THE BIOLOGICAL BOARD OF CANADA
UNDER THE CONTROL OF
THE HON. THE MINISTER OF FISHERIES

BULLETIN No. XLVII

THE HERRING FISHERY OF BRITISH COLUMBIA—PAST AND PRESENT

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OTTAWA
1935

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CONTENTS

INTRODUCTION

Within the last twenty years, the herring fishery of British Columbia has grown to such an extent as to become one of the most important fishing industries of the province. In 1927 the catch amounted to 1,724,246 cwt. with a marketed value of $1,867,429. While the unfavourable economic conditions which have prevailed during the last few years have exerted a retrogressive effect, the catch in 1933 still amounted to 1,077,373 cwt. although the marketed value had dropped to $738,522. At present the catch is considerably greater than, and the value approximately equal to that of the Atlantic herring fishery of the Maritime provinces and Quebec. These statistics serve to illustrate the commercial importance of the herring of British Columbia.

The direct monetary returns from the herring fishery, although considerable, form only a part of the true economic value of the species. The rôle of the herring as a food for larger fishes must also be taken into consideration. As several important food fishes, among which might be mentioned the halibut, spring salmon, coho salmon, and ling cod, feed on the herring, its total value cannot be readily estimated in dollars and cents.

It is the purpose of this bulletin to outline briefly the life history of the herring; to trace the development of the various methods of fishing and to describe those which are at present in use; to trace the development of each phase of the industry with reference to the preparation of the products; to discuss fluctuations which have occurred in quantity and value of the marketed products; to discuss fluctuations in the availability and size of herring; and to comment on the present condition of the fishery and its future possibilities.

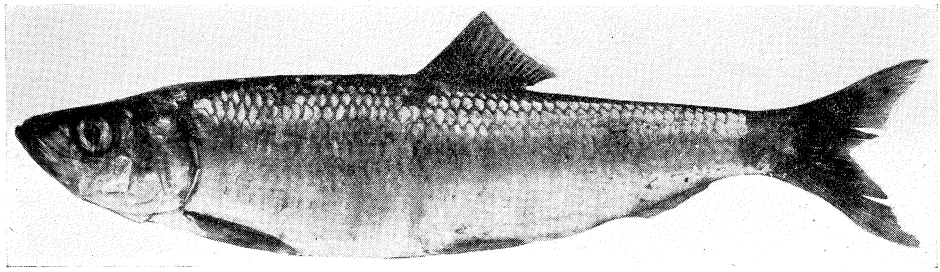

FIGURE 1. The Pacific herring (*Clupea pallasii*).

In the preparation of this article, members of both the Federal and the Provincial Departments of Fisheries and of the fishing industry have contributed much useful information and their assistance is gratefully acknowledged. Figures 4, 8, and 16 are photographs taken by Mr. W. J. Oliver, Calgary, and published with the kind permission of Mr. J. C. Campbell, National Parks of Canada, Department of the Interior, Ottawa.

LIFE HISTORY

The commercial herring fishery is most active during the fall and winter months when numerous schools of adult fish appear in the bays and inshore channels. The fish remain in these waters throughout the winter and spawn during the following spring. While spawning takes place in the vicinity of Vancouver island usually between the latter part of February and the first part of April, the exact time of reproduction varies both with locality and season. In the more northern waters of the Prince Rupert district the herring spawn at a slightly later date, some time between the first week in March and the end of April.

At spawning time the schools of herring come into the comparatively shallow water along the shore and deposit their eggs on the eelgrass or rockweed in or just below the intertidal zone. Spawning activity on any particular bed

may last from one to several days. The eggs are cemented by the hardening of a sticky mucilaginous coating to the vegetation forming thick clusters (figure 2). At the time of deposition they are fertilized by the milt of the males which is discharged freely into the water. So large is the quantity of milt liberated that it forms a dense greenish-white "cloud" in the water, sometimes as great as a mile in length and one-quarter of a mile in width (figure 3). The eggs, containing the developing young, are usually exposed at low tide and are preyed upon by thousands of gulls, ducks, and other birds (figure 4). Sun and wind in the daytime and frost at night also take their toll when the eggs are exposed, although their resistance to these agencies is remarkable. Storms are one of

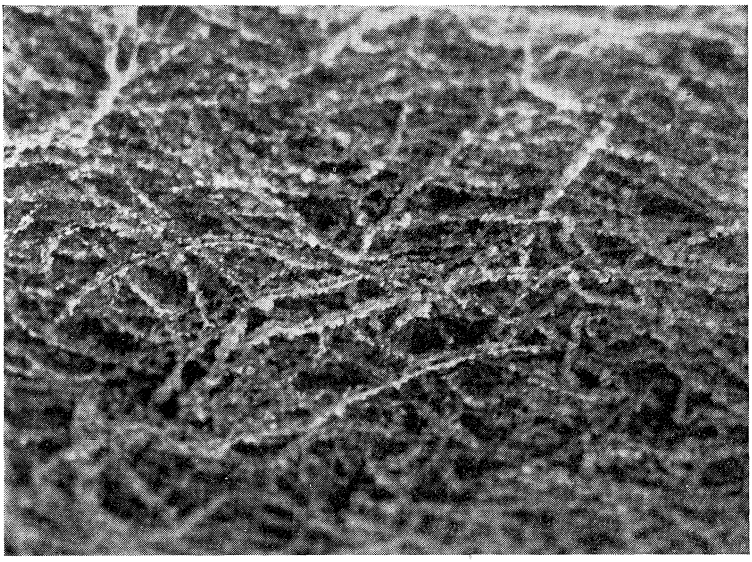

FIGURE 2. Eggs of herring on eelgrass.

the worst hazards of the spawning grounds for they cause a large percentage of the eggs to become detached from the vegetation and washed up on the beach. A recent investigation of the extent of mortality on herring spawning grounds by Hart and Tester (*Trans. Amer. Fish. Soc., vol. 64, 1934*) has shown that at least seventy per cent, and probably more, of the eggs thus washed on the beach fail to survive whereas, under ideal weather conditions, the mortality due to natural causes such as infertility and desiccation averages only about five per cent.

During a period of from ten to twenty days, the length of time depending on the temperature of the water, the larval herring gradually develops within the egg, deriving its nourishment from the supply of yolk material. It gradually begins to show signs of life, wriggling and squirming inside the egg membrane until it finally breaks through and is set free in the water. When first hatched

the larva shows a slight bulge on its undersurface below the front fins which marks the position of the "yolk sac". This contains the remaining supply of yolk which is sufficient to nourish the young fish for only a short period after hatching. Each spawning ground yields several billions of larval herring. Although they can swim feebly they are carried along by currents and back and forth by tidal action during this stage. In all probability this is the most critical period in the whole life history for not only are the larvae the easy prey of many fishes both large and small, but large numbers may also die from lack of suitable food when their embryonic supply has been used up and they must start to feed.

FIGURE 3. The shore of Departure bay at spawning time. The milt may be seen as a light area close to the shore.

By the time the larvae have grown to an inch in length, a month or so after hatching, they are no longer at the mercy of the tide and move about in compact schools. These soon acquire the habit of appearing at the surface at dusk. In the evening when the water is calm they may be detected close to shore by the fine ripples which they cause at the surface and by the silvery flash when an occasional individual jumps clear of the water. In the daytime they may be seen frequently some distance below the surface.

The young herring are present in shallow inshore water throughout the summer, and during this period grow to a length of from three to four inches, measured from the tip of the closed lower jaw to the end of the tail. In the winter they are rarely seen and presumably seek deeper water. In the next fall and winter when they are in their second year and are about seven inches in length a few of these immature individuals may join the schools of mature fish

when the latter come in to spawn. When the young herring are in their third summer, they may be found sometimes in large schools in inshore water where food is plentiful. They remain here during the summer, and in the fall and winter join the adult schools in force to form from twenty to sixty per cent of the commercial catch. The following spring these fish, now exactly three years old and approximately eight and one-half inches in length, spawn for the first time. This holds true in southern British Columbia. In the northern waters of the province a small proportion of the new recruits join the adult schools in their third year, but the majority do not appear in the commercial fishery until they have entered their fourth year.

Herring do not die after spawning; the gonads have fully recovered by the following spring when reproduction again takes place. Normally, it is repeated once every spring throughout the remaining life of each fish.

The commercial catch consists mostly of fish in their third, fourth, fifth, and sixth years, with a small percentage of older individuals. In the southern waters the bulk of this catch is usually composed of fish in their third and fourth years. The fishery here is therefore mainly dependent on younger age groups than that of Alaska and Europe. In the Prince Rupert district the rate of growth is slower than in southern British Columbia and consequently, even though the spawning run consists of fish of about the same average length as those to the south, it is made up of older individuals. The age groups which are present in the northern runs are similar to those in the commercial fishery of south-eastern Alaska. Naturally, the percentage in each age group in the run to any locality will vary from year to year depending on the relative success of and survival from each spawning. The significance of the age composition of the run in regard to the condition of the fishery will be discussed later.

The importance of an adequate supply of suitable food for the newly-hatched larvae was indicated above. They subsist at first on the minute plankton organisms in the water. The microscopic eggs of small marine animals sometimes comprise over fifty per cent of their food; minute floating plants called diatoms are eaten very extensively; the young or nauplii of small shrimp-like animals known as copepods are also a very important food item; the larvae of clams, snails, oysters, and of other lower animals are also eaten but to a smaller extent. As the fish grow larger the type of food which they take changes somewhat. At the fingerling stage when the young fish frequent inshore water, it is varied and depends largely on the kind of shallow-water organisms that are present. However, juvenile and adult copepods generally comprise a large percentage. Mature herring appear to feed mostly during the spring after spawning and during the summer, as specimens obtained at other times of the year very rarely contain food. Large copepods and other shrimp-like forms known as schizopods are the chief food organisms taken by herring of commercial size.

Throughout the whole life span, the enemies of the herring are many. The developing eggs on the spawning grounds are devoured by sea gulls, ducks, and

crows. The larvae are easily captured by small fishes and other marine animals. Young and adults are preyed upon by dogfish, salmon, trout, halibut, ling cod, and other fishes; they are also eaten by gulls and other birds; they form a large part of the food of sea lions and seals. Thousands of tons of adult fish are removed annually by possibly the most formidable of all predators, man. Considering the enemies that are present at all stages of development and considering the dangers of the critical larval period, it is not astonishing that only about one in ten thousand of the eggs which are deposited on the spawning grounds survives to become an adult fish and to propagate the species.

FIGURE 4. Typical spawning grounds at low tide, Nanoose bay. The gulls are feeding on the eggs.

FISHING METHODS

DRAG SEINES

In the early days of the industry, from its beginning about 1877 to about 1905, fishing was carried on almost entirely by the use of drag or beach seines. These are large nets, from 10 to 30 fathoms in length and from 2 to 5 fathoms in depth, which are operated from the shore. The middle portion of the seine is made of small-meshed web, sometimes as small as $\frac{1}{2}$-inch stretched measure, while the two outer portions or wings consist of web of larger mesh. The central part is hung somewhat more fully than the wings to form a "bag" or "pocket".

The web is fastened to ropes running along the top and bottom. The top one, or "cork line", has distributed along it at regular intervals floats of cork or wood, which keep it afloat; the bottom one, or "lead line" has weights clamped to it at regular intervals, which sink the lower part of the net and keep it vertical in the water. At either end of the seine a rope bridle joins these two lines, and to its middle is attached a long line by means of which the net may be hauled ashore. The seine is piled in the stern of a skiff ready for use. When a school of herring is located close inshore, one man retains the line fastened to one end of the seine on the shore, the skiff is rowed so as to encircle the school of fish as quickly as possible, and the net is paid out over the stern. The crew lands, and the lines attached to both ends of the net are hauled in simultaneously until the fish are enclosed between the encircling net and the shore. The ends of the lead line are brought close together, forming a pocket in which the fish are completely enclosed. The herring are then landed either on the beach or into the skiff.

The early method of capturing herring in a drag seine could be used only when the schools came into the shallow water of bays and inlets in the winter or when they came along the shore to spawn in the spring, but the yield was quite adequate to meet the local demands. With the development of the industry, it became more and more difficult to secure a sufficient quantity by this method. Moreover, the schools were broken up and gradually deserted bays where they were formerly easily obtained. A new method of capture which could be used in deep water was indicated.

Drift Gill Nets

As early as 1900 fishermen began to consider the possibilities of the use of drift gill nets and purse seines for the capture of herring in deep water. By 1905 the use of gill nets was well established at point Grey, near Vancouver, and on the east coast of Vancouver island, particularly at Departure bay and Nanaimo. In 1915 a failure of the point Grey fishery resulted in an influx of gill-netters to Pender harbour where a fishery, similar in extent to that of point Grey, has gradually developed.

The boats used by the drift gill-netters are from 30 to 40 feet in length with a 9- or 10-foot beam, and are usually propelled by small gasoline engines. A cabin, containing the engine and living quarters, is situated forward. Abaft the cabin is a hold covered by a hatch. Behind this is a cockpit in which the nets are piled. Sometimes an iron rack is placed between the hold and the cockpit and is used for segregating sections of the net which need repairing. The boats are similar in size and structure to salmon trolling craft and some are convertible into the latter. The crew usually consists of two men.

The web is made of cotton twine from 2- to $2\frac{1}{2}$-inch stretched mesh. Each "piece" is 20 fathoms in length and 3 to 4 fathoms in depth with a cork line along the top and a lead line along the bottom. The corks are situated at intervals of about 2 feet and the leads at intervals of 1 foot along these two lines, the numbers and intervals being so arranged that the net just sinks below the surface

of the water. Usually from 10 to 20 pieces are fastened together at a set making a total length of from 200 to 400 fathoms or up to half a mile of web. The number of pieces used depends on the abundance of the fish. An inflated canvas bag called a "Scotch buoy" or a suitable float consisting of a sealed tub or a group of corks, is attached at the juncture of the cork lines of successive pieces on about a fathom of rope. Immediately below these large floats, at the juncture of two lead lines, is attached a weight, usually consisting of a rock or stone at the end of half a fathom of line. These additional floats and weights cause the web to be suspended about a fathom below the surface.

Fishing usually takes place at dusk and at daybreak or during the intervening hours of darkness. When fish are very plentiful or there is a large demand, sets are also made in the daytime but these are usually not as successful as those made during the twilight hours or at night. In the case of the point Grey fishery, the boats run offshore until sounding shows that a sufficient depth has been atained. The net is then set towards the shore, the exact direction depending on the wind. In other instances, nets may be set offshore in deep water. First a float carrying a lighted kerosene lamp, and attached to the first piece of web by about 10 fathoms of line, is thrown overboard. The first buoy and weight then follow and the whole net is gradually set over the stern while the boat travels slowly ahead, one fisherman paying out the net and freeing snags while the other is navigating the boat. When the entire web is out the last piece is attached to the stern by about 10 fathoms of line. Usually boat and net are then allowed to drift with the current for a half an hour or more. Sometimes, however, the net may be set at dusk and lifted at dawn. In attempting to pass through the net the herring become entangled, the twine getting behind the cheek bone or operculum which covers the gills. This method of capture is therefore known as "drift gill-netting".

After the net has been out a sufficient length of time it is hauled back into the boat by both men; the fish, if any, are shaken from the web; torn portions of the net are looped free of the main pile in the cockpit, to be repaired during the daytime. The herring are placed in baskets in the hold and are later sold to the public either direct or through a fish buyer. Herring caught in this manner are favoured as food by the local market, as the gill net selects only the larger fish.

The present gill-net fisheries are located at point Grey in the summer, at Pender harbour in the summer and fall, and occasionally at Nanaimo, Departure bay, and Nanoose bay in the spring (figure **9**).

Purse Seines

Purse seines first came into extensive use on the east coast of Vancouver island about 1910. Previous to that time they were opposed by many fishermen as destructive to small fish. However, the drag seines and gill nets did not supply a sufficient quantity of fish to meet the demands of the growing export trade, particularly in dry-salted herring. The British Columbia Fisheries Commission, 1905-1907, had recommended either the prohibition or limitation

of purse-seining. However, after much controversy local objections were finally overcome and the use of purse seines became established by law in 1913 outside of certain restricted areas. Since that time an enormous fishery has been gradually built up on both the east and west coasts of Vancouver island.

The early methods of purse-seining were naturally somewhat crude as compared to those of the present day. At first, a small purse seine manipulated by means of a small power boat and skiff was used. While the principle of the method of capture was similar to that of the more modern methods which are described in the following pages, there has been an increase in the size and efficiency of the boats and gear and an increase in the skill of the fishermen with the development of the industry.

The boats, crews, equipment, and methods of the herring and pilchard fisheries of British Columbia are very similar. In the following description of the herring fishery any outstanding differences between the two will be pointed out. For more detailed information on the pilchard fishery the reader is referred to a bulletin by Dr. J. L. Hart (*Biol. Bd. Can. Bull. 36, 1933*).

BOATS

A modern herring seine boat is about 65 feet in length with a beam of from 16 to 18 feet, and is usually propelled by a full-diesel engine. The essential equipment consists of a seine, a turn-table with a power driven "live" roller, a brailer, and, for single-seining, a sturdy flat-bottomed skiff. Each seine boat has a hold for stowing fish, the capacity of which may be from 30 to 40 tons. Herring and pilchard seine boats are identical and the same boats are often used in both fisheries.

Tenders, boats used for "hauling-off" during a set, or for carrying fish, vary considerably in size and construction. They are usually larger than seine boats but are built along the same lines. Sometimes seine boats which are not actively engaged in fishing are used as tenders.

SCOWS

The scows used in transporting fish are of two kinds: "well" and "deck". Well scows are essentially large water-tight boxes with a float built on either end and with a capacity of from 50 to 100 tons of fish. They float lower in the water than deck scows and so are favoured by the Japanese fishermen who brail by hand. They are also cheaper in construction, but can only be used in protected waters. Deck scows (figure 8), as the name implies, consist each of a flat-bottomed hull, on the deck of which is built an enclosure with a capacity of from 30 to 80 tons. They float higher in the water than well scows and so can stand rougher weather.

NETS

A herring purse seine may be 275 fathoms in length on the east coast and 200 fathoms in length on the west coast of Vancouver island. It is usually

deeper than a pilchard seine, the depth ranging from 30 to 50 fathoms or more. In the Prince Rupert district, however, seines with a depth not exceeding 10 fathoms are used, as fishing takes place in comparatively shallow water.

Essentially, a seine consists of a large expanse of web bounded by lines and manipulated by means of other sets of lines. To a narrow strip of heavy web at the top of the net is attached the cork line and along this are threaded disks of cork at short intervals. A number of Scotch buoys are also attached to the cork line in such a way that their positions may be readily changed during a set. A heavy lead line, on which are strung numerous small lead weights, is fastened

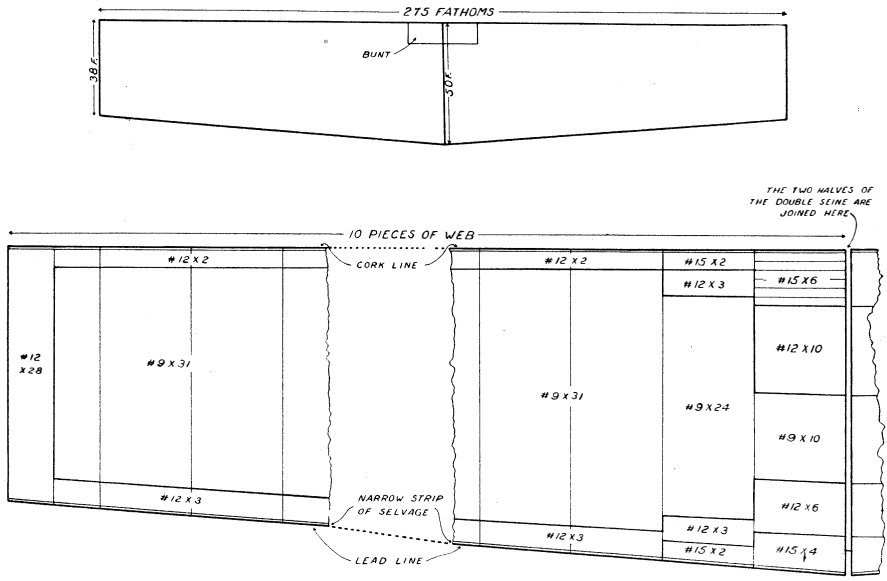

FIGURE 5. Arrangement of web of a double purse seine used by an operator on the east coast of Vancouver island. Numbers indicate size of twine and number of pieces of web, *e.g.*, No. 12×2 means 2 pieces of 12-thread web. Each piece is 20 fathoms long and about 2 fathoms (100 meshes) deep when stretched.

to the bottom of the web. Brass purse rings, through which runs the purse line, are distributed along the bottom of the net about four fathoms apart. These are fastened to the middle of short pieces of rope which are lashed at both ends to the lead line. The purse line may be either a heavy rope or a wire cable. Breast lines, running through smaller rings which are lashed to ropes bounding the ends of the net, are joined to the lead line below each end.

The dimensions, structure and web of herring seines vary according to the preferences of the operators and also according to whether the single- or double-seine method of fishing is used (see below). The size of the thread and the arrangement of the web of a double seine used by one operator on the east

coast of Vancouver island is shown in figure 5. The web consists of numerous pieces laced together, each piece with a stretched length of 20 fathoms and a stretched depth of about 2 fathoms (100 meshes). After the web is hung, the total length of the double seine is 275 fathoms (20 pieces). Similarly the depth at the central portion or "bunt" of the net is about 50 fathoms (36 pieces) and tapers to about 38 fathoms (28 pieces) at the outer edges of the "wings". The whole web, except the narrow strip of heavy selvage along the cork and lead lines, is of $1\frac{1}{2}$-inch stretched mesh. From the figure it may be seen that the size of the twine is different in the various parts of the net. The wings consist mostly of 9-thread twine but this is bounded at the top, bottom, and end by strips of heavier web, consisting of 12-thread twine. The bunt of the double seine, in which the fish are enclosed after pursing, and other parts of the web which are subjected to the greatest strain, are made of still heavier twine, 15-thread.

The arrangement of the web of a single seine is essentially similar to that of either half of the double seine described in the preceding paragraph. Again, however, the exact arrangement and the size and strength of the web varies according to the preferences of individual operators. In a single seine the bunt is at one end of the net and along its edge runs the second breast line. On the west coast of Vancouver island, frequently the same seines are used for both pilchard and herring fishing.

LOCATING THE FISH

In contrast to pilchard fishing, purse-seining for herring is mostly done inshore. On the south-east coast of Vancouver island the activities take place in the channels and bays among the numerous islands; on the west coast, fishing takes place within all the larger sounds and inlets. The grounds are fished usually at night, from dusk to daybreak. When the schools are at the surface, they are located either by watching for the flipping of the fish or by listening for the sound caused by this activity. When they are below the surface they are located by "feeling". This consists of dropping a heavy weight attached to a fine wire from a skiff or from the bow of the seine boat while the latter is under way at slow speed. An experienced fisherman can tell by the feel of the wire when it passes through a school of fish. Moreover, having located the school, by feeling back and forth he can determine the direction and the speed at which the fish are travelling, knowledge that is essential for a successful set.

SETTING

The method of fishing on the east coast of Vancouver island is somewhat different to that employed elsewhere. Two seine boats drift side by side on the fishing grounds. Although each has an individual seine, the ends of the two are laced together at the bunt end to form one long net, half of which is piled on the turn-table at the stern of each boat. When the scout has located a school of herring he signals with his lantern; the boats are cut apart and move at first in almost opposite directions, each paying out its portion of the net over the

stern (figure 6, 1A); both boats quickly describe a half-circle around the scout in the skiff and come together again when all the net has been set (figure 6, 1B).

To some extent on the east coast of Vancouver island and exclusively in all other localities, seine boats operate individually, as in the pilchard fishery.

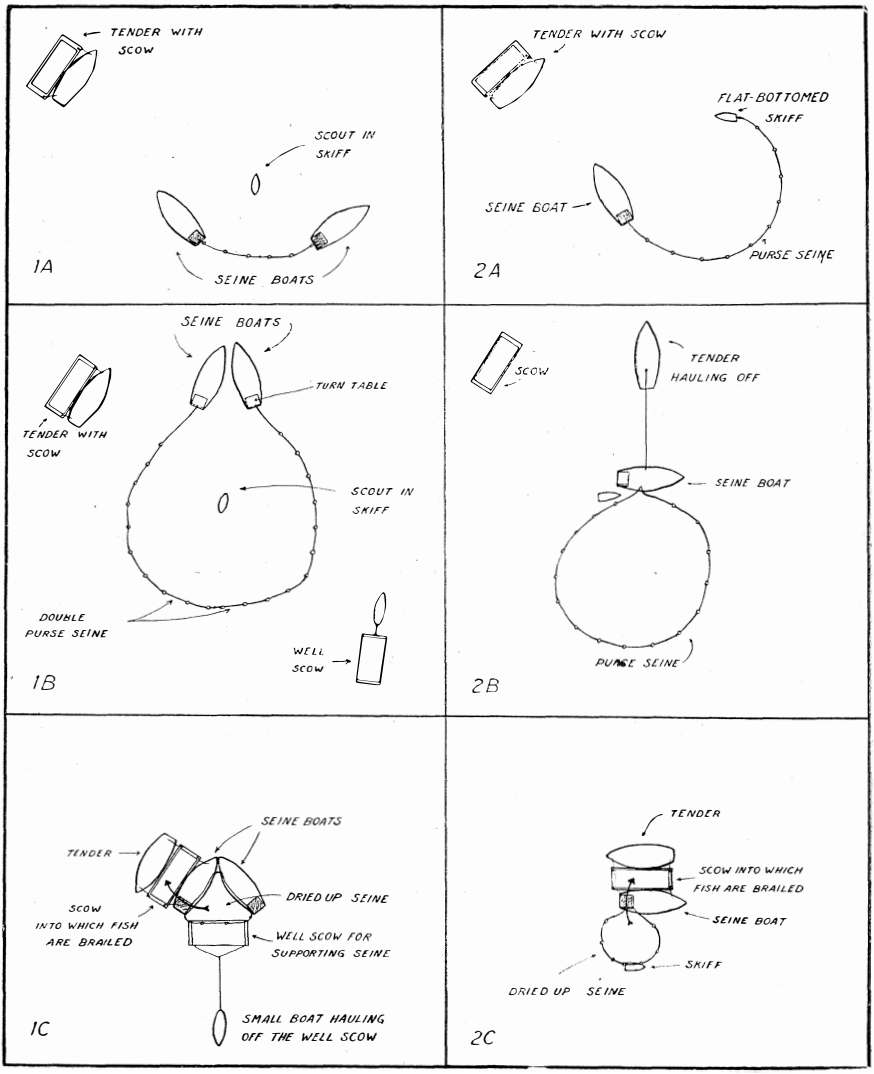

FIGURE 6. Double- and single-seine methods of fishing. Boats and seines are not drawn to same scale.

A skiff is towed behind the seine boat while scouting for fish. The skiff line is fastened to a loop in the cork line of the net to which is also fastened the breast line and the lead line. The lines from the other end of the seine, which is piled

on the turn-table with the roller facing aft, are made fast to the boat. When fish are located the skiff is set free from the boat and its occupant rows in the opposite direction to which the boat is going. This drags the net off the turn-tabel into the water and the seine boat describes a complete circle to starboard at full speed, passing around the school of fish (figure 6, 2A). The lines fastened to the skiff are then taken aboard the seine boat and both sets of lines are hauled as quickly as possible.

PURSING

In the double-seine method of fishing, once the net has been set, both boats quickly haul on their own ends of the purse line by means of power winches until the net is completely pursed and the lead line is brought to the surface and finally to the boats.

In the single-seine method, after the set has been made, the seine boat must be hauled-off by its tender by means of a steady pull on a line attached amidships on the opposite side to which the net is being pursed in order to prevent the seine boat from drifting over the seine (figure 6, 2B). The two ends of the purse line are passed over a roller at the middle of the boat and are hauled with a power winch until the whole lead line is brought aboard.

While pursing is in progress the fish are gradually enclosed on all sides except for the opening between the two ends of the net. Until the process is complete the fish are scared away from this opening by agitating the water with a long pole, an oar, or a board. Hauling on the breast lines prevents the ends from bellying out and enlarging this opening. When finally the ends of the net and the whole purse line are brought aboard, the fish are completely enclosed on the bottom and on all sides by the web.

DRYING UP

In "drying up", part of the net is hauled aboard until the fish are closely confined in the bunt. This is done by "fleeting in" the net, hauling it with the live roller, or hauling it by hand. In fleeting, a sling is put under a portion of the net close to the water: this is raised by means of the boom and winch to a position above the turn-table; it is then lowered and the net is piled on the turn-table ready for another set.

In the double-seine method, during the process of drying up, the bows of the two seine boats are lashed together and the sterns are held apart by a well scow. The bunt of the net, containing the fish, is thus suspended in a triangular opening, held up on two sides by the seine boats and on the third side by the scow. The latter is hauled off by a small power boat until the process of drying up is complete (figure 6, 1C).

In the single-seine method, as the net is being dried up, the Scotch buoys are adjusted by a man in the skiff to support those portions of the net subjected to the greatest strain by the weight of the fish. A considerable length of the cork line is supported by the skiff (figure 6, 2C).

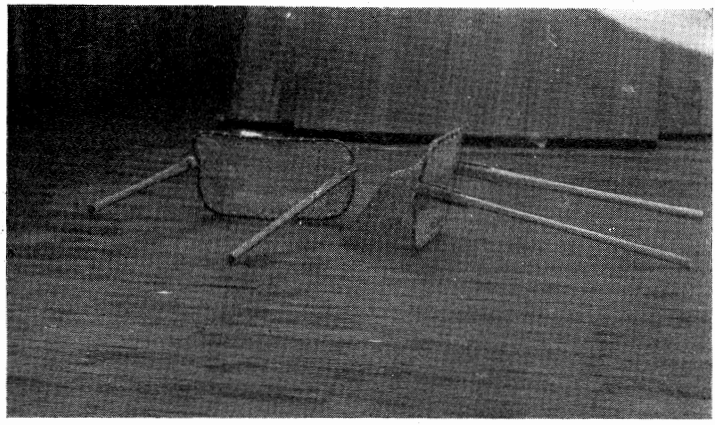

FIGURE 7. Hand-brailers used by Japanese fishermen on east coast of Vancouver island.

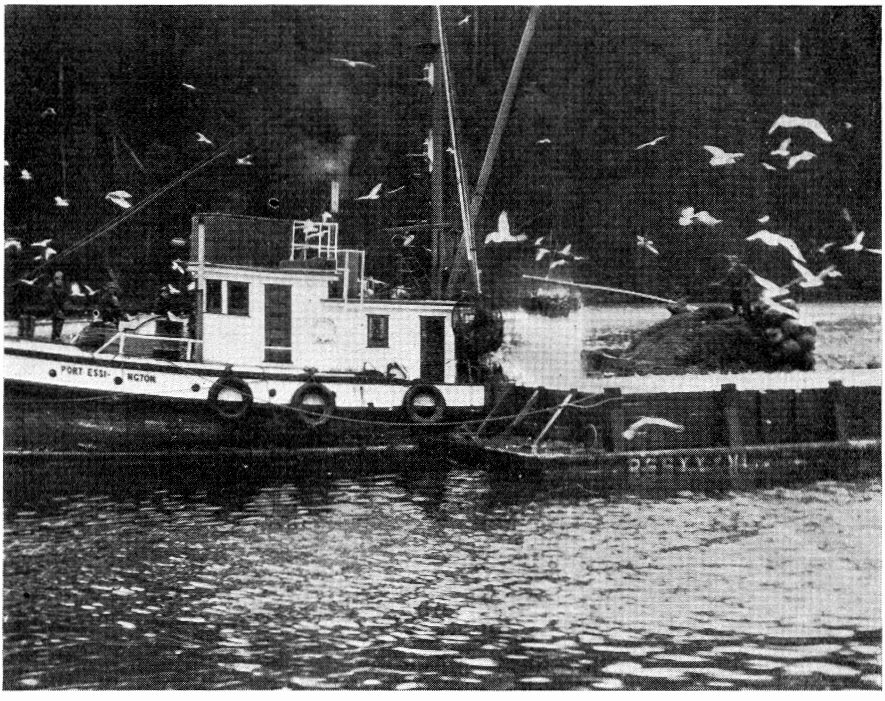

FIGURE 8. Fish being brailed from the net, across the seine boat and into the awaiting deck scow, Barkley sound.

BRAILING

Japanese fishermen on the east coast of Vancouver island brail by hand into a large well scow which is alongside supporting the net. The brailers consist essentially of a pocket of netting and two sturdy wooden handles attached to a rectangular metal hoop (figure 7). Two fishermen operate each brailer,

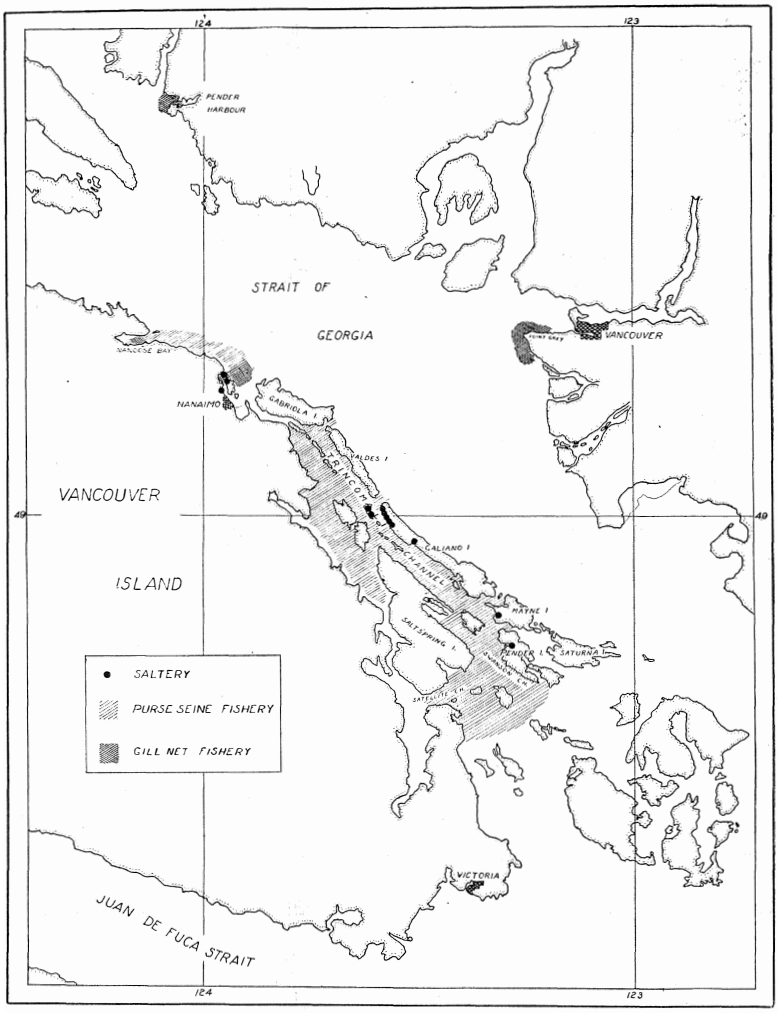

FIGURE 9. Location of fishing areas and salteries on the strait of Georgia. Only plants that have been active at some time during the past five years are indicated.

one at either handle. As many as thirty men line the side of the scow and scoop the fish from the net into it.

The usual type of brailer used by white operators consists of a large dip net on the end of a long pole. The bottom of the net is opened or closed by means

of a trip line attached to a brailing block. It is lowered into the mass of fish from a boom and is guided by means of the long handle. When full of herring it is raised with the power winch, moved across the seine boat by the boom and tripped when above the scow which is tied alongside the seine boat on the opposite side to the dried-up net (figure 8).

TRANSPORTING THE FISH

When the well or deck scows are loaded, they are towed either behind or alongside the tender to the plant. They are usually covered with netting to

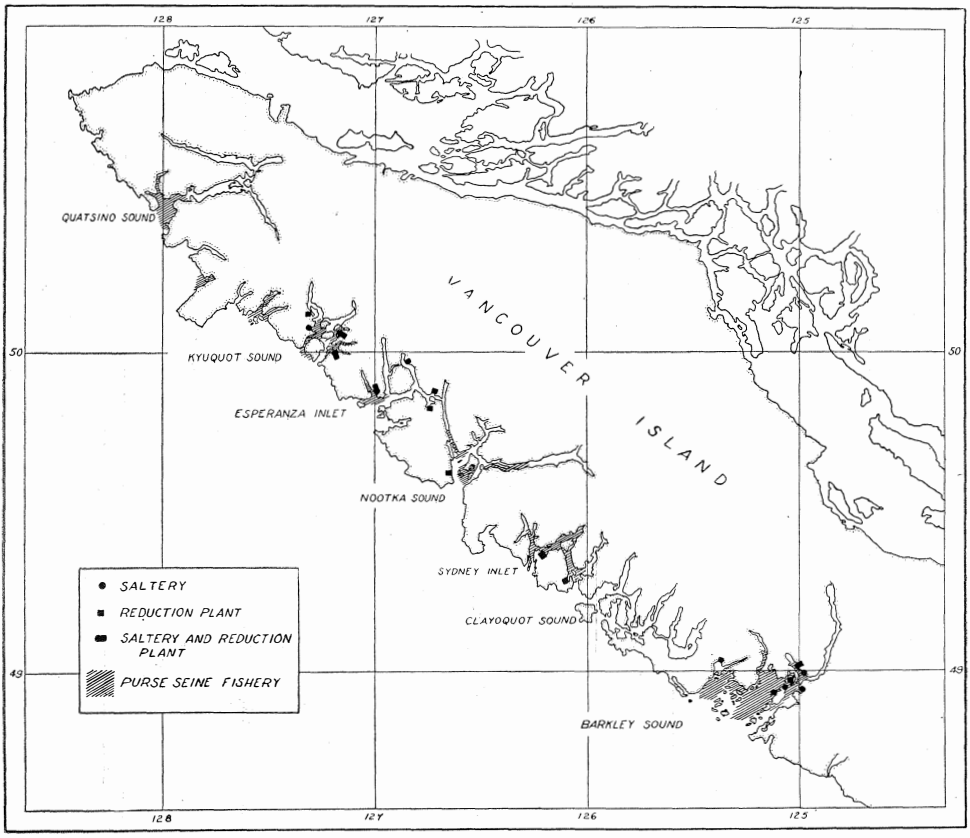

FIGURE 10. Location of fishing areas, salteries, and reduction plants, on the west coast of Vancouver island. Only plants that have been active during the past five years are indicated.

prevent the thousands of gulls which are congregated on the fishing grounds from getting at the fish.

Scows are preferred for transporting fish, but if they are not available or if the fish are to be carried any great distance in the open sea, they are loaded into the holds of tenders or seine boats.

In purse-seining for herring a single set usually captures from 25 to 100 tons of fish, the quantity depending on the size of the school and on whether the single or double type of gear is used. In some instances catches of over 200 tons have been landed but when such a set is made, the chances of bursting the net are considerable.

The purse-seine fishery of the east coast of Vancouver island is usually active from October to the beginning of January, and of the west coast from the beginning of November to February 5 when the season is officially closed.

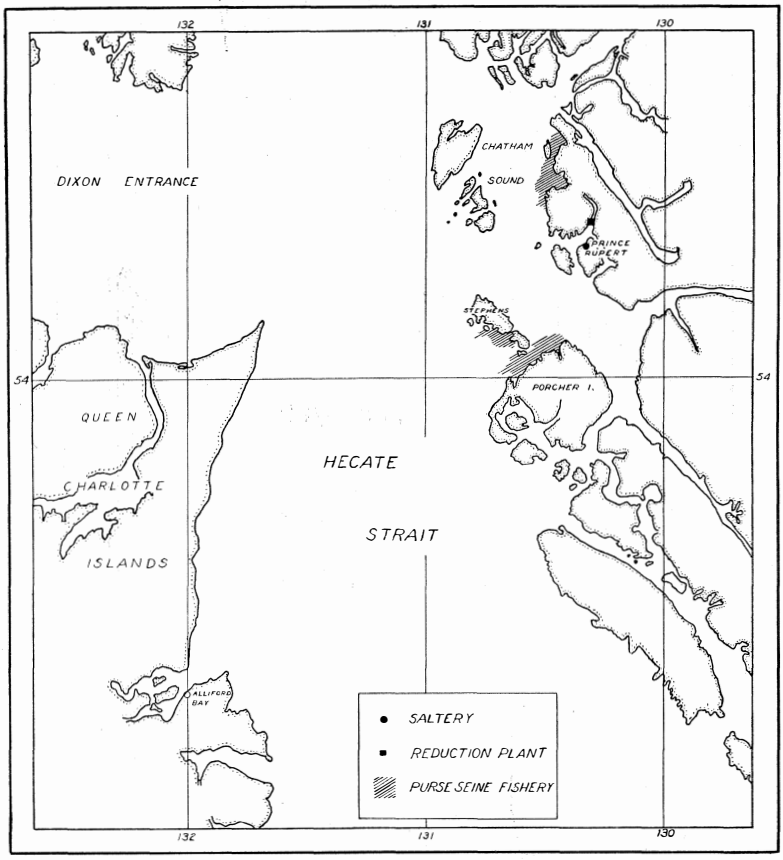

FIGURE 11. Location of fishing areas, salteries, and reduction plants in the Prince Rupert district. The saltery indicated at Alliford bay was the first erected in this district but has not been active for several years.

In the Prince Rupert district the fish appear somewhat later and the fishery is active during March and April. The locations of the fishing grounds in these three areas are shown in figures 9, 10, and 11.

MARKETED PRODUCTS

The beginning of the herring fishery of British Columbia on a commercial basis is described in the *Report of the British Columbia Fisheries Commission, 1905-07*, as follows:

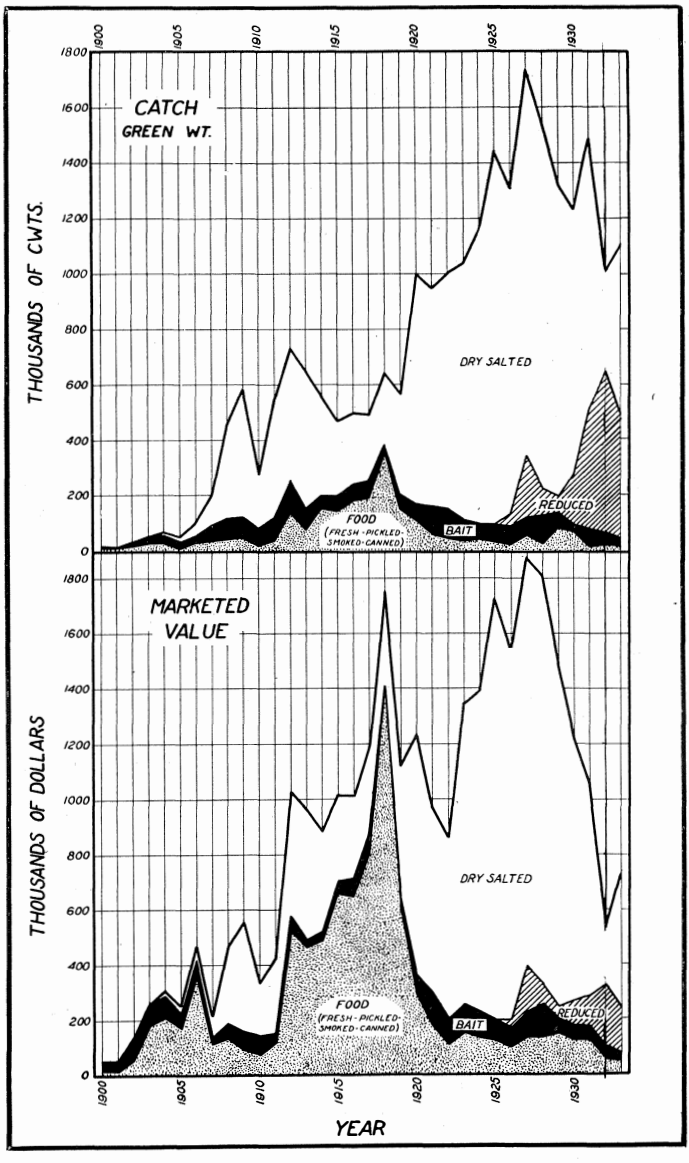

FIGURE 12. Annual catch in green weight and its marketed value from 1900 to the present. The proportions used for food, bait, dry-salting, and reduction are indicated.

"The superabundance of herring on the coasts of British Columbia has been recognized from early times; but as the local demand was insignificant, no herring fishery can be said to have existed until about thirty years ago, when the pioneers in the business, Messrs. Holbrook and Co., of New Westminster, cured (in 1887) between 500 and 600 barrels of herring, which they exported to South America."

From 1887 to 1900 the quantity of "green" (raw—as landed) fish used in the industry slowly increased from about 1,500 to 10,000 cwt. Since the beginning of the present century the annual catch has undergone a phenomenal increase from 10,000 to over 1,000,000 cwt. with a corresponding increase in the marketed value. At the present day the quantity and value of this catch depend almost entirely on the demand and, hence, on existing economic conditions. A decrease in marketed value from $1,867,429 in 1927 to $536,491 in 1932 has been largely due to these causes.

The annual catch in green weight and the corresponding value of each marketed product and of the total are shown in figures 12 and 13. These figures are compiled from data given in the *Annual Reports of the Fisheries Branch, Department of Marine and Fisheries* and *Fisheries Statistics of Canada*. As the records from 1900 to 1910 are inadequate, the proportions used for various purposes shown in figure 12 are only approximate. The records from 1909 to 1916 represent the catch for the fiscal year which includes an entire herring fishing season, but the records for all other years represent the catch for the calendar year. As fishing takes place mostly from October to February inclusive, the catch for the calendar year includes the latter half of one season and the first part of the next. For the sake of uniformity, the quantity used for each product is expressed in green weight using the following conversion factors:

1 cwt. dry salted	=1.25 cwt. green
1 barrel bait	=2 cwt. green
1 barrel pickled or salted	=2×1.25 cwt. green
1 cwt. smoked	=2 cwt. green
1 ton meal	=110 cwt. green

These approximate conversion factors are sufficiently accurate to enable the proportions of raw herring used for various purposes to be traced from 1900 to 1933.

In the following pages, the historical development and fluctuation of each marketed product is discussed under a separate heading.

Fresh

Fresh herring have been used as food since early times. The commercial fishery for fresh herring was at first dependent on drag-seines but since 1905 gill nets have been used almost exclusively to supply the local markets. Previous to 1905 large quantities were occasionally shipped to Seattle in a fresh or frozen state but, because of the difficulties of proper preservation, the Fisheries Commission (1905-07) recommended that this practice be prohibited. At the present

day, with the development of faster boats and better facilities for preservation, a few tons are occasionally exported fresh or frozen to this market. The quantity used in a fresh state has varied from 10,000 to 100,000 cwt., the demand being greatest from 1913 to the close of the Great War in 1918. A slight increase in the quantity consumed occurred in 1929 but it has fallen off since that year. From 1912 to 1918 the marketed value of fresh herring averaged about $350,000. In recent years, however, the value has been lower, averaging $68,000 from 1919 to 1930, and $26,000 from 1931 to 1933.

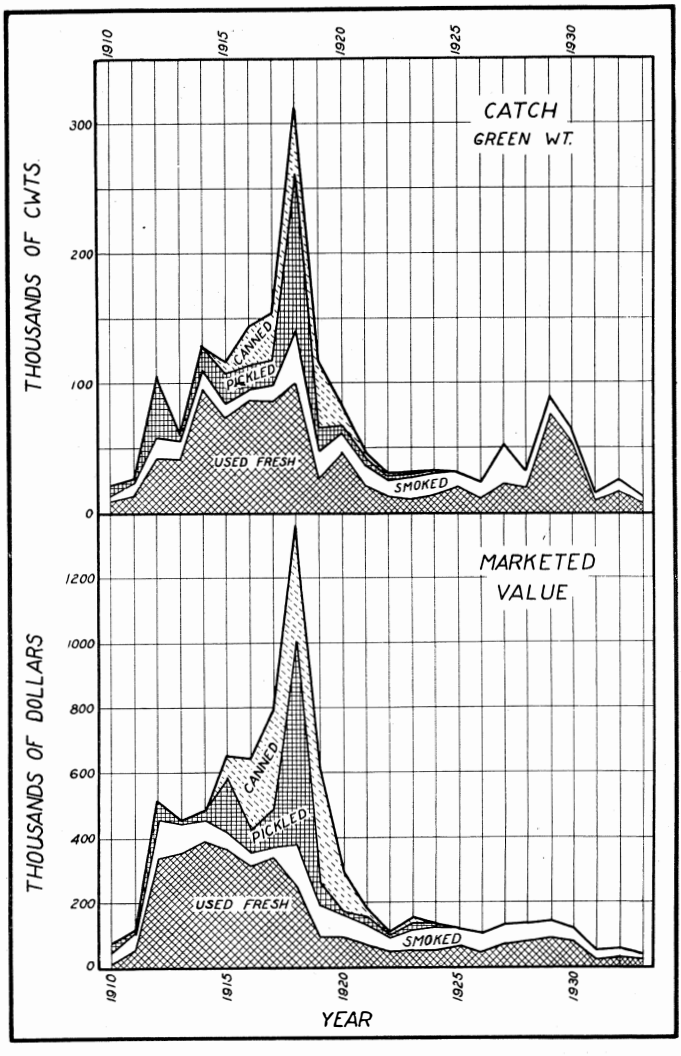

FIGURE 13. Quantities in green weight, and the marketed values of various herring food products (exclusive of dry-salted herring) since 1910. Note that the upper scale is four times as great as the lower.

SMOKED

Ever since fishing began on a commercial scale there has been a limited local market for smoked products, including bloaters, kippers, and boneless herring. *Bloaters* are herring which are smoked in the round, without gutting. Large fish, preferably not too fat, are selected; these are first salted, either dry or in brine, for a few hours; they are then placed in a smoke house and smoked lightly using the sawdust or shavings of alder, although birch is preferable if it is available. *Kippered herring* are first split down the back from head to tail and are cleaned; they are then placed in a brine for about an hour after which they are smoked lightly. The amount of salting and smoking depends on the preferences of the consumer and the length of time the product is to be kept before marketing. Frequently kippers are frozen for preservation. "Hard-cured" bloaters, fish which have been pickled in brine, drained, and heavily smoked for three or four weeks, are used in the manufacture of *boneless herring*. By removing the head, backbone, belly bones, skin, and fins from a hard cured bloater, two strips of flesh are left which are practically boneless. The method of preparation of the above and other herring food products are described in more detail in the August (1934) issue of the periodical, *Western Fisheries*.

The quantity of herring used for these purposes has averaged annually about 15,000 cwt. with a marketed value of $60,000. The largest pack, 39,000 cwt. with a value of $131,766 was put up in 1918. Since that time the quantity of fish used and the marketed value has decreased to about 5,000 cwt. and $20,000 in 1933.

PICKLED

Although there are several methods of pickling herring, the most satisfactory results seem to be obtained by that which has been in use for many years in Scotland. According to the Scotch method the herring are first graded according to size and condition and are then cleaned by removing the head, gills, front fins, and intestine with one stroke of a short, sharp knife. The fish are then roused or turned over in salt and are packed in barrels in layers, each layer being sprinkled with salt. The barrels are allowed to stand for three days after which more fish which were processed at the same time are packed in the tops; and the barrels headed. After ten days or so the barrels are opened, the brine drained from a bung hole in the side, the barrels filled tight with herring of the same day's curing, the head replaced and the brine put back through the bung hole.

The pickling industry in British Columbia received a considerable impetus in 1905 and 1906 when the government sent Mr. J. J. Cowie and a staff of expert Scotch-curers to Nanaimo to demonstrate the Scotch method of curing. During the war when almost any kind of herring were in demand markets for British Columbia Scotch-cured herring were developed in Puget sound, San Francisco, Chicago, New York, and Australia. The quantity of fish used in this process and the value of the marketed product increased rapidly until 1918, when 123,000 cwt. (49,127 barrels) with a value of $623,169 were put up. In this year

the value of pickled herring surpassed that of any other herring product. Over half of the total pack was cured in Barkley sound on the west coast of the island, a relatively new fishery which had made great progress since 1910. Other centres of the pickling industry at this time in order of importance were Vancouver and Pender harbour, Nanaimo district, and the Queen Charlotte islands.

Following 1918, the industry suffered a severe slump and from 1925 to 1933 but a negligible portion of the catch has been used in pickling. The value of the industry has dwindled from over half of one million dollars in 1918 to less than one thousand dollars at the present day. The immediate cause of the decline is summed up in the following quotation:

"Unfortunately, however, market conditions following the signing of the armistice, were greatly changed. During the war the Canadian trade with the United States and Australia improved greatly owing to the lack of European supplies. This drew a number of inexperienced packers into the trade during the winter season of 1917-18, with the result that a large proportion of the output was badly cured. With the ending of hostilities and the expected immediate resumption of trading in herring with Europe, the demand for Canadian herring fell off in the United States and much of the poorly packed fish remained unsold." (*Ann. Rep. Dept. Mar. Fish., Fish. Branch, 1918, p. 43.*)

The export trade suffered a final blow when the United States erected the Fordney-McCumber tariff which permitted herring to be shipped to the eastern states from Alaska at one cent per pound lower than the British Columbia product. It is stated by those having long experience in curing herring in this country and in Great Britain that another factor may be the unsuitability of winter caught herring generally for the markets using Scotch cured herring. Since that time the output of Scotch-cured herring has been limited to the demands of the local markets.

Canned

The first experiment in canning herring was made in 1903 with a pack of 3,500 cases. The experiment, however, was undertaken merely to utilize cans left over from a poor salmon season rather than to establish a canning industry. No further attempts were made until 1915 when the Wallace Fisheries Ltd., operating in Barkley sound, put up 11,468 cases with a value of $68,808. This industry made rapid progress in Barkley sound until 1919 when 46,156 cases were produced. Other canneries also became active at Vancouver and on the east coast of Vancouver island, increasing the yield in 1919 to 64,002 cases with a value of $345,571, and utilizing about 51,200 cwt. of green fish or 44 per cent of the total quantity used as food exclusive of dry-salted herring. In the years following the Great War, this industry also suffered a severe decline, however, and by 1924 had dwindled to negligible proportions. With the exception of 43 cases in 1931, no herring have been canned from 1927 to 1933.

Dry-salted

Dry-salted herring have usually been regarded as an inferior product and the value per hundredweight of green fish has always been considerably lower

than that of other herring food products. Fish prepared in this way are marketed only in the Orient, chiefly in China.

The industry began in 1904 when 4500 cwt. of salted fish were shipped to Japan for the first time. In the following years the quantity of fish used for this purpose increased rapidly. One of the most important centres of the industry from early days to the present has been the south-east coast of Vancouver island. Numerous salteries were erected in the vicinity of Nanaimo. Smaller quantities of fish were used in dry-salting at plants located near Victoria on the island and at Pender Harbour, Vancouver, and New Westminster on the mainland. However, the fishery on the south-east coast of Vancouver island has always surpassed these others and has been of paramount importance.

In 1911 dry-salting began on the west coast of Vancouver island at Clayoquot sound and Barkley sound. The industry in the latter area increased rapidly and from 1918 to 1925 rivalled that of the east coast. Since 1925, however, the pack from Barkley sound has gradually decreased. From 1923 to 1931, small quantities of herring were dry-salted in other localities on the west coast—Kyuquot sound, and to a lesser extent, Esperanza inlet and Clayoquot sound.

The first saltery was erected in the northern part of the province in 1912, at Alliford bay on the Queen Charlotte islands. Following this, others were built on the mainland near Prince Rupert. Although small quantities were exported in subsequent years, mostly from 1923 to 1929, the industry has never proven a success in this locality.

Unlike other food products, the dry-salt pack suffered a decline during the period of the Great War. Even in these four years, however, the quantity of green fish used for this purpose averaged almost 50 per cent of the total catch. With the decline of markets for Scotch-cured herring following the war, more attention was paid to the dry-salted product. The quantity of green fish used increased rapidly from 216,000 cwt. in 1918 to 1,340,000 cwt. in 1928 and the value from $346,908 to $1,489,501. In 1925, 94 per cent and in 1928, 86 per cent of the total catch was dry-salted. From 1928 to 1933, as a result partly of the unsettled political situation in China and Japan, partly of the economic depression, and partly of uncontrolled marketing conditions, both the quantity of fish used and value of the product decreased considerably.

It was mentioned previously that from 1918 to 1925 the output from Barkley sound rivaled that of the east coast of Vancouver island, but had decreased in recent years. In figure 14 is given the seasonal catch of herring used in dry-salting on the east and west coasts of Vancouver island from 1926-27 to 1933-34 (compiled from bulletins issued by the Department of Fisheries at Vancouver). The seasonal catch is more representative of the fishery each year than that of the calendar year for the latter includes the second half of one season and the first half of the next. The curve for the east coast dry-salt production shows a decrease from 1928-29 to 1932-33 with a slight increase during 1933-34. The curve for the west coast of the island, while reflecting mostly the catches made in Barkley sound during the seven seasons, also includes fairly large catches

landed at Kyuquot sound from 1927 to 1931 and small catches landed at Esperanza inlet from 1928 to 1930. The catch for 1931-32, while landed and cured in Barkley sound, was obtained in part at Sydney inlet. This curve illustrates a more or less steady decrease in dry-salt production in Barkley sound from 1926-27 to 1933-34. This decrease has been partly the result of economic conditions. In the struggle for markets during the last few years, east coast operators have been favoured by the fact that fishing usually starts about a month earlier on the east coast as compared with the west coast of Vancouver island. However, it must be pointed out that, during certain fishing seasons in recent years, herring have been rather scarce in Barkley sound. The run appears to be more erratic both in regard to abundance of fish and time of appearance than that of the east coast. This factor may have contributed partly to the decline illustrated in figure 14.

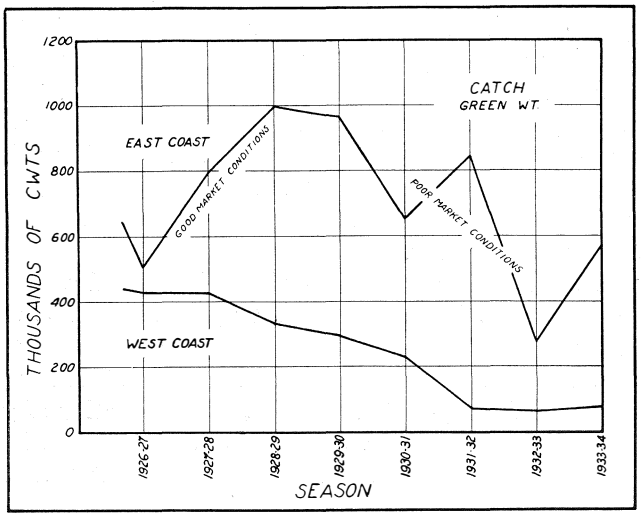

FIGURE 14. Seasonal catch of herring used for dry-salting on east and west coasts of Vancouver island from 1926-27 to 1933-34.

Dry-salted herring are cured "in the round". Under the present regulations they must be in the salting tanks within 24 hours after being taken from the sea. The fish are removed from the boats or scows by means of conveyors into which they are pushed or shovelled (figure 15). In the process of unloading, the water must be allowed to drain from the fish. The conveyor is usually an adjustable elevator of some kind. In the type of conveyor usually employed the fish are moved up an incline into the saltery by a series of parallel wooden or metal bars fastened to an endless chain in a trough (figure 16). From the elevator they are conveyed along the undersurface of the roof of the saltery to the tanks. The tanks are usually arranged in one or two series on either side of this aerial conveyor and are filled by means of inclined chutes leading from it (figure 17).

Each tank is made of heavy 3-inch planking and is 19 to 20 feet long, $8\frac{1}{2}$ to $10\frac{1}{2}$ feet wide and 3 to 4 feet deep with a capacity of about 12 to 14 tons. There may be as many as 40 or more individual tanks to a saltery. They must be water-tight and so the cracks between the planks are caulked; frequently they are lined with canvas. As the tanks are filled, about 70 sacks each containing 125 lb. of coarse-ground commercial salt, are added. The salt extracts water from the fish forming a brine which must be kept over 90 per cent saturated. The fish must remain in the brine for five or six days, depending on the season, and must be stirred or trampled frequently to insure perfect pickling of the upper layers. At the end of this period the herring have lost about 30 per cent of their moisture content and present a shrivelled or shrunken appearance. Their

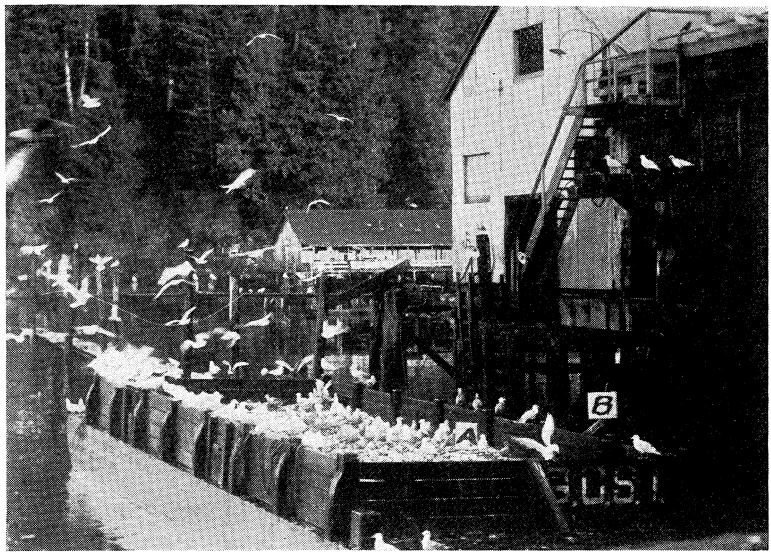

FIGURE 15. A scow-load of herring waiting to be unloaded at Kildonan, Barkley sound. Planks (A) are removed from the side of the scow and the fish are unloaded into a trough at the base of the conveyor (B). The gulls constitute a real nuisance to the industry and scows must be covered with nets to prevent these birds from foraging.

proper preservation depends on this dehydration and on the permeation of salt into the tissues. They are then removed from the tanks, allowed to drain for 24 hours, and are ready for packing.

The boxes for shipment are of standard size, 42 inches long, $24\frac{1}{2}$ inches wide and 14 inches deep, with a capacity of about 4 cwt. The cured fish are shovelled into these boxes, sprinkled with salt, packed tightly by trampling underfoot or by a specially constructed machine and the lid is nailed in place. The boxes are then ready for shipment.

In the early years of the dry-salting industry the pack was of inferior quality. There were no regulations governing the methods of curing and frequently the

fish reached the Oriental market in a poor state of preservation. Within the last few years, however, the value of the industry has been realized and the herring have been subject to a rigid government inspection throughout the whole dry-salting process, from the time they leave the scows or holds until they are packed in the boxes. The brine saturation is checked daily. A record is kept of the date on which each tank is filled and emptied. Before exportation, the packer must obtain a formal certificate of inspection from the local government official. The present regulations insure the proper preservation of the marketed product.

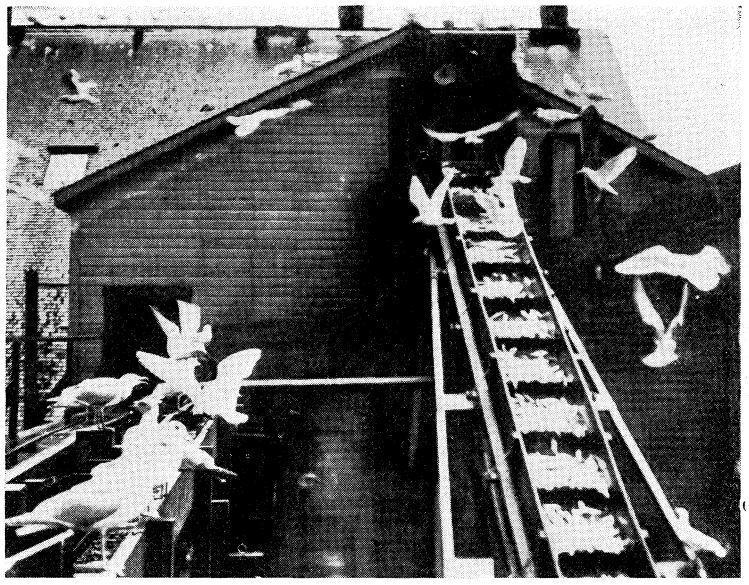

FIGURE 16. Herring being conveyed into a saltery at Kildonan in Barkley sound.

REDUCED

The first reduction of herring into oil and meal—or guano as it was then called—in British Columbia, dates back as early as 1890. In 1905 about 40,000 cwt. were seined and used for this purpose "to the great detriment of the legitimate fishermen and packers, as the immature fish were taken in large quantities, and the schools broken up on their way to the spawning grounds. Large quantities of fish were also killed and left to decompose, thus fouling the waters" (*B.C. Fish. Comm. Rep. and Rec., 1905-1907, p. 47*). Thus the practice was considered a "useless waste" and was forbidden by law following the investigation of the commission.

In recent years, science has discovered new uses for oil and meal which have enhanced their value and have created a demand for them (see Bulletins 36 and 37 of this series). The reduction of fish can no longer be described as a "useless waste". This fact was realized in 1925 and, in January of that year,

the use of herring for reduction was permitted in localities where fish were not used extensively for other purposes. This included the Vancouver and Prince Rupert districts but excluded Vancouver island, the centre of the dry-salting industry. Since 1927, the reduction industry has developed in the vicinity of Prince Rupert. The greatest production up to the present occurred in 1930 when 182,000 cwt. of green fish were reduced, the resulting oil and meal having a combined marketed value of $85,471.

In the fall of 1926 reduction privileges were extended to include the west coast of Vancouver island where pilchard reduction plants were already located and where only a limited amount of dry-salting took place. Operations were restricted however to the period between the beginning of the season in the fall and the end of December. In the fall of 1927, 154,000 cwt. and in the fall of 1928, 39,000 cwt. of green fish were reduced in this region. During the year 1929 no reduction was permitted. The following year it was again allowed, and, as the herring were unusually late in arriving on the fishing grounds, the time limit was extended to February 5, with additional extensions beyond this date in 1931 and 1932. In the last few years, until the recent closure to reduction (1934-35), the output from this area increased considerably and exceeded that of Prince Rupert.

It might be pointed out that the reduction of herring on the west coast of Vancouver island is not an independent industry and is only incidental to pilchard reduction. The latter is active during the summer months. The fishing and reducing of herring in the winter months, using the same boats, gear, and equipment as the pilchard fishery, enables the operators to keep the plants in operation and to keep men employed during several months of the winter, and, at the same time, to make a small margin of profit on the winter's activities. The profit in herring reduction as compared to pilchard reduction is relatively less because of the low oil content of herring in the winter season.

A detailed description of a reduction plant and the processing of fish has been given in Bulletin 36.

It has been shown that there are two centres of the reduction industry in British Columbia—the Prince Rupert district and the west coast of Vancouver island. In 1932, the quantity of herring reduced, for the most part in the latter locality, formed 60 per cent of the total catch of herring in the whole province. This high percentage was caused by an actual increase in the quantity reduced and by a decrease in the quantity used for dry-salting. In 1933, the quantity reduced formed 41 per cent of the total catch of herring. In this year, the meal amounted to 4,078 tons with a value of $127,416 and the oil to 316,213 gal. with a much smaller value, $38,073. The chief markets for these products have been in Canada, United States, South America, Europe, and Australia.

Bait

Since early times there has been a steady annual demand of herring for bait by halibut fishermen, and to a lesser extent by ling cod fishermen and

salmon trollers. From 1900 to 1933 the quantity used annually for this purpose averaged 50,000 cwt. with a value of $60,000. In the Prince Rupert district in past years there have been acute scarcities of herring for bait but these occurred when the operators used drag seines and waited for the fish to enter the shallow water of Prince Rupert harbour. The purse seine fishery of recent years has usually supplied a sufficient quantity to meet the yearly demand. The availability of herring to the halibut boats has also been increased by the use

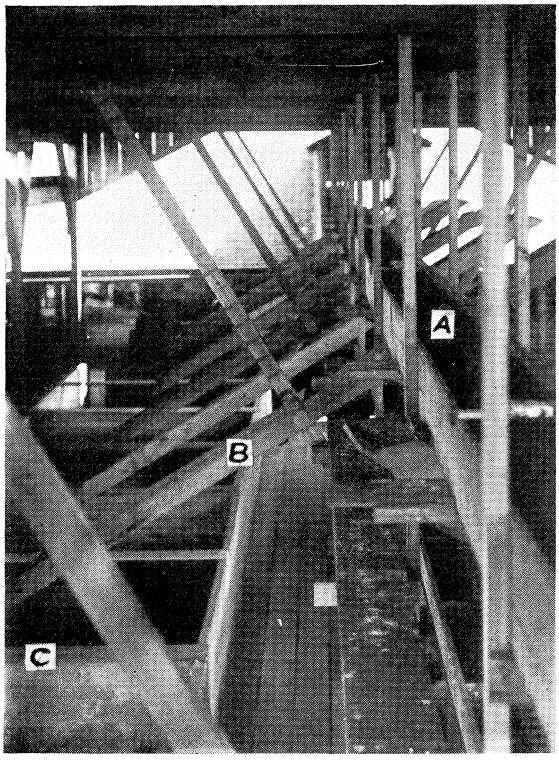

FIGURE 17. The interior of a saltery at Jessie island, showing the aerial conveyor (A) and the chutes (B) leading to the salting tanks (C), Departure bay.

of cold storage plants at Prince Rupert and at Kildonan in Barkley sound, and by the establishment of several bait pounds located on the south-east and north-west coasts of Vancouver island and in the Prince Rupert district. Bait pounds are large enclosures in shallow water in which up to 200 tons of live herring may be kept until they are needed by the fishermen.

COMPARATIVE VALUES OF MARKETED PRODUCTS

In the preceding section it was shown that the history of the development of the herring fishery of British Columbia has involved a constant struggle for

markets. The Great War stimulated an enormous development of herring food products consisting of pickled, smoked, canned, and fresh herring, the quantity of green fish used for these purposes amounting to over three hundred thousand hundredweights and the marketed value reaching a peak of one and one-quarter million dollars in 1918. Since the war the quantity of fish used in this way has dwindled to negligible proportions. The annual catch has continued to increase however, and during the last ten years it has averaged over one and one-quarter million hundredweights. This increase has been the result of the phenomenal development of the dry-salting, and more recently, of the reduction industry. It may be of interest now to consider briefly the economic phase to obtain some idea of the comparative values of the marketed products and to decide which should be encouraged from this point of view.

Using data contained in *Fisheries Statistics* and the conversion factors given on page 19, the marketed values per hundredweight of green fish were calculated for each year from 1924 to 1933. The results for the principal products are shown by a series of graphs in figure 18. It is very apparent from the figure that the ultimate value of one hundredweight of green fish varies greatly according to how it is prepared for the market. Aside from minor fluctuations, over the ten-year period the products may be arranged in order of marketed value as follows: pickled, smoked, fresh, bait, dry-salted, and reduced.

Pickled, smoked, and fresh herring bring the highest values of the six products under consideration, although at present the quantity of herring used for these purposes forms but a very small portion of the total catch. For the most part these products are sold locally and the retail prices have fluctuated greatly according to the demands of the local market and the local availability of herring. From an economic point of view the production of these three commodities should be encouraged. The herring caught by gill-netters off point Grey are among the largest, fattest, and best herring found in British Columbia and are therefore ideal for use as food. If additional markets could be developed there is little reason why the cured herring industry at least, should not flourish and increase far beyond its present output and value.

Herring sold for bait rank fourth in value per hundredweight of green fish. As small firm fish are most suitable for this purpose this commodity fits into any scheme for the most advantageous utilization of the catch. Both the halibut fishery and the spring and coho salmon fisheries are partly dependent on an adequate supply of herring. The price has varied according to the availability of fish and the demands for bait.

Over the ten-year period dry-salt herring have averaged about one dollar per hundredweight of green fish and have ranked fifth in value. The graph in figure 18 shows a relatively stable market with a steady fall in value during the recent "depression" years to a minimum of 64 cents in 1932. It must be remembered, however, that the total marketed value of this product has exceeded all others during all years except 1932.

The marketed value of the reduced products—oil and meal—per hundred-

weight of green fish has been consistently the lowest of all product values. The combined price of oil and meal has fallen gradually from 79 cents in 1927 to 34 cents in 1932 increasing slightly in 1933. Again it must be pointed out, however, that the total marketed value has increased greatly during this period and in 1932 exceeded that of the dry-salt product.

It is clear, therefore, that while almost the entire catch is absorbed by the dry-salt and reduction industries, and while the total marketed values of the products of these two industries greatly surpass all others, the ultimate values per hundredweight of green fish are the lowest. Nevertheless, because of market

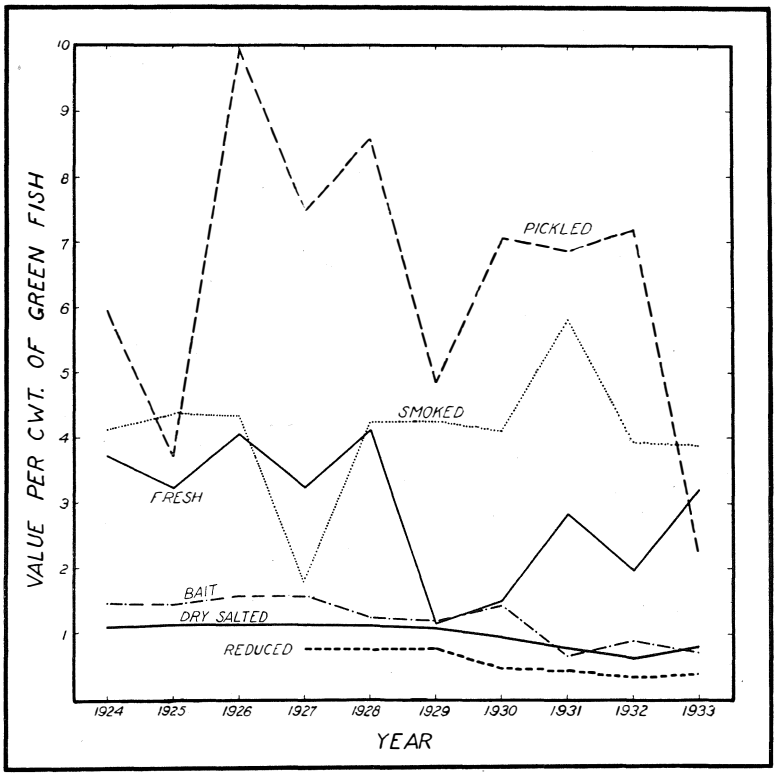

FIGURE 18. Ultimate marketed values of various herring products per cwt. of green fish.

conditions, they are at present of prime importance and the relative merits of each from the point of view of the most advantageous utilization of the supply of herring should be considered in detail. This would involve a comprehensive investigation of the total cost price of each commodity and a comparison of cost price with selling price. The cost price should include such expenses as the initial cost of fish as purchased from the fishermen; cost of unloading; cost of labour during processing; depreciation on machinery, boats, and gear; cost of upkeep, fuel and repairs; insurance on plants and boats; cost of salt and boxes

for the dry-salt product and cost of sacks for the meal. Such a survey, however, is beyond the scope of this paper. A rough idea of the money actually brought into the country by the sale of each commodity may be obtained by deducting from the selling price, expenditures made in other countries in connection with the processing of the fish. Without taking into consideration capital expenditures such as the purchase of machinery, the main items include the cost of commercial salt in the case of the dry-salted herring and the cost of repairs to the imported machinery and of fuel oil to run this machinery in the case of reduced herring. Considering only these foreign expenditures, the money brought into the country per hundredweight of green fish by the reduced product was, in 1932, only 40 per cent, and in 1933, only 58 per cent of that brought in by the dry-salted product. The returns, from an economic point of view, are therefore greater when the herring are dry-salted even under present market conditions which are particularly unfavourable to this product. Were these market conditions remedied, the value of the product and the returns both to the operators and to the country as a whole would increase considerably.

If herring occur in a certain locality in an abundance sufficient to supply the fishery there seems to be no reason why all or any one of the various methods of processing should not be employed, providing the stock is not being depleted unduly. For it must be remembered that fish are continually dying from natural causes, and if the surplus over the quantity necessary to propagate the species satisfactorily were not taken by the fishery, it would be wasted. However, if there is competition for a limited supply of fish, it is reasonable that those industries which yield the greatest profit, not only to the operator but to the country as a whole should be encouraged, provided there is a sufficient market to absorb the commodities.

FLUCTUATIONS IN ABUNDANCE AND SIZE OF HERRING

It has been shown that the size of the catches of herring are influenced almost wholly by market conditions. They do not, therefore, reflect to any great extent, fluctuations in abundance of the fish.

In the early years of the fishery there is no doubt that herring were extremely abundant in Nanaimo harbour. In 1903-04 the "run of herring at Nanaimo was very large. The water of the harbour was so full of them at one time, that large numbers were washed upon the beach by the waves of a passing steamer." (*Ann. Rep. Dept. Fish., 1904, p. 216*). Another reference states that,

"only last January, near Nanaimo, the coast was for two miles knee-deep with herrings, they were simply crowded on shore by millions more, on their way to the spawning grounds. The people were at their wits end as to what to do with them. They were carted to farms for manure, used for fuel, burned in heaps, buried, yet millions of fish lay on the shore to the danger of health." (*B.C. Fish. Comm. Rep. and Rec., 1905-07, p. 46*).

The superabundance of herring in Nanaimo harbour persisted for several years. Since 1910, there have been several noticeable fluctuations in the supply both

at Nanaimo and in other localities. Seasons of marked scarcity and great abundance have both occurred.

In 1910-11 there was a serious scarcity of herring at Nanaimo and in Barkley sound. In the former locality, although fish were reported in the strait of Georgia, they failed to enter the harbour. In 1915-16 there was a general scarcity in all localities, particularly at Prince Rupert and at point Grey. Poor runs to Barkley sound are reported during the fall of 1925, 1929, and 1931, although in the spring of 1930 the spawning grounds were well stocked with eggs by late runs of fish.

Seasons of exceptional abundance are recorded in 1912-13 at Prince Rupert harbour and in more southerly localities; and also in 1918-19 and in 1924-25 on the east coast of the island and in Barkley sound.

Noticeable fluctuations in the size of herring have also occurred. In 1907-08 at Nanaimo and in 1912-13 at point Grey, the fish were reported to be unusually large. When Sydney inlet, on the west coast of Vancouver island, was first exploited extensively in the season of 1931-32 the catches consisted of exceptionally large herring. During the early summer of 1933 and 1934 the gill-netted fish taken at point Grey were also unusually large.

Undoubtedly, the abundance and size of herring in the various fishing areas fluctuates from season to season through natural causes over which, at present, there is no control. On the other hand, the intensive fishing activities of the last twenty years may have been partly responsible for certain downward trends which may therefore represent a real depletion. Hence it is necessary to examine the fishery and its fluctuations from this point of view.

MOVEMENTS AND EXPANSIONS OF THE FISHERY

The onset of depletion through overfishing is frequently disguised by the exploitation of new areas. In other words, the fishermen are gradually forced to go farther afield for their catches. In the herring fishery of British Columbia, movements and expansions have taken place to some extent and must be investigated critically to determine the motivating causes.

As mentioned in the preceding pages, prior to 1910, fishing activities on the east coast of Vancouver island were centred at Nanaimo harbour and Departure bay. Herring entered these waters in such abundance each year, that fishermen had no difficulty in meeting the current demand. Following the scarcity of fish in the season 1910-11, with the exception of an occasional run (as in 1918-19) herring no longer returned to these areas in their former abundance. At the present day, they are no longer piled "knee-deep" on the shores of Nanaimo harbour and Departure bay at spawning time. There is but little doubt that the agency of man has either caused a partial destruction of the run or has caused a large part of the herring which formerly frequented these waters to spawn elsewhere.

With the employment of purse seines, fishing became possible in deeper water and the centre of activity moved to the more open waters of the strait of

Georgia, to Nanoose bay, and to the channels between the islands immediately south of Nanaimo. In recent years the fishery has moved still farther to the south. In 1929 it was stated that a feature of the operations on the east coast was "the seiner's practice, during the last three years, of going farther south and meeting the herring as they come round the south end of the island." (*Ann. Rep. Dept. Fish., 1929-30, p. 97.*) Although scientific evidence at present does not support that part of the statement concerning the migration of herring from the open sea to the strait of Georgia, the quotation serves to illustrate the changes which have taken place in the scene of fishing activities. While the increased catch has been accompanied by a slight expansion of the area of fishing and while the herring do not appear to be as numerous in certain localities at the present day as in the early years of the fishery, there has been no pronounced scarcity in this area as a whole in recent years, and the size of the catches are at present limited only by market conditions.

A local decline, similar to that at Nanaimo harbour and Departure bay, has also occurred in Prince Rupert harbour. In 1912-13 and previous seasons, herring entered the harbour sometimes as early as November or December in large numbers, and were easily taken in drag seines. In the season 1914-15 the schools came into the harbour, remained for two weeks, and then disappeared. In the following season, 1915-16, the fishing was a total failure and there was an acute scarcity of bait for the halibut boats. Since that time the fish have not arrived in this vicinity until late in the season, usually in March. Purse seines have replaced drag seines and the fishery has moved from Prince Rupert harbour to localities to the north and south. In February 1935, however, for the first time in many years, good catches were made in Prince Rupert harbour.

On the west coast of Vancouver island, fishing operations in Barkley sound until 1931-32 were confined to the channels, bays, and inlets of the sound proper. In 1931-32, local scarcities of fish led to the temporary expansion of the fishing grounds to include Sydney inlet, some distance to the north, where excellent catches were made.

The scene of fishing operations of seine boats supplying reduction plants and salteries in Esperanza inlet and Nootka sound has also undergone several changes in recent years. The following figures (furnished by Mr. A. Park, Fishery Inspector, Nootka, B.C.) show the estimated percentages of the catch taken each year in localities extending from Quatsino sound southward to Barkley sound.

	1927-28	1928-29	1929-30	1930-31	1931-32	1932-33	1933-34
Quatsino sd	..	..	..	..	..	..	14
Kyuquot sd	100	70	50	5	20	49	19
Nootka sd	..	30	50	95	20	8	1
Sydney in	..	..	..	..	60	38	+
Barkley sd	..	..	..	..	..	5	66

It is evident that there has been a gradual expansion of the fishery and a southward trend of fishing activities. Each year the centre of activity has tended to

move to the area of greatest abundance. The great expansion in the last two seasons has been the result of actual scarcities of fish in Nootka sound and adjacent waters.

From the above discussion it would appear that, in several cases, the movements and expansions of the herring fishery have been definitely associated with local scarcity or unavailability of herring. The poor fishing encountered in certain localities might quite possibly have resulted from the intensive fishing in preceding years.

CRITERIA OF DEPLETION

The degree or extent of migration of schools of herring has an important influence on the way in which overfishing will affect the fishery. If herring wander for considerable distances along the coast and free intermingling of the stock on a large scale takes place, the schools in a locality subject to intensive fishing would be supplemented by the migration of fish from other localities. Overfishing in one locality would gradually drain the stock of herring in all waters and would gradually result in a general depletion. If, on the other hand, extensive migrations do not take place and herring in each general fishing area are more or less localised, overfishing in a particular area would be manifested more quickly by a local depletion, as the local supply would not be replenished by the immigration of fish from adjacent waters.

Again, the reaction of a fishery dependent on a highly migratory species will be somewhat different to that dependent on one which is non-migratory. If a migratory species were being exploited over-intensely, fishing would continue until inadequate catches were made; more efficient gear might then be devised; fishing would continue until the species could not be further exploited profitably and a condition of *economic* extinction would be reached. In the case of a non-migratory species, however, the more accessible populations would first be fished to the point of economic extinction; gradually the fishery would expand to include the less accessible stocks; in the meantime the old fishing grounds would be traversed again and again and the remaining schools gradually captured until finally a condition of or approximating *biological* extinction would be reached.

Recent research by the author (*Trans. Amer. Fish. Soc., vol. 63, 1933*) has demonstrated that the herring of British Columbia is essentially a non-migratory species. Extensive migrations up or down the coast do not take place. The run to each locality tends to form a "local population" which is sometimes distinct in many ways from similar local populations in adjacent areas. Therefore, it is essential that overfishing be guarded against, for, as pointed out above, such a species is more quickly depleted and the consequences may be more disastrous than in the case of a species of the migratory type. The condition of the fishery should therefore be investigated with this in mind.

There are at least two methods by means of which the condition of a fishery may be investigated. The first of these depends on the complete analysis of catch records to obtain the reward per unit of fishing effort. In the case of the

herring fishery this would be expressed as the average catch per seine per day's fishing. A decrease of this unit over a period of years would indicate depletion. Until quite recently the method of collecting and recording catch statistics in this province has not yielded sufficient data to make use of this valuable measure of availability. At the beginning of the season 1933-34 the Biological Board, in collaboration with the Department of Fisheries, initiated a system of collecting herring catch statistics from which the reward per unit of fishing effort could be calculated. This system involves the recording of the daily catch of each seine boat in operation and the locality in which the fish were captured. When additional seasonal data have been gathered it should be possible to determine the condition of the fishery in each locality.

A second test of the condition of a fishery is afforded by a consideration of the length and age composition of the runs. Intensive fishing tends to reduce the numbers of larger and older fish in the catches. Naturally this results in an apparent increase in the abundance of smaller and younger fish. Over a period of years the effects of intensive fishing might appear as, (1) a decrease in average length, (2) a decline in length and age composition, the fishery becoming dependent on smaller and younger fish, and (3) a smaller spread in length and age distribution.

As the herring in British Columbia tend to form a series of local populations, any changes in length and age composition due to intensive fishing might be expected to appear more quickly than in the case of a highly migratory species. In our waters, the rate of natural mortality is evidently higher than in Alaska or Europe, for the normal age distribution is considerably smaller and the herring on the average are considerably younger. If a decline in length and age composition should take place, the fishery would come to depend more and more on the three-year-olds which have just entered the fishery and are ready to spawn for the first time.

A study of length and age composition to determine the condition of the fishery is complicated by variation in the abundance of members of each year class caused by natural causes over which at present there is no control. Exceedingly well-represented or "dominant" year classes frequently appear in the catches. In other fisheries these may persist and form the bulk of the catch for many years; in the herring fishery of this province they also occur but are less pronounced and usually do not persist for more than three or four years because of the high rate of natural mortality and the resultant small spread in age composition. Consequently it may be possible for intensive fishing to reduce the predominance or even obliterate such a dominant group prematurely, a possibility which must also be taken into account in investigating the condition of the fishery by a study of this kind.

PRESENT CONDITION OF THE FISHERY

An intensive biological study of the herring fishery has been in progress for only a short period and therefore only tentative conclusions with regard to

the condition of the fishery have been formed. The length and age compositions of the runs to the two most important localities, the south-east coast of Vancouver island and Barkley sound on the west coast of Vancouver island, have been subject to considerable investigation in this regard.

Data have been accumulated which show that certain changes in length and age composition have taken place in the fishery of the south-east coast which are very probably the result of fishing effort. Since 1915, apart from annual fluctuations, there has been a slight decrease in average length, a decrease in the spread of lengths about the average, and a decrease in the number of older fish present in the catches. Moreover, there is also evidence that the frequency of occurrence and the persistence of dominant year classes have been somewhat reduced in recent years. It seems therefore that the fishery has had some effect on these characters but it is not known with certainty as yet what the ultimate outcome would be, should fishing be maintained at a level of intensity similar to or higher than that of recent years. Age compositions of the catches for 1932-33 and 1933-34 have indicated some degree of recovery, possibly as a result of the curtailment of fishing activities due to economic conditions.

In Barkley sound three-year-old fish have predominated in the catches each season from 1929-30 to 1933-34. The fishery during these years, therefore, has been largely dependent on the new recruits which have been caught before they have had an opportunity of spawning. This young age group has not always predominated in this locality. In 1916, Dr. W. F. Thompson (*Rep. B.C. Comm. Fish., 1916*) found that five-year-old fish formed the bulk of the catch and that older fish were relatively better represented than at the present day. It would seem therefore that the herring population in Barkley sound has suffered a decline in length and age composition similar to or even greater than that in the case of the east coast herring. Again, however, the ultimate outcome is not known with certainty and the whole problem must be subject to additional research.

It is interesting to note that, in localities such as Quatsino sound on the west coast of Vancouver island and the coastal waters to the north of Vancouver island, older fish predominate in the runs, a condition which might be expected as these areas have been exploited only to a limited extent as yet.

Thus it would appear that the intensive fishing of recent years has had some effect on the length and age compositions of the runs and possibly on the abundance of the herring in the two localities exploited most intensely, in a manner which suggests some degree of overfishing. However, fishing activities in the last three or four years have been curtailed by unfavourable market conditions and this temporary relief may be of benefit in rebuilding the runs and in increasing the abundance and size of herring, particularly in Barkley sound.

FUTURE POSSIBILITIES

There exist many possibilities in regard to the development of markets and the improvement of methods of curing and canning of herring for food pur-

poses. With modern refrigeration, the markets for large fresh or frozen herring could be extended inland from the coast, provided that suitable regulations regarding freshness, packing and refrigeration were promulgated and enforced. By means of graders, the larger and fatter herring could be selected from the purse-seine catches to be used for food purposes as bloaters, Scotch-cured, kippered, boneless, Holland, Bismark or spiced herring. Canning alone offers many possibilities and improved methods should facilitate the production of a variety of low-priced, wholesome, and at the same time, delectable canned products which would find ready sale both at home and abroad. As the population of the country increases there will be a corresponding increase in the demand for superior sea-foods and among these, the herring, if suitably prepared, should assume a prominent position. With increased production the utilization of by-products from herring should become practical and present wastes such as herring roe, scales and livers may have economic possibilities as table delicacies, for the manufacture of artificial pearls and therapeutic extracts respectively.

With regard to the herring fishery of British Columbia, it seems highly probable that the fishing grounds are capable of considerable expansion to the northward. There are several areas which have not been exploited commercially to any great extent as yet and which offer many possibilities. Of these might be mentioned the region between the north-east coast of Vancouver island and the mainland, the coastal waters between this region and Prince Rupert, and the west coast of the Queen Charlotte islands. These potential fisheries await investigation and development should future economic conditions yield markets for the products.

Therefore it is possible that, under suitable administration and biological supervision, the catch could be increased with safety to even a greater extent than that of recent years. Exploitation, however, must be distributed throughout all areas according to the size of the runs and the intensity of fishing which each will withstand without endangering its perpetuity. Local and general depletion must be assiduously avoided for not only is the fishery itself a great asset, but the rôle of the herring as a food for other species is of inestimable economic importance to the province.