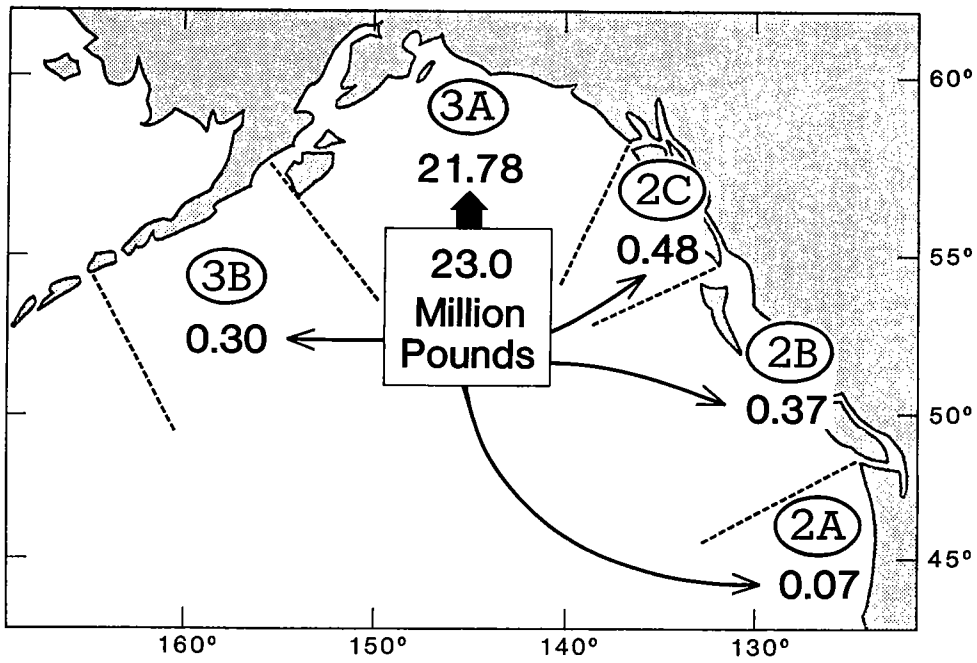


Figure 25. Effect of setline catch limit in Area 3A on future yield in other areas, based on historical distribution of tag recoveries for halibut over 80 cm long.

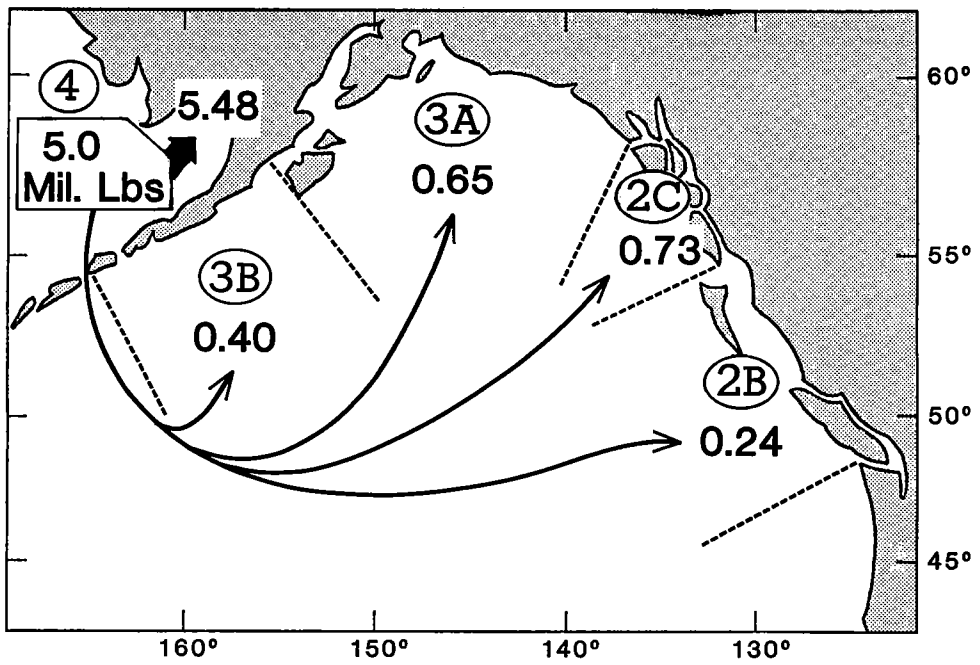


Figure 26. Effect of a 5 million pound incidental catch in Area 4 on future setline yield in other areas, based on historical distribution of tag recoveries for halibut less than 80 cm long.

have a relatively greater impact on yield than halibut caught on setlines. IPHC has worked successfully with other management agencies in both Canada and the United States to reduce incidental catches. In 1984, the total incidental catch was about 10 million pounds, down substantially from earlier years. The lower incidental catch in 1984 partly reflects reduced fishing for crab and groundfish and may not be representative of future catches. If future incidental catches can be held at the 1984 level, substantially higher yields in the setline fishery should be available over the next several years.

Commission Organization

COMMISSIONERS

Three commissioners are appointed by the Governor General of Canada and three by the President of the United States and serve without remuneration. The commissioners appoint the director who supervises the scientific staff, who collect and analyze statistical and biological data needed to manage the halibut fishery. The commissioners annually review the regulatory proposals made by the scientific staff and consider proposals from the industry and the Conference Board that represents vessel owners and fishermen. The regulatory measures adopted by the Commission are submitted to the two governments for approval and fishermen of both nations are required to observe the approved regulations.

The average tenure of the commissioners since 1924 has been eight years, and 15 of the members have served 10 years or more. The length of service and the overlapping terms of the members has had a stabilizing influence on the Commission and the management of the resource.

In recent years, one commissioner from each country has been an employee of the federal fisheries agency, one a fisherman, and one either a buyer or processor. One U.S. commissioner usually is from Alaska and one Canadian commissioner usually is from Prince Rupert. The chairmanship of the Commission alternates annually between countries. Initially, most of the Commission meetings were held in Seattle. Later a system was devised to hold every third meeting in either Canada or Alaska. In 1972, the Commission adopted a policy to alternate its meetings between Canada and the United States.

STAFF

The Commission staff of Canadian and United States employees consisted of four biologists and four supporting personnel in 1925. At present, there are 12 biologists and 11 adminstrative, clerical, and technical persons; 18 are U.S. citizens and 5 are Canadians. The staff is supervised by the director who is responsible to the Commission for its research, regulatory, and administrative functions. The Commission headquarters have been on the campus of the University of Washington in Seattle since 1924 (Figure 27), except for five years (1931-1936) when the staff was housed in a laboratory of the U.S. Bureau of Fisheries.

Each summer, temporary employees are engaged to collect data on the landings and the fishery. The temporary employees usually are undergraduates from different universities in Canada and the United States. The temporary staff members work in the ports of Seattle, Vancouver, Prince Rupert, Petersburg, Sitka, Excursion Inlet, Seward, Homer, Kodiak, and Dutch Harbor collecting data from the fishery. In addition, some temporary employees serve at sea on the Commission's charter vessels.

ADMINISTRATION

The Convention specifies that expenses of the Commission are to be shared equally by the two governments. The director submits a budget to the commissioners

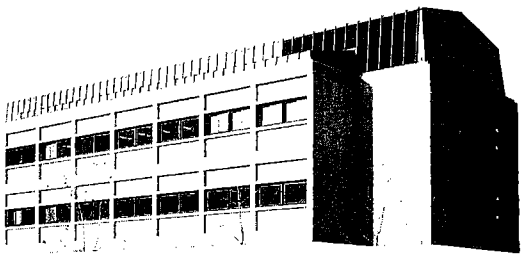


Figure 27. IPHC headquarters on the University of Washington campus since 1969.

and, when approved, it is forwarded to the Canadian Department of Fisheries and Oceans and to the U.S. State Department. The Commission budget in fiscal year 1924/1925 was $20,000, most of which was for staff salaries. The combined Canadian and United States appropriations for fiscal year 1985/1986 of $1.5 million brought the total funds appropriated during the 63-year history of the Commission to $22.7 million. Until the 1970's, all billings and salaries were paid by the Canadian Government in Ottawa. Then, the United States government was billed and reimbursed Canada for one-half these payments. In 1971, IPHC petitioned the governments for its own financial regulations. This request was approved and the Commission adopted its own fiscal year (April 1 to March 31); thereafter, appropriated funds were deposited in a Commission account and billings were paid directly by IPHC.

For the most part, the administrative policies and salaries are consistent with those of the U.S. Civil Service. The Commission has a pension plan under the auspices of the International Fisheries Commission Pension Society.

Industry Organizations

A number of organizations have been formed by people in the halibut industry to promote their respective interests. Some of these organizations have been in existence for several decades and represent hundreds of members. These organizations not only provide many services to their members, but also have contributed substantially to the management of the halibut fishery.

HALIBUT ASSOCIATION OF NORTH AMERICA

Many of the fish processing companies that buy and sell halibut in Canada and the United States belong to the Halibut Association of North America (HANA). Membership includes 28 companies; 10 from Washington and Oregon, 10 from British Columbia, and 8 from Alaska. The Association maintains a fund for promoting sales of halibut and works to maintain standards that provide a high quality product for the consumer. The Association frequently consults with the IPHC staff and commissioners on matters concerning the management of the fishery and sends a representative to IPHC's annual meeting. Seven members of HANA are represented on the Advisory Group.

FISHERMEN'S UNIONS

Many halibut fishermen are active union members although their earnings are based on shares of the net proceeds from the sale of the fish. Some unions represent only halibut fishermen, others represent members from several fisheries, and at least one represents shore workers at fish processing plants as well. One of the primary functions of the unions is to negotiate financial arrangements for the fishermen. The unions frequently maintain funds for the welfare of their members and may assist their members in filing tax returns. Fishermen's unions are interested in preventing accidents at sea and encourage the use of navigational and life saving equipment on vessels. Union and vessel owner associations jointly have adopted gear maintenance standards. The degree of union organization varies from port to port and tends to be stronger among the fishermen who work on the larger vessels and who fish out of larger ports.

FISHING VESSEL OWNERS' ASSOCIATIONS

Many owners of halibut vessels belong to associations of vessel owners which provide a number of useful functions for their members. Some of the associations maintain an insurance pool and provide coverage for accidental loss of the fish catch, a type of insurance usually not offered by commercial companies. Many associations assist their members with tax returns and other accounting services. They also may participate in price negotiations on behalf of their members as well as in labor negotiations with fishermen's unions. Association spokesmen provide information to executive and legislative branches of government and participate in national and international meetings.

CONFERENCE BOARD

The Conference Board is an advisory panel representing Canadian and United States halibut fishermen and vessel owners. The Board was created by the Commission in 1931 to obtain recommendations from the fishing fleet on conservation measures. After the Commission staff has presented information on stock condition and has made its proposals for regulations in the coming year, the Conference Board meets to develop its own regulatory proposals which are presented to the Commission for consideration. Conference Board members are designated by union and vessel owner organizations at the various ports where halibut are landed. To insure broad representation, the Commission pays the expenses for 6 to 10 delegates who attend Commission annual meetings. The Board sets its own rules for participation and voting. A consensus of recommendations is presented to the Commission, but minority views are also expressed.

ADVISORY GROUP

In 1972 and 1973, the Conference Board asked the Commission to allow a few Board members to be observers at the Commission's sessions when regulatory decisions were made. In 1974, the Commission established an Advisory Group consisting of representatives of fishermen, vessel owners, and processors. The Commission asked that the members of this body be selected from all geographic areas of the fishery. The Advisory Group originally consisted of 14 members: 7 selected by the Conference Board and 7 by the Halibut Association of North America (HANA). However, the Commission has allowed the number of members to vary in recent years.

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