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Canada's Pacific herring

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CANADA'S PACIFIC HERRING



THE HOUSE THAT HERRING BUILT

Probably no fish has influenced the course of human history as much as the common herring. Down through the ages herring have determined the location of towns, evoked acts of parliament, caused wars—and created modern fish factories similar to that shown here. Their numbers are legion. The very word herring is derived from an ancient Teutonic term "heer" meaning an army; an apt description of the legions of these fish swimming through the water. *(Photograph of Reduction Plant courtesy of British Columbia Government.)*



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CANADA'S PACIFIC HERRING

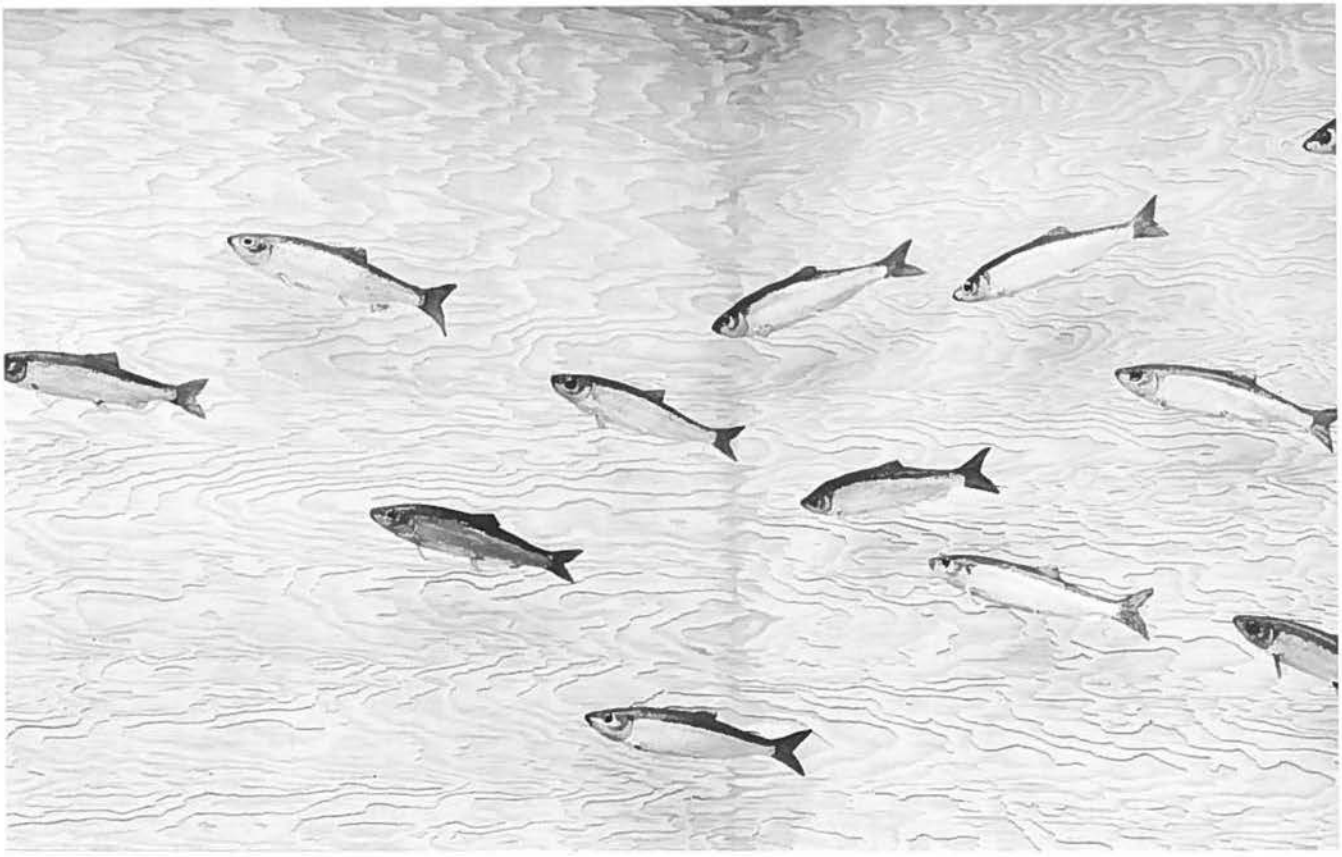
By Donald N. Outram

Fisheries Research Board of Canada, Biological Station, Nanaimo, B.C.

Photographs by C. Morley unless otherwise credited

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Canada's Pacific Herring

AT THE PORTALS of Canada's most westerly province lies the Pacific Ocean, a vast reservoir containing a bountiful array of plant and animal forms. The fish fauna alone consists of over two hundred and fifty species, big fish and little fish, flat fish and round fish, swift fish and slow fish, solitary fish and schooling fish. In the last category are herring, possibly the most plentiful of all. They form a natural resource that is renewable year after year with very little help from man. Since herring schools move to and fro in a submarine world their migrations, their fluctuations in abundance and their struggles to survive are not easy to fathom. Their annual migrations from offshore, summer feeding-grounds to inshore spawning-grounds bring this living resource within easy reach of man.

Scientifically, herring belong to the family *Clupeidae;* other Pacific coast representatives are the pilchard (California sardine) and an introduced species, the shad. Clupeoid fishes occur in enormous numbers and in addition to being important commercially, they are of incalculable value indirectly as a food supply for a great number of predatory fishes that are themselves vital to the fishing economy.

In 1847 the herring along the Pacific shores was officially classified as *Clupea pallasii* to distinguish it from the closely-related but somewhat larger Atlantic species *Clupea harengus.*

The Pacific herring is a bony, streamlined fish about eight inches long. The mouth is large with a slightly projecting lower jaw and the tail is deeply forked. The single dorsal fin is centrally-placed on a back blue-green in colour shading away to iridescent silver on the sides. Like most *Clupeoids* the Pacific herring have very oily flesh. A swim bladder enables them to adjust to any given depth. Herring are fast and graceful swim-

mers, characteristically travelling side by side in vast schools; single fish are seldom seen.

ANCIENT SOURCE OF FOOD

Undoubtedly, herring were among the first coastal fishes to be used by man. They have been a source of food since before written history, particularly in northern Europe. Along the Danish coast ancient shellmounds dating back to 3000 B.C. have been found to contain bone fragments of cod, eel, and herring. The existence of a herring fishery near Yarmouth, England can be traced back to 500 A.D. In 830 A.D. records indicate Dutchmen journeyed to Scotland to purchase salted herring. The influence of the humble herring on the economy and national history of the countries bordering the North Sea is widespread. Out of interest in herring have sprung merchant fleets, the expansion of trade routes, treaties and acts of parliament, town locations and wars. In 1429, a struggle known as the Battle of Herrings was fought over a convoy of salted herring being sent as food to an army besieging the French town of Orleans.

Elsewhere in the world, herring fisheries have never attained the importance of those in Europe. Along Canada's Atlantic seaboard the herring fishery developed along with the cod fishery. The herring were used as bait by early French, Spanish and Portuguese fishing fleets.

The role of the herring in the early history of the west coast of Canada is not as well documented as the European and the Canadian Atlantic fisheries. Undoubtedly herring and herring roe were a source of food and an article of barter among Pacific coast Indians for centuries, possibly as far back as 800 B.C., the date of the earliest known coastal site. Sites in the adjacent interior in the Fraser Canyon show evidence of fishing, presumably for salmon, as long as 9,000 years ago.

The first written record of the presence of herring schools in British Columbia waters appears in the diary of Archibald Menzies, naturalist, aboard H.M.S. *Discovery* (Fig. 1) commanded by Captain George Vancouver. While mapping

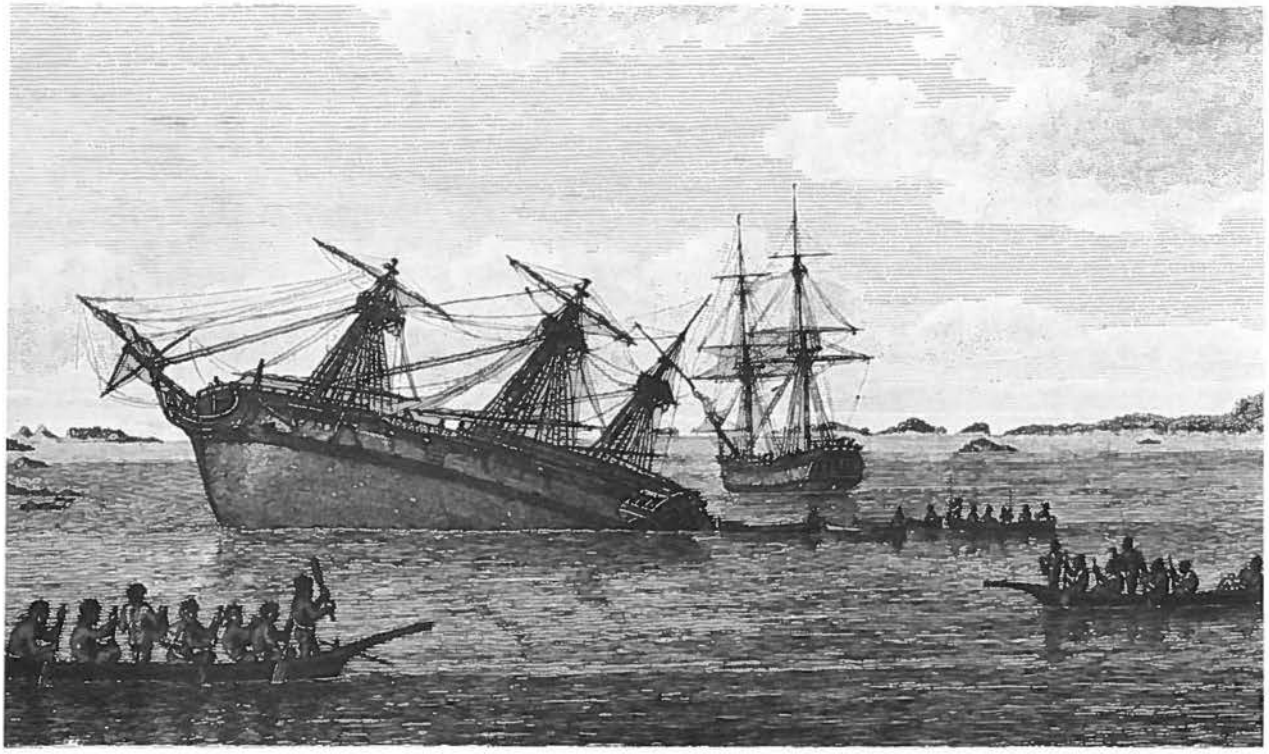


Figure 1. H.M.S. DISCOVERY—This well-known exploratory vessel was engaged during the 1790's in charting the then little known west coast waterways. Records of a naturalist aboard this boat were the first to note the presence of herring schools in local waters. This old steel engraving shows H.M.S. Discovery aground in Queen Charlotte Strait.



Figure 2. HERRING HAUNTS—An aerial view of the northern portion of the "Gulf Islands" archipelago. Amid island-studded waterways like Trincomali Channel shown above, heavy herring catches are made each year. Herring spawn annually in the inlets and bays of Saltspring and Prevost Islands visible at the upper left.

the British Columbia coast in July, 1792, herring were purchased for the ship's mess from Indians at Stuart Island.

Pacific herring from the Strait of Georgia were first used commercially as food by European settlers around 1880.

HERRING-HAUNTED SHORES

Under present-day conditions, a profitable fishery for herring requires that the schools be readily located, easily fished and available in large numbers. Herring of the Pacific seaboard certainly fulfil these qualifications, particularly those shoals which inhabit the channels off the southeastern coast of Vancouver Island. Amid an island-studded waterway known locally as the "Gulf Islands" (Fig. 2) reaching from British Columbia's capital city, Victoria, northward about 70 miles to Nanaimo exists one of the most prodigious and possibly the longest-utilized stock of herring in the northeastern Pacific Ocean. An archipelago of over 100 islands ranging in size from kelp-covered, rocky outcroppings of less than one acre to inhabited islands of over 70 square miles provides ideal haunts for these herring.

It should be noted here that at least ten other relatively separate populations of herring occur along the British Columbia coast; two off the west coast of 285-mile long Vancouver Island, two bordering the northeast coast of Vancouver Island, two amid central mainland waters, one along the northern mainland and at least two in the Queen Charlotte Islands. The locations of these fish populations are shown in the accompanying map (Fig. 3). Information is given in the figure legend on the average catch (in tons) and amount of spawn (in miles) in each population. These populations, although not of equal size, have a similar biological background. Rather than discuss each separately a review of

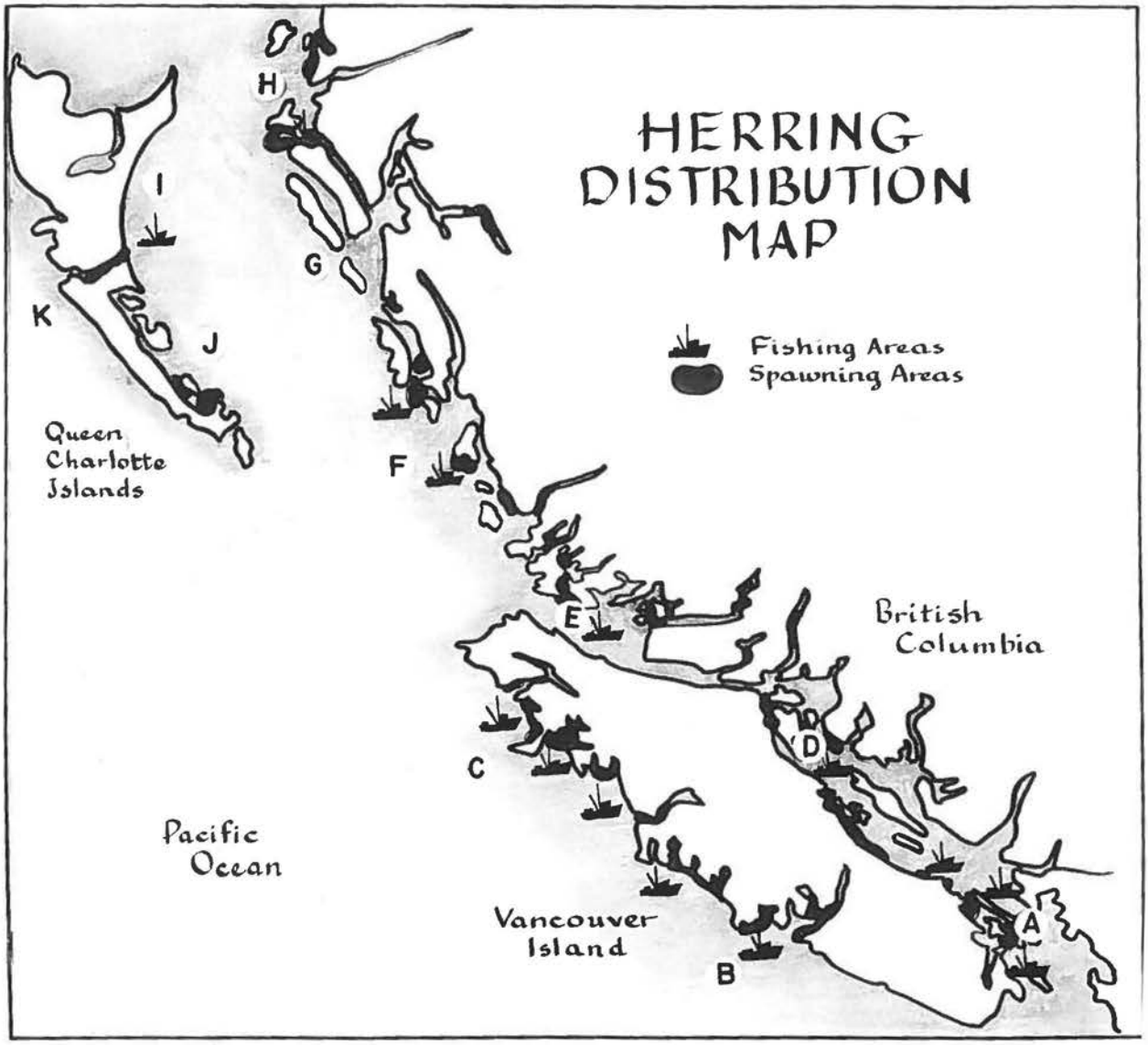


Figure 3. HERRING POPULATIONS OF BRITISH COLUMBIA—Herring occur along the coast in a series of relatively separate populations. Each population migrates annually from an offshore, summer feeding-ground to an inshore spawning area. The locations of all the coastal herring populations are indicated in the map by the letters "A" to "K". Catch and spawn data show that these populations are not of equal size; the lower east coast of Vancouver Island population (A) had averaged over a 20-year period (1941-60) 43,700 tons and a spawn deposition of 29 miles, the lower west coast of Vancouver Island population (B) 18,600 tons and 17 miles of spawn, the upper west coast of Vancouver Island population (C) 14,700 tons and 20 miles of spawn, the middle east coast of Vancouver Island population (D) 13,000 tons and 28 miles of spawn, the upper east coast of Vancouver Island population (E) 7,100 tons and 15 miles, the lower central mainland population (F) 19,300 tons and 33 miles, the upper central mainland population (G) 8,600 tons and 19 miles, the northern mainland (H) 21,500 tons and 24 miles, the upper east coast of the Queen Charlotte Islands (I) 12,800 tons and 2 miles, the lower east coast of the Queen Charlotte Islands (J) 16,000 tons and 14 miles. Fish have been caught only once along the relatively unknown west coast of the Queen Charlotte Islands (K) and little is known about the size of the spawning stock.



Figure 4. SPAWN-LADEN VEGETATION—Blades of green eel grass are utilized by the spawners. Up to 500 eggs may be attached to an inch of vegetation. On a mile-long spawning-ground averaging 30 yards in width there may be billions of eggs. Many spawning grounds become exposed at low tide.

the activities of the most important, that found along the south-eastern Vancouver Island shoreline, is presented.

SPAWNING MIGRATION

In the fall, the herring "legions" begin to appear among the "Gulf Islands" waterways. Fulfilling an instinct to reproduce their species these fish annually undertake a migration of some 150 miles. They leave the rich, ocean pastures beyond the rocky headlands of Cape Flattery and move inshore through the Strait of Juan de Fuca, following the southerly shore of Vancouver Island past Victoria to rendezvous in the "Gulf Islands" waterways (Fig. 3). These herring spend the winter months massed together above the sea floor awaiting the ripening of their reproductive cells. During this winter resting period the normally-active herring schools become sluggish. It is at this time that the fishermen make their catches.

MALE AND FEMALE PRESENT IN EQUAL NUMBERS

Pacific herring are shore spawners. For a few hours each spring myriads of these fish crowd along the beaches to perpetuate their race. Although male and female are present in about equal numbers there is no actual pairing off. Females discharge streams of adhesive eggs onto shoreline vegetation (Fig. 4). Males shed milt containing the fertilizing sperm (Fig. 5) "en masse" into the surrounding area, forming extensive bands of milky, opaque water (Fig. 6). This white water also serves as a protective blanket hiding the spawners at a time when they

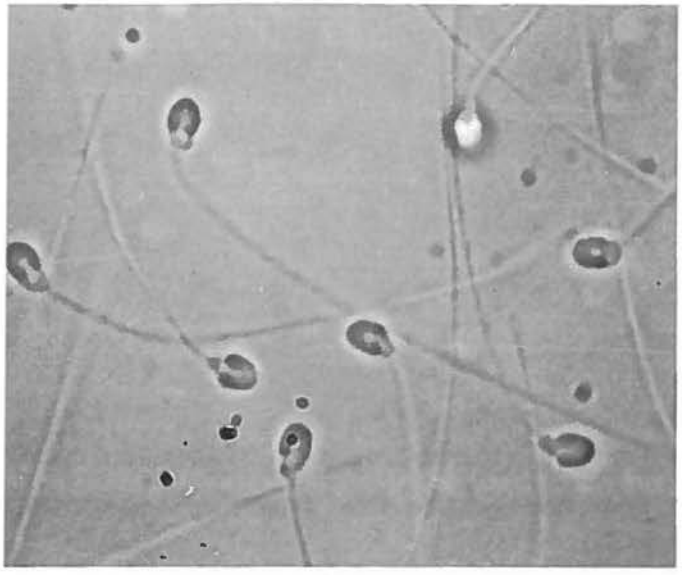


Figure 5. WHIP-LIKE SPERMS—A group of Pacific herring sperms enlarged about 1500 times. Each sperm consists basically of a rounded head, a middle section and a long tail. The active, whip-like tail propels the sperm. On contact with an egg, the sperm penetrates the membrane and fertilization occurs.

Figure 6. MILKY WATER—As herring eggs are deposited on inter-tidal seaweeds they are fertilized by milt ejected into the surrounding water. A suspension of sperms in salt water turns the ocean along the shoreline milky and opaque. The "white water" acts as a protective blanket, hiding the spawners from their cardinal enemy, the seagull. (British Columbia Government Photo.)

are liable to capture by seagulls and ducks (Fig. 7).

Spawning is an incredible mass activity that may continue for several days. Herring do not possess any parental instinct to care for their brood. After spawning, most of the spent fish return again to offshore waters to recover and feed. Some schools, however, are found in the inside coastal passages all year round and provide the basis for an occasional small summer fishery.

PREFERRED SPAWNING SITES

Herring do not spawn at random on any beach. Certain beaches are habitually used year after year while there are many miles of apparently suitable shoreline on which herring have never been known to spawn. Some of the preferred spawning grounds of the lower east coast of Vancouver Island herring population (Fig. 3A) are along the southern shore of Saltspring Island, in Ganges and Fulford harbours; others farther north are located below Nanaimo in the Yellow Point region and above Nanaimo in the Departure Bay-Nanoose Bay area.

On the sand flats of Nanoose Bay herring spawn on blades of green eel grass and fronds of sea lettuce. Along the rocky shores of Evening Cove, brown seaweeds known locally as japweed and rockweed are used.

Pacific herring have never been known to

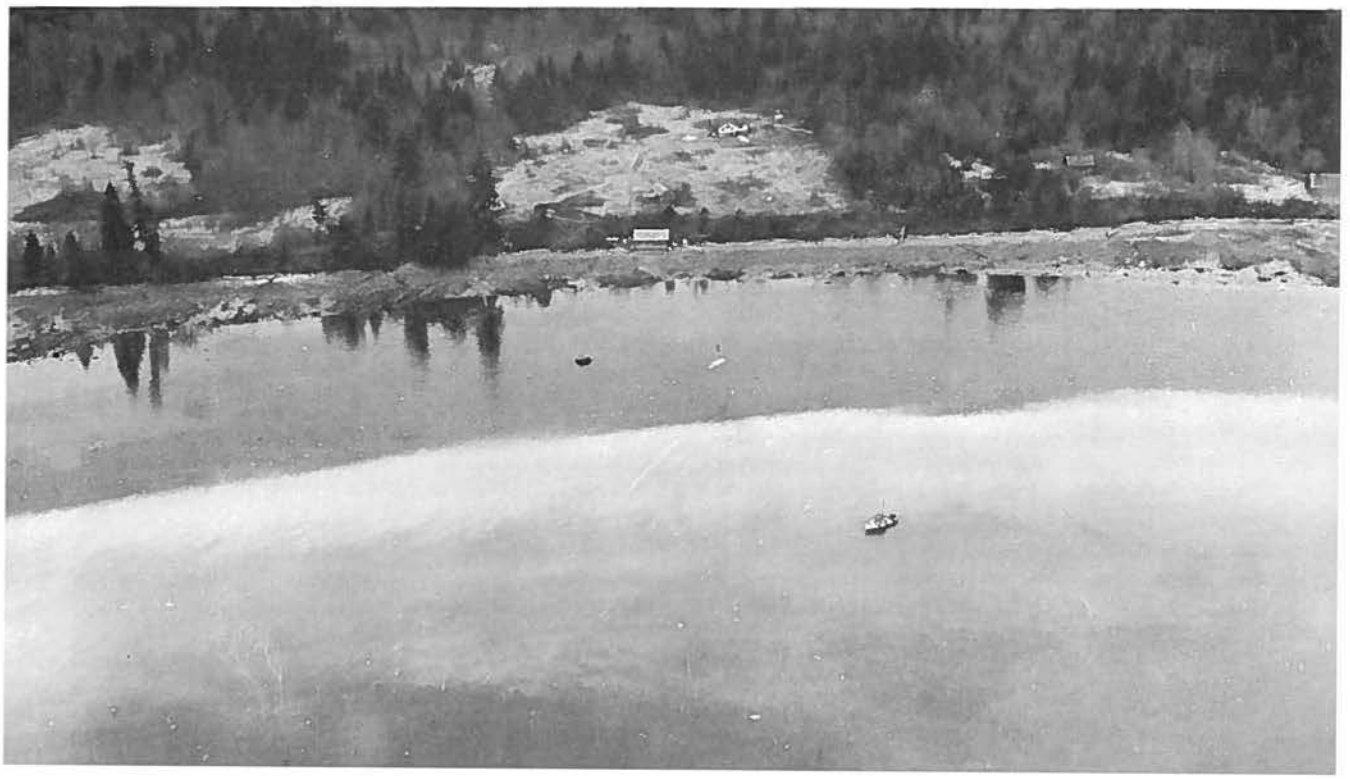




Figure 7. SPAWN HUNTERS—Seagulls are attracted in large flocks to the spawning beaches, first to feed on the spawners and then on the eggs as the latter become exposed at low tide.

spawn in deep waters away from the shore. In this respect, they differ markedly from their cousins, the Atlantic herring, which deposit their eggs on the gravelly ocean floor at depths down to thirty fathoms.

Although the actual spawning time of Pacific herring cannot be predicted, some spawning grounds have characteristically early and late spawning runs. In the "Gulf Islands" herring can be expected to spawn first in Ganges Harbour in early February. The last spawning of the season usually occurs towards the head of picturesque Saanich Inlet in mid-April. Spawning activity reaches a peak in the "Gulf Islands" about the third week in March.

In northern and central British Columbia, however, the spawning season is on the average two weeks later than in southern British Columbia.

An average-sized female herring deposits about 20,000 eggs. In 1962, a census showed that there had been over 198 miles of spawn deposited by the herring populations of British Columbia; an average amount. This represents more than two trillion eggs, an inconceivable quantity.

STORMS, BIRDS AND MEN DESTROY SPAWN

During the two-week incubation period, while fastened to moist seaweeds, many millions of eggs are destroyed. Storms frequently annihi-



Figure 8. ANKLE-DEEP IN DEAD SPAWN—Many thousands of eggs are destroyed during the brief two-week period that spawn develops on marine vegetation. In exposed localities spawn-covered seaweeds may be piled knee-deep in mile-long windrows along the high-tide mark by storm action.

late whole spawnings by uprooting and piling the spawn-covered vegetation ashore, often knee-deep along the high tide mark (Fig. 8).

The arrival of spawning herring on the beaches attracts a variety of predatory bird and animal life, ranging in size from one-celled protozoans to man (Fig. 9). Seagulls descend in flocks onto a spawning-ground to feed first on the spawners and later, during the low tide period, on the eggs. As many as twelve thousand of these voracious birds have been observed feeding at a spawning site, 1,000 yards long by 75 yards wide. Also present may be hordes of diving ducks and crows. It has been estimated that seabirds may consume 40 per cent or more of the spawn.

During the incubation period on the beaches many remarkable changes take place in the form of the developing embryo (Fig. 10). The time of hatching is variable; in relatively warm water of 48° F. hatching takes place in 14 days while in colder water of 44° F. development is slowed and hatching occurs only after 20 days.

FRAGILE INFANTS

By late April the sea lanes of the "Gulf Islands" archipelago are populated with tremendous numbers of almost invisible, threadlike, newly-hatched herring less than ¼ of an inch long. These larval herring bear little resemblance to the silvery adult fish. Larval herring (Fig. 11) lack scales, the head and eyes are greatly enlarged and they can barely swim! They are transparent to such an extent that the brain, backbone and other organs are visible through the body tissues. Within two months, however, these odd-looking creatures grow rapidly to about one and one-half inches. By this time they have completed a gradual but dramatic metamorphosis that changes their outward appearance into that of a miniature adult; the body deepens and more than doubles its weight while scales and coloration appear. At this time the urge to form schools occurs.

Because larval herring are such feeble swimmers they are subject to heavy casualties. Unable to stem the ocean currents they are swept passively into deep offshore waters. Being a weak swimmer, a larval herring cannot actively search for food but must depend on that which happens to exist in its immediate vicinity. There may be nothing, while only a few yards away there could be plenty. In some respects, however, dispersion may act as a protective factor

Figure 9. SPAWN EATERS—Many categories of life from microscopic one-celled animals to men feed on herring eggs. A centuries-old method of collecting herring spawn shows native women gathering evergreen tree boughs that have been submerged a few days earlier in a region of active spawning. Spawn gathered in this manner is hung up to dry and used in a variety of ways as food.



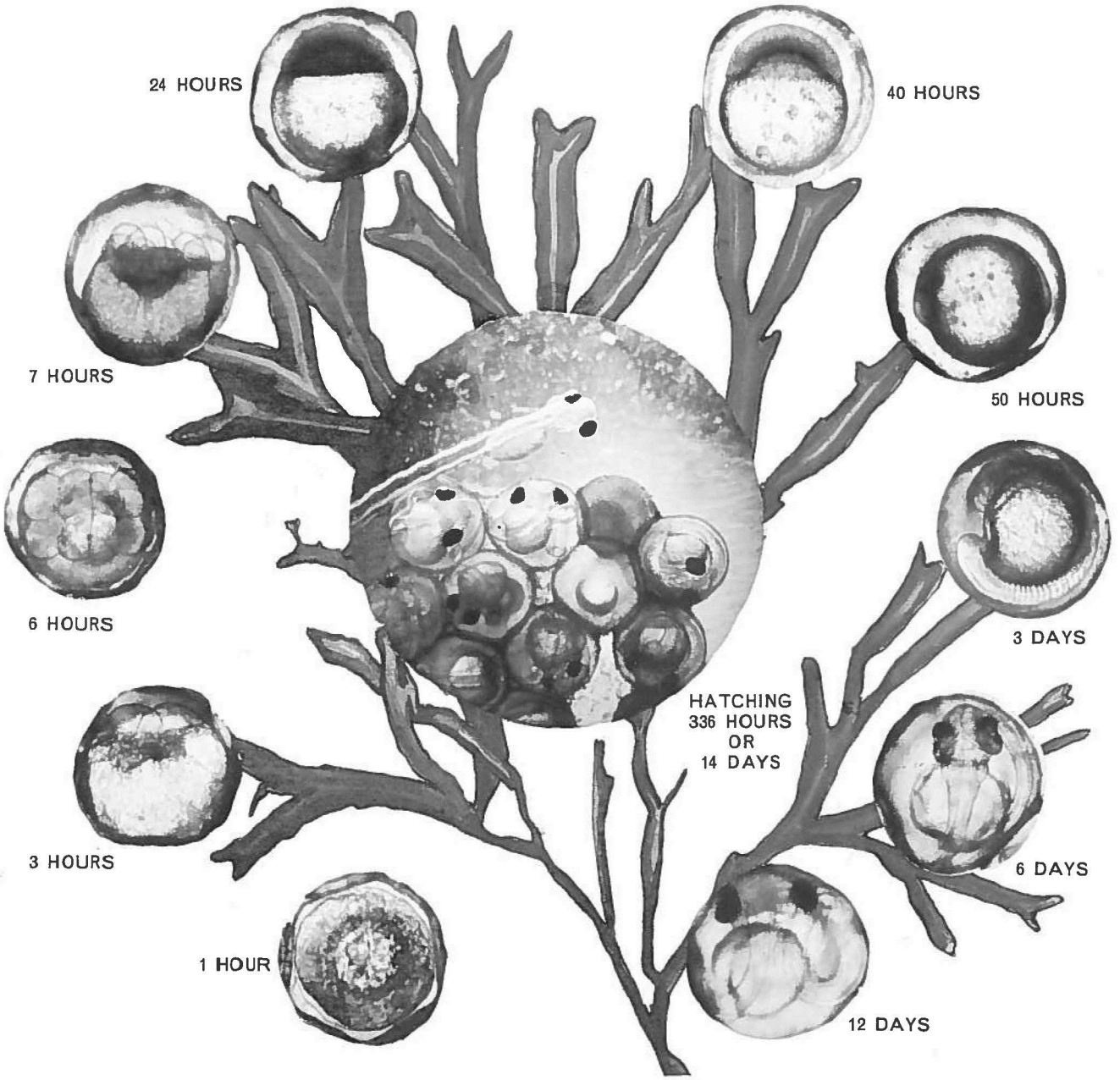


Figure 10. EMBRYO HERRING—The changes in the embryo that occur in the developing herring egg can be observed through a microscope. Some of these external changes (enlarged 25 times), are reproduced above. The incubation period can be arbitrarily divided into three main phases. PHASE ONE—a period of cell division (left side of photo). From one hour until 40 hours after fertilization no structures that resemble a fish embryo are visible through the transparent membrane. When three hours old the egg consists of only two large cells on a yolk mass; the food for the developing embryo. In six hours the original cell has divided into eight smaller cells. By the end of the first day repeated cell division has produced a multi-celled, dome-shaped "cap". At 40 hours cellular differentiation causes a thickening along the mid-line of the cap as the outer edge spreads out towards the edges of the yolk surface. PHASE TWO—a rudimentary fish-like embryo is now visible, from 50 hours to three days after fertilization. A definite head and tail region are discernible. PHASE THREE—the formation of a well-developed embryo capable of jerky movements. During the last half of the incubation period (from six days until hatching) further growth causes the body to coil several times around the now diminishing yolk. Enormous black eyes are present and the heart is pulsating regularly. The embryo normally breaks out head first through the confining egg membranes about two weeks after fertilization.

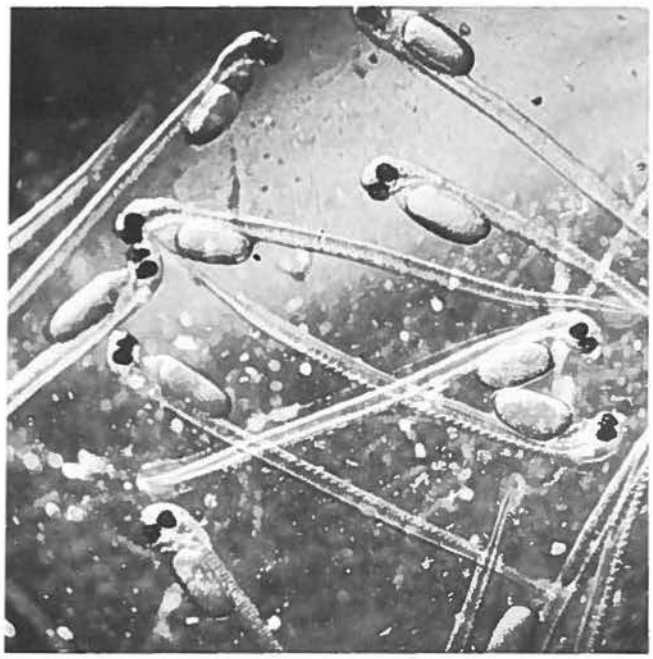


Figure 11. INFANT HERRING—The collection of tiny fish shown here (enlarged 10 times) are only two days old. These transparent, fragile creatures are scarcely recognizable as herring. Herring larvae are incompletely developed and as a result live a hazardous existence at the mercy of ocean currents and predators.

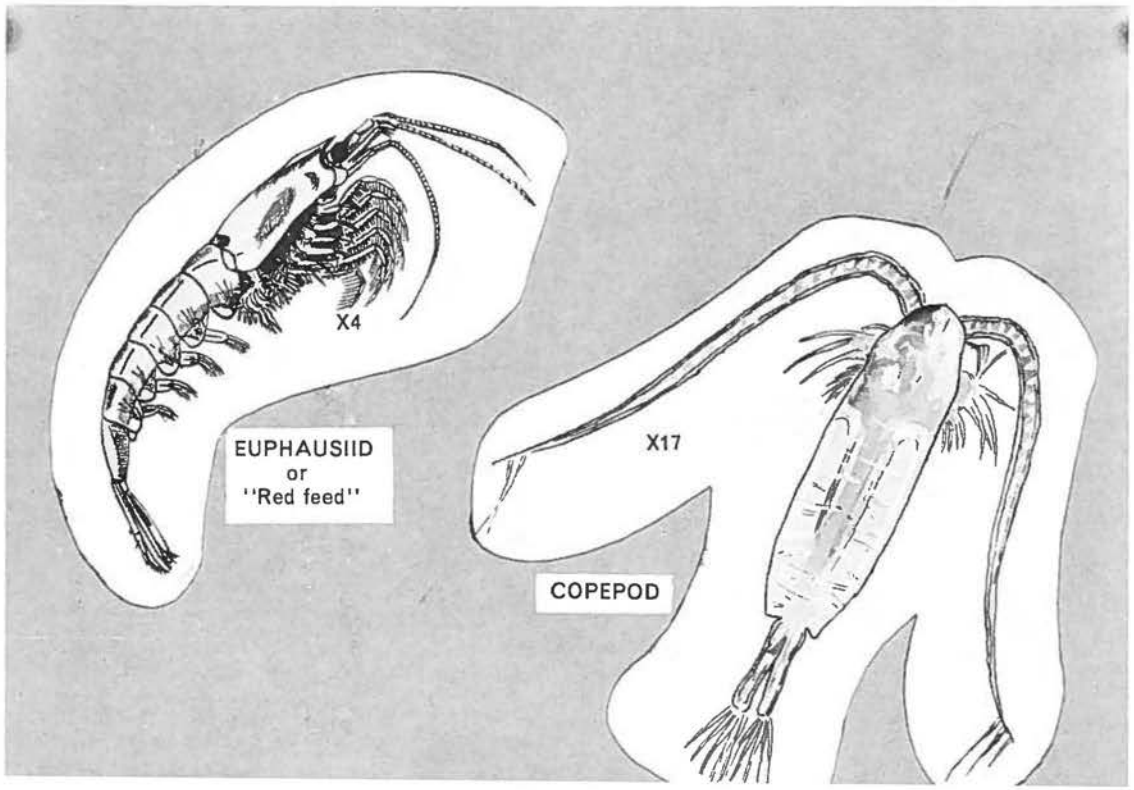
rather than a hazard since an individual would be less readily found by its slow-swimming predators—comb jellies, arrow worms and jellyfish. Many researchers in the fisheries field believe that the eight to ten week period of larval existence is the most critical phase of all in the life span of the Pacific herring and that over 99 per cent of those that hatch may die at this time.

PINT-SIZE JUVENILES HIDE IN KELP BEDS

After schooling-up, juvenile herring grow rapidly (Fig. 13) and can usually be found frequenting kelp beds along the shore and in sheltered bays during the summer months. These sardine-sized fish are a favourite bait of sports fishermen in the salmon-rich waters of the Strait of Georgia. The young fish are not commercially exploited like those of the same size along the Atlantic seaboard where they are canned as sardines.

In October, when about four inches long, juvenile herring normally forsake their inshore haunts and move seawards to mix with their elders. Those that survive return in the spawning runs as mature herring (Fig. 13) two years later. The wanderings of herring along the British Columbia coast have been traced by

Figure 12. PLANKTONIC FISH FOOD—Herring feed on swarms of tiny animal organisms collectively called zooplankton. An examination of the stomach contents of a herring would indicate that the chief articles of diet are copepods and shrimp-like euphausiids. These two categories of sea life are shown here greatly enlarged.



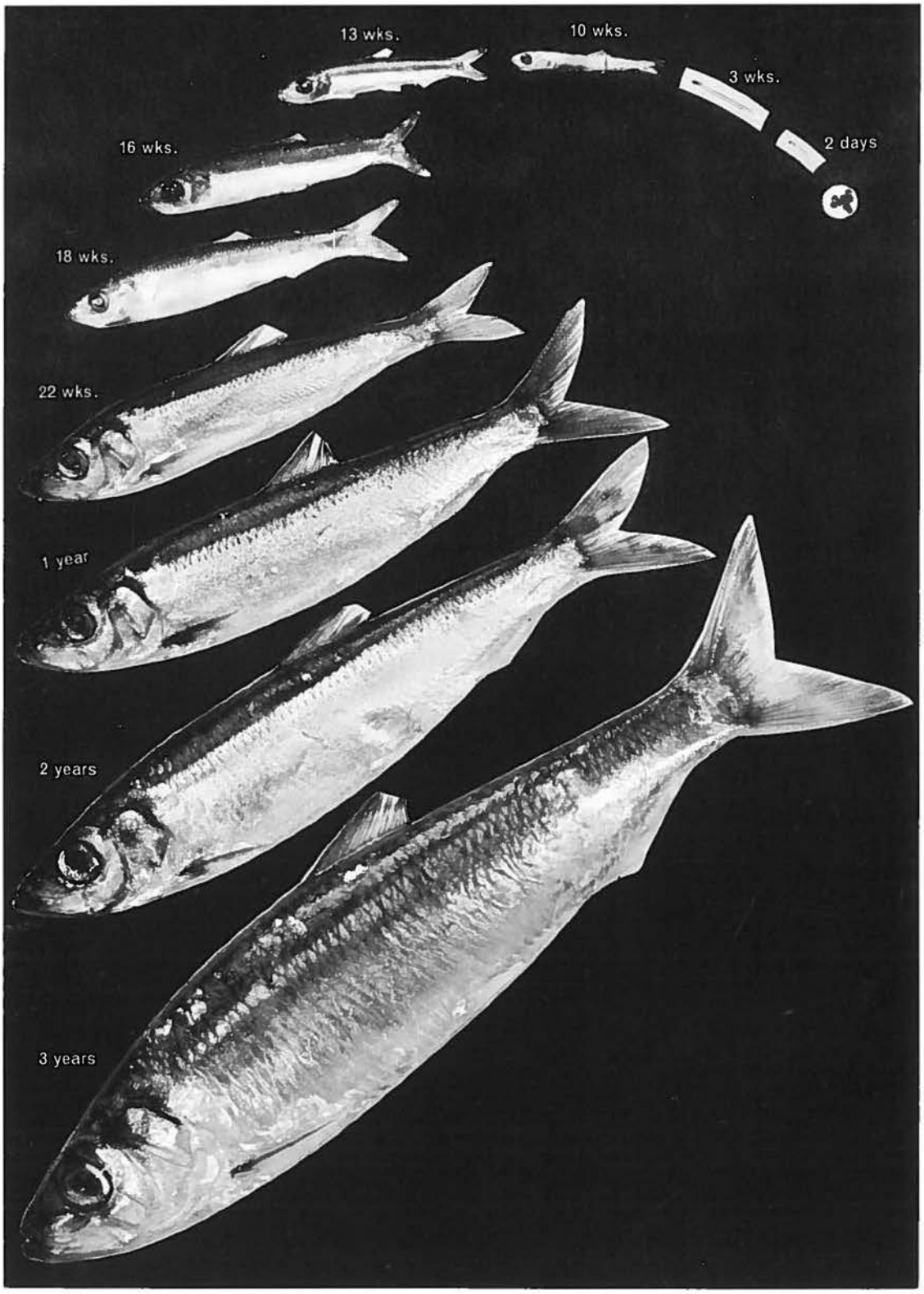


Figure 13. HERRING LIFE-HISTORY PROFILES—(¼ natural size.) From eggs 1/16" in dia. hatch ¼" transparent, larval herring. In about 10 weeks, when over 1" long these fish have grown to resemble their adults. Over the summer these juvenile herring grow to 4" long. By the time young herring are one year old they will be 5" long; 2 years old, 6" to 7" long. At three years and 8" long they become mature and are ready to spawn for the first time. Unlike birds and mammals fish never entirely cease growing, provided an adequate supply of food is available. However, the older the fish becomes the less the amount of annual growth. The oldest herring taken along the British Columbia coast proved to be over 15 years of age, 12 inches long and ¾ of a pound in weight.

tagging studies. Migratory stocks of Pacific herring exhibit a moderate homing urge—once they have joined the spawning stocks of a region such as the "Gulf Islands" archipelago, 75 per cent will return the following year to spawn again in the same region.

A LINK IN AN OCEANIC FOOD CHAIN

Herring are part of a complex food cycle in the ocean. Practically every living creature in the waters of the north-eastern Pacific Ocean is at once hunter and hunted. One-celled plant plankton, diatoms, are eaten by larger animal plankton, copepods, for example, (Fig. 12) that are in turn consumed by herring which fall prey to the swift salmon and other large fishes which in turn are consumed by marine mammals or exploited by man. Through a succession of predations, minute creatures are transformed into large food fishes. In this chain of dependence, might and size generally determine the oceanic hierarchy.

A characteristic of the tiny, planktonic food organisms is their rhythmic up and down migrations. Layers of plankton rise at dusk towards the sea surface and descend again at dawn apparently seeking a favourable light intensity. Schools of Pacific herring react to light and exhibit a similar up and down movement as they feed on the plankton layers. It is this nocturnal habit of ascending to the surface, the "swim," that brings the close-knit herring schools within reach of the fishermen's nets.

HIGHLY ORGANIZED FISHING FLEET

A fleet of 80 or more vessels, each with a purse-seine net 1,650 feet long and about 180 feet deep removes about 200,000 tons of herring annually from the coastal waters of British Columbia. Prior to 1910 herring were captured almost entirely by drift nets and beach-seines. Since 1913 purse-seining has been the principal method of harvesting the herring crop. (Fig. 15).

The fishing fleet is equipped with the latest in electronic fish-detection equipment that enables the fishermen to "see" the schools before setting the net (Fig. 14). Ship-to-ship and ship-to-shore radiotelephones aid in fleet deployment. Fishermen have long known that on dark nights many varieties of sea life are attracted to a light and in the "Gulf Islands," particularly, high-power mercury-vapour lamps are frequently used to attract herring. At the peak of the winter fishery the herring fleet at night resembles a floating city because of these lights.

The purse-seine is set from the stern of the seiner and after encircling a herring school the ends of the net are brought together and a "draw" string or purse-line along the bottom is drawn in, closing off the net bottom in the form of a bag. The herring are now unable to escape. The net is hauled aboard, concentrating and confining the herring in one portion, the "bunt." The fish are then scooped out two tons at a time into the hold of the fishing vessel by a giant dipnet or brailer, and transported to the shore plants.

Catches average 70 tons, but sets of 300 tons or about three million fish are not uncommon (Fig. 16). The largest catch by a single boat occurred in 1950 when 1,260 tons of herring were taken from Ogden Channel near Prince Rupert by the seiner "Maple Leaf C."

FISHING SITES

The stocks of herring which inhabit the waterways of the Gulf Islands and the nearby shores of Vancouver Island regularly appear each autumn in well-known fishing localities. Adjacent to Saltspring Island excellent catches are made year after year in Satellite and Trincomali Channels. Farther north, the waters near Porlier Pass and Nanoose Bay consistently yield large numbers of fish. In addition to the regular, winter fishery, an occasional summer fishery takes place on small local stocks of herring known as "homesteaders" in the tide-swept channels of the "Gulf Islands." These local stocks are fish that did not migrate offshore after spawning with the main body.

Off Pender Harbour and Point Grey near Vancouver, small quantities of herring are caught by gillnets for the fresh fish market. Midwater trawl nets that can capture herring at any depth during the day and night have proved useful to small vessel owners. Forty-foot "draggers" working in Trincomali Channel may take up to three tons of herring in a 15-minute tow. Trawl-caught fish may either be sold fresh or reduced into fishmeal.

The productive fishing grounds of the "Gulf Islands" are only four hours by sea from the shore plants, strategically located at Steveston. This busy fishing village is on the estuary of the Fraser River, one of the world's major salmon-producing streams. At these plants herring are unloaded at the rate of 100 tons an hour by giant suction hoses and metal conveyor belts (Fig. 17). The raw fish is converted into fishmeal

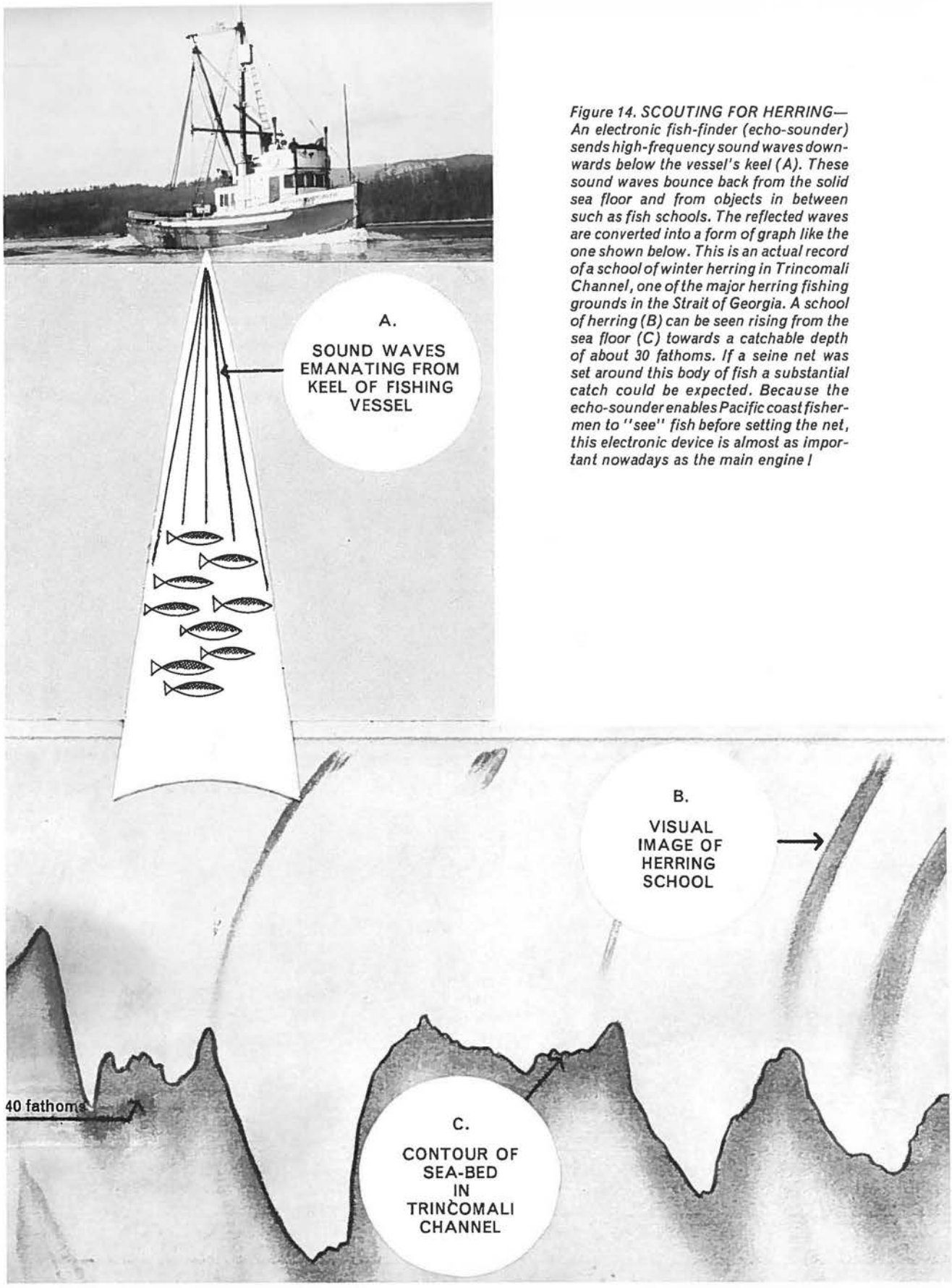


Figure 14. SCOUTING FOR HERRING— An electronic fish-finder (echo-sounder) sends high-frequency sound waves downwards below the vessel's keel (A). These sound waves bounce back from the solid sea floor and from objects in between such as fish schools. The reflected waves are converted into a form of graph like the one shown below. This is an actual record of a school of winter herring in Trincomali Channel, one of the major herring fishing grounds in the Strait of Georgia. A school of herring (B) can be seen rising from the sea floor (C) towards a catchable depth of about 30 fathoms. If a seine net was set around this body of fish a substantial catch could be expected. Because the echo-sounder enables Pacific coast fishermen to "see" fish before setting the net, this electronic device is almost as important nowadays as the main engine!

(Fig. 18) and oil. A ton of herring yields approximately 365 pounds of meal and 180 pounds of oil, worth some $30 to $40.

Summer caught herring are more valuable per ton than winter fish since they are fatter and have a higher oil content. Herring meal, rich in proteins, minerals and vitamins is in demand as a supplementary food for poultry and livestock (Fig. 19).

Herring oil is used in many diverse ways: in the manufacture of cosmetics, candles, soaps, shortening and paints. The bulk of the British Columbia herring harvest is utilized in this manner. Unlike the Atlantic species only about five per cent of the catch is used directly for human consumption, either salted, pickled, canned, or fresh. A small proportion of the catch, less than one per cent, is used as bait.

Frozen herring is the principal bait used in the halibut fishery, British Columbia's third most valuable fishery. Lingcod fishermen rely in large part on live herring as bait. There is also a growing demand among salmon sport fishermen for frozen six-inch herring as bait. Their effectiveness seems to stem largely from the film of oil which leaches out as they are trailed



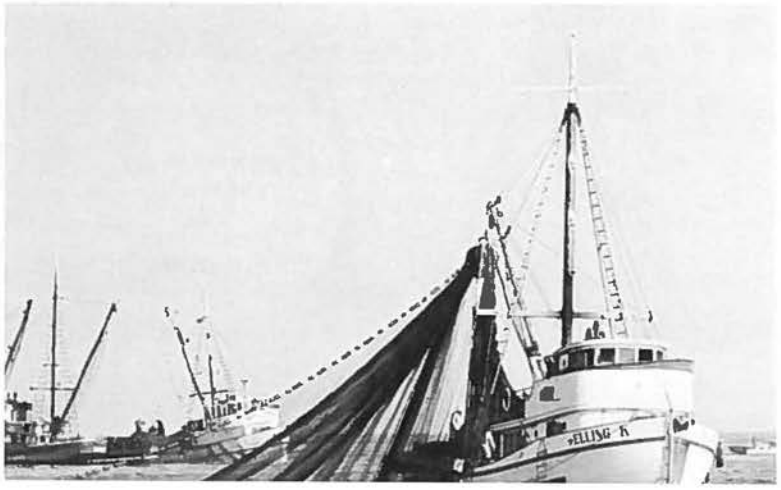


Figure 15. FAMILIAR SCENES— Ninety-five per cent of Canada's Pacific herring are captured with 275-fathom-long seine-nets. The photograph above shows seine boats scouting and "setting on" schools of herring near Porlier Pass. In the photograph at right a seiner is "fleeting in" a heavily-laden net with a hydraulic-powered block.



Figure 16. THE HERRING HARVEST—Purse seiners similar to the "Marine Girl" shown above average 70 tons of herring per set. Here, the churning fish are being transferred from the net into the hold two tons at a time by a giant dipnet or brailer. An 80-foot seiner and net is valued at well over $150,000. Night fishing is common. The inset at the upper left shows two seiners fitted with several brilliant lights. These lights sometimes help to concentrate dispersed or moving schools of herring.





Figure 17. (above) HERRING IN TRANSIT —Herring about to enter one of the shore plants on a metal conveyor belt. The fish are subsequently weighed and deposited in vast storage bins before the processing into fish meal and oil begins. (Photo courtesy Imperial Cannery, Steveston, B.C.)

Figure 18. (left) HERRING PRODUCT— Rail cars filled with sacks of fishmeal await shipment to markets in Canada and the United States of America. Herring are not utilized directly as food along the Pacific Coast. Only five per cent of the total catch is canned, salted, pickled or sold fresh; the remainder is processed into fishmeal and oil.

through the ocean. Salmon and other fish are able to detect minute traces of such oils.

During the five seasons 1958 to 1963 the British Columbia herring catch averaged over 215,000 tons a year, yielding an average of 39,000 tons of fishmeal and 4,307,000 gallons of oil. Herring rank first in British Columbia in landed weight but second to salmon in landed value.

The British Columbia catch forms about five per cent of the world herring catch. In 1959, the world catch was 3,490,000 tons; of this total, Atlantic herring formed 76 per cent, Pacific herring 16 per cent and Baltic herring eight per cent. Of the total Pacific catch, Canada (British Columbia) contributed 220,000 tons, Russia 260,000 tons and the United States 53,700 tons.

REGULATIONS AND RESEARCH

The herring fishery has had a history characterized by great expansion in productive capacity and fishing effort. The total catch has increased

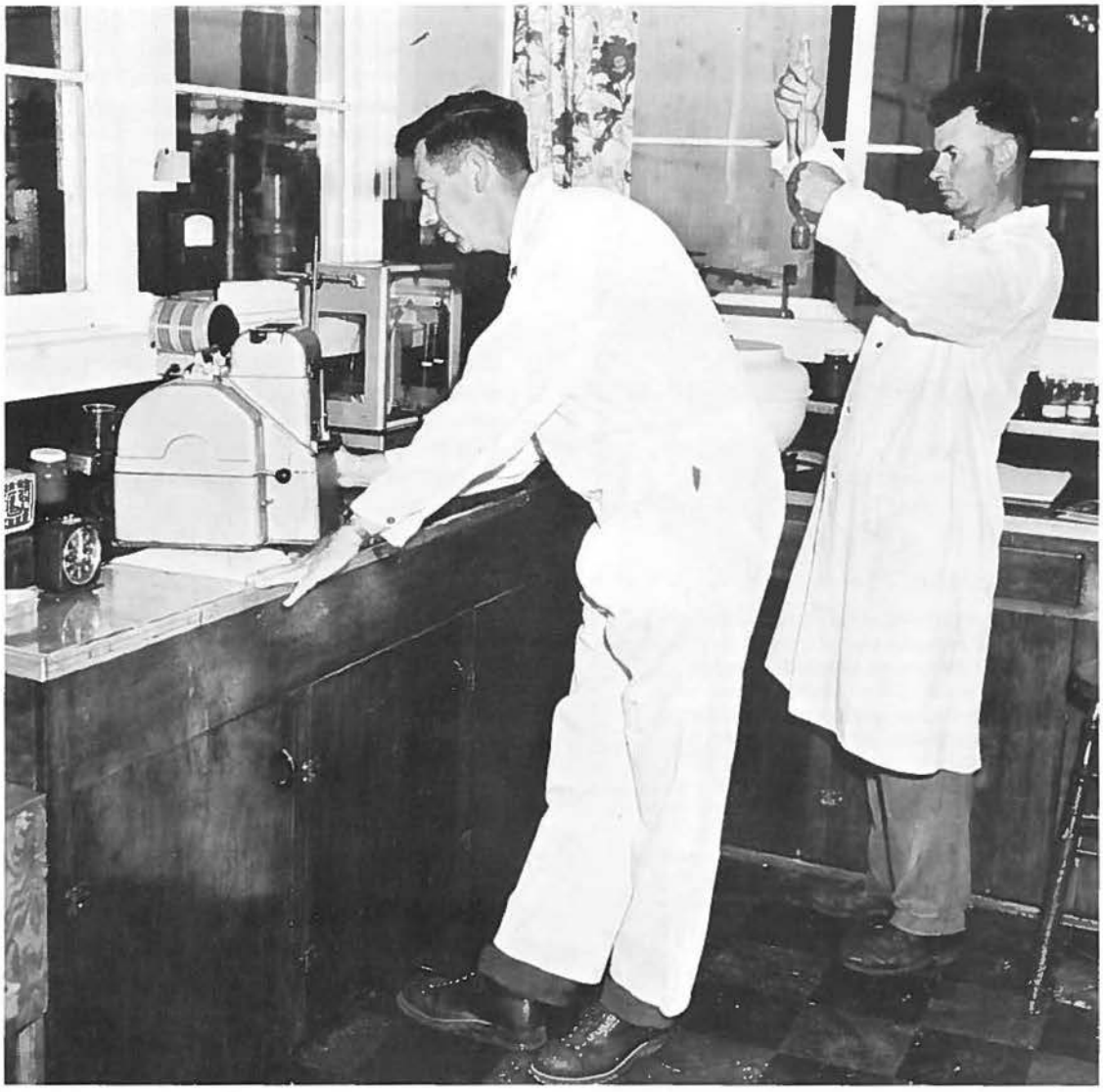


Figure 19. LABORATORY ANALYSIS—During the process of reducing herring into fishmeal and oil, the products are constantly being tested to ensure a high quality yield. Herring meal, rich in proteins, minerals and vitamins, is used in poultry and animal feeds. Oil is employed in the manufacture of candles, cosmetics, rubber, leather, soaps and shortening. (Photo courtesy Imperial Cannery, Steveston, B.C.)

from 500 tons in the 1900's to 100,000 tons in the 1940's and to over 200,000 tons today. At times concern has been expressed about the supply of Pacific herring. Is it limited or almost inexhaustible? Erratic catches along the east and west coasts of Vancouver Island in the 1930's led to the introduction of conservation regulations by the federal government. A closed season from February or March to June protects the fish during and immediately after the spawning season. Catch quotas were applied to most of the major herring populations. Thus, 40,000 tons may be taken each year from the herring population along the lower east coast of Vancouver Island. However, if surveys by patrol vessels (Fig. 21) of the Department of Fisheries of Canada indicate fish are unusually abundant, extensions to the quota are often granted. By mutual agreement between the fishermen and companies a 48-hour closure is in effect each weekend as well as a three-week shutdown over Christmas.

Herring research has shown that two types of herring stocks occur in the coastal waters of British Columbia; large migratory stocks and small resident stocks, the latter present in local waters all year round. A 20-year tagging program undertaken by the Fisheries Research Board of Canada at its Nanaimo biological station (Fig. 20) indicated that herring occur along the British Columbia coast in a series of more or less separate populations. Mixing between populations amounts to about 25 per cent and is greatest between those closest together. Each population undertakes an annual migration from an offshore feeding ground to an inshore spawning locality.

The quantity of herring present in the coastal waters is not static but varies from year to year primarily because of changes in infant or larval mortality. Some broods are more fortunate than others in surviving the many dangers which befall the young. When such a brood matures in its third year and enters the fishery, it may bolster the stock to a high level, producing a year of plenty. Other broods may be less fortunate and suffer a high larval mortality. When such broods mature they may fail to maintain the stock at its former level and abundance declines temporarily until another large brood appears.

The age of herring can be determined by a microscopic study of the markings on herring scales (Fig. 22). Imprinted on each scale is a pattern of alternating wide and narrow bands. Like growth rings on trees these bands reflect periods of rapid, summer growth and arrested winter development. The oldest herring ever



Figure 20. RESEARCH CENTRE—An aerial view of the buildings and dock comprising the Fisheries Research Board of Canada's Biological Station on the shores of Departure Bay near Nanaimo, B.C. From small beginnings in 1908, it has now become one of the largest fisheries research units in the Pacific area. All phases of fish and invertebrate biology are covered including studies of the growth, reproduction, predation, and behaviour of many marine species.

Figure 21. FISH GUARDIAN—Fishery patrol vessel "Atlin Post" at the government dock, Nanaimo, B.C. Vessels of this type are maintained along the Pacific coast by the Department of Fisheries of Canada to facilitate the regulation and management of living renewable marine resources like salmon, herring, cod, halibut and shellfish. The 54-foot research trawler "Investigator No. 1" can be seen aft of the patrol vessel.



captured was a 15-year old male taken near Prince Rupert in 1951. Most of the fish taken in the commercial catches, however, are three to four years old.

To follow changes in the level of abundance and to ensure that signs of "overfishing" do not pass unnoticed, a continuing management program has been established. Data are collected on the age, size and sex compositions of the stocks, on catch and on the amount of spawn deposited, the latter an indication of the quantity of fish that survived the fishery since spawning occurs shortly after the close of the fishery. An analysis of the numbers of fish at each age in the various populations has shown that about 50 per cent of the herring present at the start of the year will die naturally (from causes other than fishing) by the end of the year. This natural mortality varies with age; it is less among younger fish and greater among older fish. Of the 50 per cent that survive, the fishery takes about 60 per cent. Thus, of the quantity of herring present at the start of a year 80 per cent (50 per cent plus 60 per cent of 50 per cent) will have died by the end of the year. In spite of this high mortality the herring populations are able to maintain themselves at a high level of abundance.



Figure 22. AGE DETERMINATION OF HERRING— Projection equipment enlarges one-quarter-inch wide herring scales about 20 times. This enables the operator to see the imprint of alternating broad and narrow zones; markings which reflect periods of fast, summer growth and arrested winter development. The number of winter "rings" on the enlarged image of a herring scale at the lower left corner indicates that the scale came from a seven-year old fish. Note the actual size of the scales mounted on a glass slide. The collection of age-composition data is used in conjunction with catch and spawn information to provide valuable knowledge on herring abundance.

RAISON D'ETRE

Pacific herring are one of the most preyed upon coastal fish. At every stage in their life span herring seem to be a basic food for some invertebrate, fish, bird, or mammal. While biological evidence suggests that salmon, halibut and cod could subsist on alternative foods, many fishermen believe that adequate stocks of herring are necessary to sustain these valuable west coast food fishes.

Whether we consider the biology, the method of harvesting or the herring's struggle against predators, the story of these fish is fascinating. Herring are preyed upon by a host of creatures. Eggs are consumed by gulls and ducks, larvae by zooplankton (arrow worms and jellyfish), older herring by mammals, lingcod, salmon, halibut, dogfish and many other fish. It is truly amazing that the species escapes extinction! Only one herring in ten thousand is destined to return to spawn! Despite these great depredations herring continue to exist in enormous quantities in the temperate waters off Canada's western seaboard. This abundance can be translated into actual numbers of fish. On the average, 200,000 tons are captured annually. At 10,000 fish to a ton, this represents a catch of at least two thousand million herring a year. The fishermen take only 60 per cent of the fish present so that there must have been between three and four thousand million herring at the start of the fishing season. Furthermore, if 50 per cent of the stock die naturally in a year then altogether there must have been between six and eight thousand million fish present at the start of the year. If all the herring taken in British Columbia were aligned tip to tail they would reach from the earth to the moon, a distance of over 239,000 miles.

It is reassuring to know that the northeastern Pacific Ocean supports such vast schools of high-grade animal protein. Today, this natural resource is only utilized indirectly as food for humans. Changing economic patterns, however, may lead to the greater use of this fish stock directly as food for human consumption.