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

BULLETIN No. LIV

THE LING COD, *OPHIODON ELONGATUS* GIRARD

BY
G. V. WILBY
Pacific Biological Station

OTTAWA
1937

THE LING COD, *OPHIODON ELONGATUS* GIRARD

By G. V. Wilby
Pacific Biological Station

INTRODUCTION

The ling cod in some respects is a rather unique fish. It is found only in the northeastern Pacific with its centre of distribution in British Columbia waters. It is not closely related to any other species of food fish. It resembles the sculpins or bullheads in habits and habitat rather than the true cods, with which it is associated in name only. Even its fishery is unlike that of other fishes.

During recent years the fishery has become one of major importance. With the ever increasing demands from the fresh fish trade it has developed rapidly in volume through the development of special technique in the methods of capture and the discovery of new fishing grounds. The ling cod fishery has now attained fifth position in value amongst the food fishes of the province of British Columbia, and second amongst the ground fishes, ranking next to the halibut. In addition to its food value the ling cod has been found to be one of the richest known sources of insulin among the fishes of the world. Quite recently the vitamin "A" content of the liver oils has been found to be almost as high as that of the halibut, and in some instances even higher.

Acknowledgements

The author wishes to acknowledge the support of the Biological Board of Canada throughout the investigation, and to extend his thanks for assistance in various ways to the staff of the Pacific Biological Station, particularly to Dr. W. A. Clemens for his co-operation and encouragement and to Dr. J. L. Hart for criticisms and suggestions. Furthermore, the kindly assistance of Captain John Shannon of Vancouver and Mr. F. Koyama of Nanaimo in obtaining material for study has been of great value.

NAME AND EARLY RECOGNITION

The ling cod, *Ophiodon elongatus* Girard, was first described by Dr. Charles Girard, medical officer with the Pacific Railway survey in 1854, from a small specimen twelve inches in length taken in San Francisco bay, California. The description was very brief and dealt entirely with external characters.

The scientific name *Ophiodon* is of Greek origin derived from ὄφις, snake and ὀδούς, tooth, having reference to the large canine-like teeth in the jaws.

The name *elongatus* is of Latin origin and refers to the elongate appearance of the body, which is particularly noticeable in the younger specimens.

Before the arrival of the white man the Indian name of "tooshqua" was applied to this fish. Upon the development of the Chinook jargon, which is a mixture of Indian words and corruptions of words from several European languages, the term "cultus" meaning "untrue" or "no good", was used to designate the ling cod. This reference was used in comparing the ling cod with the gray cod indicating that it was not a true cod, *Gadus macrocephalus*, or that there was inferiority in quality, either real or fancied.

Some of the early British settlers observed some resemblance between this fish, which was hitherto quite unknown to them, and the European ling—*Molva molva*—but to indicate that there was a difference they added the name "cod". In this way this cottoid fish, which is neither a ling nor a cod, became known as the ling cod.

As is the case with many other fishes various local names have been applied to the ling cod. The young fish are sometimes spoken of as blue cod or green cod due to the colour of the flesh when they are feeding in shallow water in eelgrass and kelp areas. Frequently the local fishermen refer to the ling cod as "codfish". In the winter months, during the closed season in the strait of Georgia district, large females brought in from deep water areas by boat are sometimes spoken of as "steamer" cod. In American waters, particularly in California, a great many different names have been used at various times, such as: bluefish, bocalao, buffalo cod, card, cod, codfish, greenling, leopard cod, testoni and white cod.

DESCRIPTION

The ling cod resembles the sculpins or bullheads in appearance and habits more than any other group, although it is related anatomically to the greenlings (Hexagrammidae) whose distribution is confined to approximately the same areas.

The body is long and closely covered with small smooth scales. The head is moderately large with a protruding lower jaw. The mouth is large and both jaws are supplied with long canine-like teeth. A large fleshy flap is present above and behind each eye. The dorsal fin is long and high, composed of a spinous portion with twenty-four to twenty-seven spines separated by a notch from a rayed portion with twenty-one to twenty-four rays (figure 1).

The colours of both male and female are extremely variable. The variation is associated with habitat rather than with sex and is subject to very rapid change both in shade and pattern. Fishes inhabiting the kelp beds are usually dark coloured, bluish brown to dark greenish brown above with large areas of dark colours outlined with tracings and small spots of pale blue or orange on the sides. The fishes found in deeper water around reefs, especially the females, are usually lighter in colour even appearing creamy brown occasionally, the lighter areas mottled with darker spots and blotches of dark green, brown or orange. In both

types the males are for the most part darker than the females, but the colour is not a reliable sexual character.

The females attain a much greater size than the males. The male ling cod can be distinguished externally from the female by the presence of a short, broadly conical, papilla immediately behind the vent.

DISTRIBUTION

The ling cod is distributed fairly generally along the northeastern coast of the Pacific from the gulf of Alaska to Santa Barbara, California, but in the extreme southern portion of the range the fish are much smaller and not nearly as numerous as they are farther north. The approximate centre of population, both geographically and numerically, is along the coast of British Columbia. Here

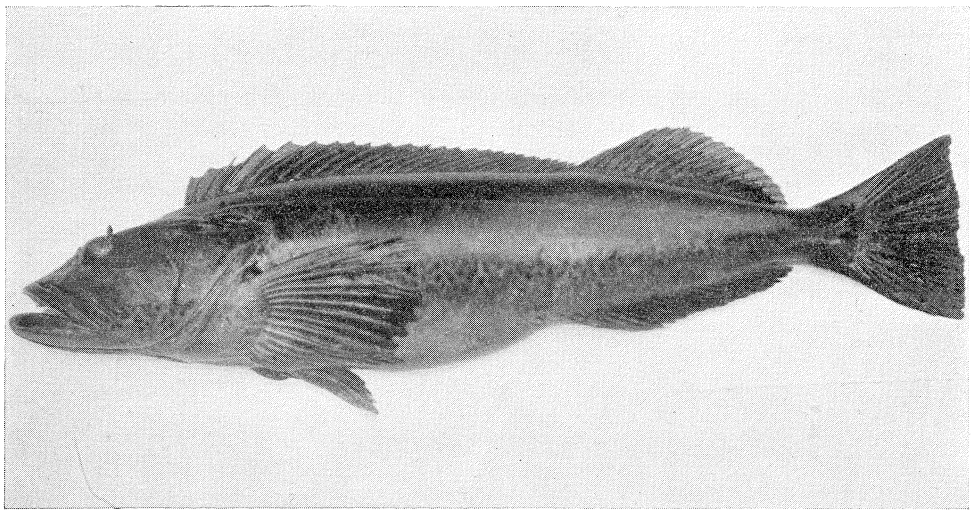

FIGURE 1. Ling cod, *Ophiodon elongatus* Girard. Male specimen 24¾ inches standard length, 28 inches total length, taken near Nanaimo, British Columbia, August 11, 1936.

the irregularly broken coastline with its many hundreds of narrow rocky channels and strong tide rips is particularly suited to this voracious fish.

The vertical distribution of the ling cod is known to be from moderately shallow water to at least 80 fathoms in southern British Columbia, while off the Queen Charlotte islands large specimens have been taken on halibut gear set as deep as 200 fathoms.

Although there is no absolute criterion of distribution vertically, in a general way it may be stated that the juveniles are nearer the shore in shallow water among the sea-weeds and eel-grass, whereas the adults are in deeper water. Usually individuals from 18 to 24 inches in length are taken in moderate depths ranging from 10 to 20 fathoms. In reef fishing, however, large females are taken

on the tops of the reefs which are from 30 to 40 fathoms below the surface and the smaller males are obtained beside the reef at a slightly greater depth.

A factor which affects the vertical distribution is the spawning urge which results in a movement toward shallow water during the winter months. At this time both sexes frequent the shores at or near the low-tide level.

While it is believed that there is no extensive migration from one area to another, as is the case with pelagic fishes such as the salmons, definite proof of this can come only from extensive tagging experiments.

HABITAT

The ling cod inhabits those areas where there is a definite water movement and an abundance of food supply in the form of fishes. As a general rule it is absent from muddy bottoms and stagnant waters but present in rocky locations over which there is a considerable current. These are two chief types of environment where it is present most plentifully.

1. The more or less precipitous slopes of submerged banks from 10 to 40 fathoms below the surface, where there is a rich growth of sea-weeds, kelp, eel-grass and hydroids forming a vast feeding ground for many species of small fishes.

2. In channels where strong currents flow over and around reefs and carry quantities of plankton and plankton-feeding fishes which concentrate in the tide-rips and whirlpools.

The habitats at different depths, on different types of bottoms and the various marine forms associated therewith at different times of the day and of the year present a situation which is too complex to be dealt with in detail in the present bulletin.

CATCH STATISTICS

Distinction of Ling Cod in the Statistics

An examination of the Fisheries Statistics of Canada reveals the fact that for many years the use of the term "cod" was very misleading when applied to the Pacific coast fishes, since not only the ling cod but several other fishes were grouped together under the same classification. This was probably due partly to the fact that the fishes included were considered at the time to be of minor importance and no attempt was made to arrange the various species as separate items in the reports, and also partly due to the fact that not enough was known about the various fishes involved to make a satisfactory classification.

A survey of the fishes which have been confused to some extent by appearance but chiefly by similarity of popular name shows that there are many kinds of fishes involved which can be separated into groups which are quite easily distinguishable as follows.

The ling cod, *Ophiodon elongatus*, the only member of the family Ophiodontidae and related to the greenlings and the sculpins, can readily be distinguished

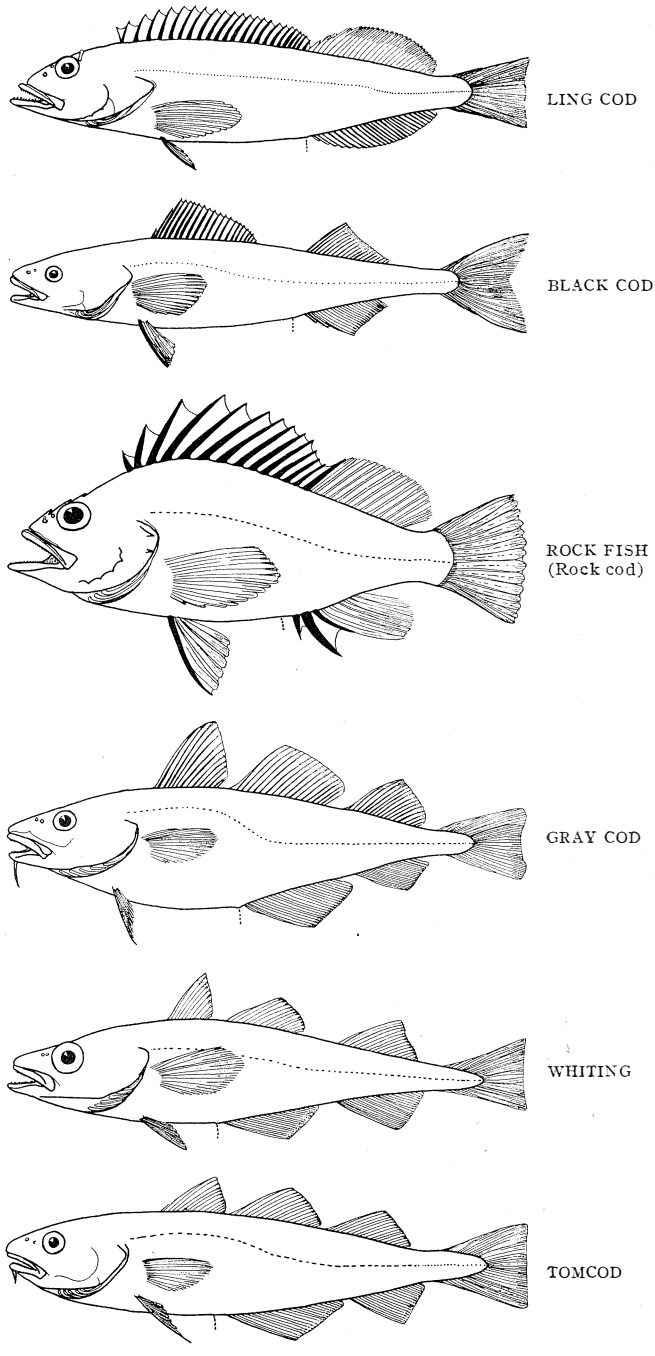

FIGURE 2. Various species of fishes which have been confused with the ling cod in the statistics prior to 1927.

by its long body, its small smooth scales, its long dorsal fin with 24 to 27 spines followed by soft rays, the large mouth with the lower jaw projecting, the long canine-like teeth and the fleshy flap over each eye.

The black cod, *Anoplopoma fimbria*, the only member of the family Anoplopomidae, resembles the ling cod somewhat anatomically, but it can readily be distinguished by its slender body, its rough scales, its two dorsal fins widely separated, its moderately sized mouth with the upper jaw projecting and the small teeth. (Known also as sable fish, skil, coalfish, beshowe, etc.).

The rock fishes, or as they are frequently called, the rock cods, belong to a large family, Scorpaenidae, and the genus *Sebastodes*, comprising some 50 species more or less common along the Pacific coast, at least 18 of which occur in British Columbia waters. This whole group can readily be distinguished by the short, deep body, the large rough scales, the dorsal fin composed of about 13 hard spines followed by soft rays and the three prominent spines in front of the anal fin.

The true cods, family Gadidae, of which there are three species in British Columbia coast waters, may be confused by name with the ling cod. The gray cod, *Gadus macrocephalus*, which is very closely related to the cod of the Atlantic, is readily recognized by the three dorsal fins, the projecting upper jaw, the barbel under the chin equal to or longer than the eye diameter and the vent under the second dorsal fin. The whiting, *Theragra chalcogramma*, which resembles small gray cod and tomcod, may have been listed with them indiscriminately. It is readily recognized by the three dorsal fins, the projecting lower jaw, the vent being under the interspace between the first and second dorsal fins and the barbel under the lower jaw absent or minute. The tomcod, *Microgadus proximus*, which is of minor importance and of small size, is readily recognized by the three dorsal fins, the projecting upper jaw, the barbel under the chin being about half the eye diameter and the vent under the first dorsal fin.

An examination of the Fisheries Statistics prior to 1917 reveals the fact that all the species mentioned above were classified as "cod (black)", with the single exception of the "tomcod" which may possibly have included the whiting and even the gray cod.

In 1918 the Annual Report of the Fisheries Department was altered to read: cod (both ling cod and gray cod); black cod; red cod (including all the rock fishes); tomcod.

In 1927 a further change was made as follows: ling cod, cod (gray cod), black cod; red cod (including all species of rock fish), tomcod.

Summary of the Catch Statistics

In table I are presented the catch statistics for the period 1927 to 1934 inclusive.

It will be evident that prior to 1917 no reliance whatever can be placed on the statistics of catch as to the proportion of ling cod to the other species represented as "cod". Even after this date until 1927 the proportions of ling cod to gray cod cannot be accurately determined although it seems justifiable to assume

TABLE I. Total weights and total values constituted by the catches of ling cod, black cod, rock fish (red and rock cods), gray cod and tomcod landed in British Columbia from 1927 to 1934 inclusive. Ling cod, black cod and gray cod are listed as dressed weights: rock fish, whiting and tomcod may or may not be dressed.

	Ling cod		Black cod		Rock fish (Red cod)		Gray cod		Whiting		Tomcod*	
	Cwt.	Value	Cwt.	Value	Cwt.	Value	Cwt.	Value	Cwt.	Val.	Cwt.	Val.
1927	49,916	287,918	16,430	85,167	4,436	15,753	165	470	69	345	50	152
1928	50,772	327,424	13,388	65,906	4,225	16,230	256	643	18	72	12	36
1929	48,489	383,462	15,308	104,719	5,224	26,240	608	2,410	12	69	83	332
1930	48,591	302,071	16,517	90,239	4,248	21,455	955	2,601	40	168	30	90
1931	50,987	213,012	5,845	22,389	2,735	9,146	1,628	3,847	87	405	..	..
1932	39,960	154,495	6,401	30,637	2,736	9,271	2,748	6,296	35	111	..	..
1933	40,283	175,358	6,069	21,811	1,382	4,521	5,170	10,707	361	876	..	..
1934	47,806	220,461	6,391	24,742	1,643	5,606	12,811	30,153	65	130	..	..

*The tomcod has always been separated from the other species but has been included for comparison as it is one of the "cods".

that about 99 per cent of the combined ling cod and gray cod weights and values as caught and landed were ling cod.

This assumption is based upon the percentages of weight and value of the ling cod in the combined ling cod and gray cod catches for the years 1927 to 1930 inclusive as shown in table II.

TABLE II. Percentage by weight and percentage by value of the ling cod in the combined catches of ling cod and gray cod for the years 1927 to 1934 inclusive.

	Per cent weight	Per cent value
1927	99.67	99.84
1928	99.50	99.80
1929	98.76	99.38
1930	98.07	99.15
1931	96.91	98.23
1932	95.81	96.08
1933	88.63	94.25
1934	78.87	87.97

The accompanying figure 3 presents the data of table I in graphic form for the ling cod, black cod, rock fish and gray cod, omitting those for the whiting and tomcod since they are inconsequential. It will be seen that there was a slight decrease in total weight of the ling cod catch in the years 1932 and 1933 but that the catch of 1934 had almost returned to the level of the years 1927-1931.

In the case of the annual values there has been considerable fluctuation. The peak value was reached in 1929 with an amount of $383,462. This was followed by a steady drop until 1932 when the total value for the year was $154,495. Since then the annual value has shown a moderate upward trend to $220,461 in 1934.

The average annual weight for the eight years is 47,100 hundred-weights and the average annual value is $258,025.

The rise and fall of the annual catch can hardly be attributed to depletion of the stock since it corresponds rather well with economic conditions with a high in 1931 and a low in 1932 and 1933, followed by a gradual rise as conditions have improved. In 1931 the rise in catch with the fall in price was due to the attempt on the part of dealers to increase the sale of fish by extensive advertising and of the fishermen to maintain their annual income. In 1932, however, prices had dropped to such an extent that an effort was then made by the dealers to limit the supply of fish in order to keep up the value. This limitation may have been responsible in part for the rise of both price and weight of the catch in 1934.

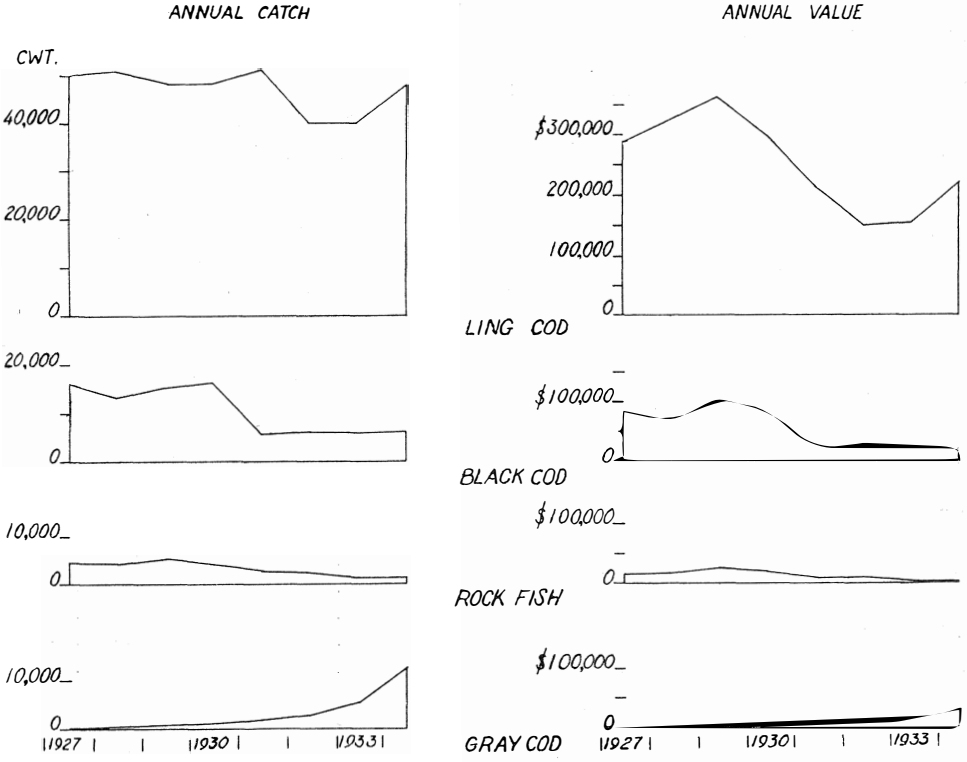

FIGURE 3. Annual catch in hundredweights of ling cod, black cod, rock fish and gray cod for the years 1927 to 1934 inclusive, together with the annual values for the same years: based on table I.

Even more striking than the variations in annual values of ling cod are the fluctuations in price per pound with economic conditions as is indicated by figure 4. The values again represent the prices as paid by the wholesale buyer to the fisherman.

Figure 4 represents the percentage weights and the percentage values of

the annual catches of ling cod, black cod, rock fish and gray cod based on the catch statistics of table I. For the purpose of calculation this includes the percentage data of whiting and tomcod but the latter do not appear in the figure. It can readily be seen that the ling cod dominates the combined catch of these fishes, representing over 70 per cent of the total catches and values for each year.

Since this discussion is restricted to the six classifications of fishes mentioned in table I it does not necessarily give an accurate picture of the grand total of

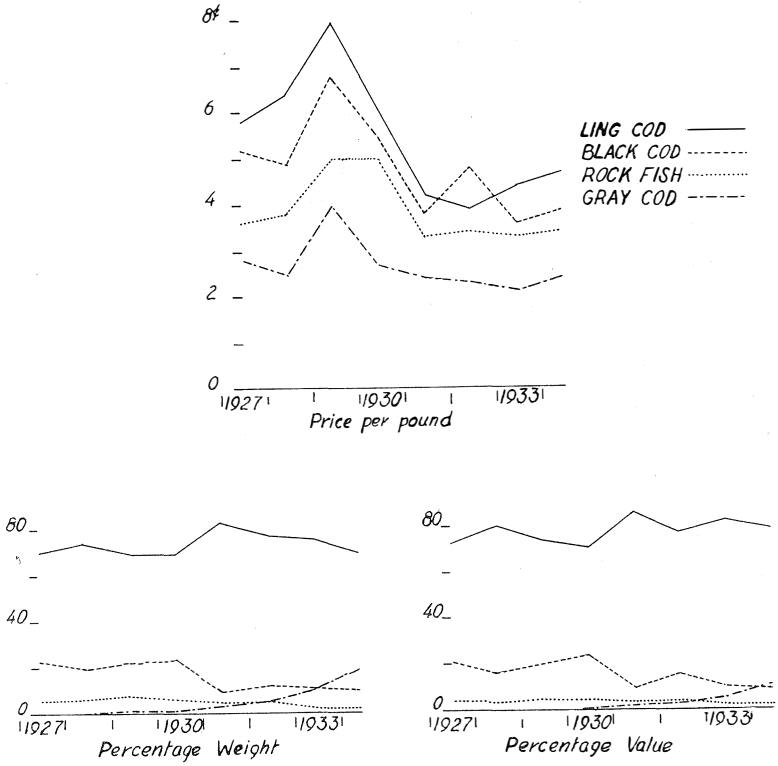

FIGURE 4. (Above) Price per pound of ling cod, black cod, rock fish and gray cod for the years 1927 to 1934 inclusive, based on the catch records shown in table I. (Below) Percentage weight and percentage value of ling cod, black cod, rock fish and gray cod for the years 1927 to 1934 inclusive, based on the catch records shown in table I. (Whiting and tomcod are included in the calculations but are omitted from the figure.)

fishes which enter into the annual catch of British Columbia or the influence of the rise and fall of these other species upon the annual ling cod catch. It does indicate that of the heterogeneous aggregation of fishes which have been grouped together through a similarity of common names the ling cod is by far the most important both from the standpoint of total weight of available food and of value. It also indicates that the industry has an average annual value of over a quarter of a million dollars, which is an important addition to the income of the province.

THE LING COD FISHERY

Previous to the great war the ling cod fishery was of comparatively little commercial importance, being confined to the needs of the Indians and the people scattered along the coast who were at some distance from supplies of fresh meat. The taste for fish, which grew during the period of meat shortage in the war years, had not yet developed, and as a consequence the demand for the comparatively unknown ling cod was relatively slight. With the more frequent appearance of fish on the restaurant and hotel menus and the introduction of "fish and chips", the market for fresh fish expanded rapidly and the ling cod became established as a popular and palatable fresh fish. This increase soon became further accelerated as the supply in the winter months could readily be maintained when

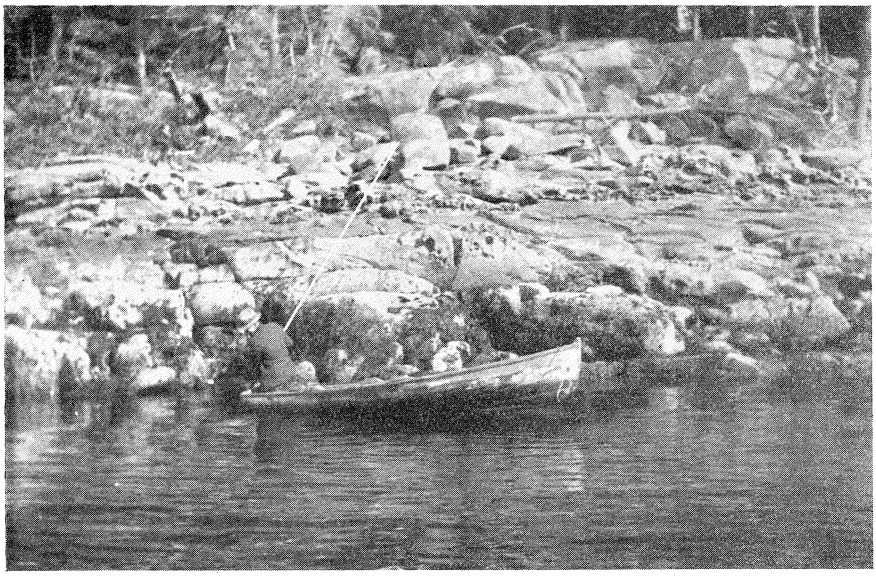

FIGURE 5. Native method of spearing ling cod. The currents flow rapidly along the rocky shores carrying plankton and plankton-feeding fishes and it is in such localities that the ling cod obtain food and spawn in the winter months.

salmon were not available. The industry, while still in its infancy, has developed into an important branch of the fish trade, the fishery ranking next to that of the salmon, halibut, herring and pilchard.

PRIMITIVE METHODS OF CAPTURE

Before the arrival of the white man the native Indians fished for the ling cod in various ways. Some fishermen employed the wooden hooks used in "skil" (black cod) fishing; others speared their prey after attracting them towards the surface with bright-coloured pieces of cloth, but one of the most ingenious methods used was that of employing a "hee-hee". This lure was made of wood and

sinews or roots and shaped like a giant three-feathered shuttlecock. The "feathers" were about 12 inches long and carefully carved to give a spinning motion when released. This curious contrivance was thrust down into the water by means of a three-pronged spear 18 to 20 feet long attached to a short line with the spear-points fitting into the spaces between the "feathers". A sharp jerk on the line would release the shuttle which wobbled and spun slowly upwards. The spear would be drawn up quickly and held in readiness for the ever-curious ling cod and as it followed the lure to the surface a quick stab would secure the unwary fish. (The lure is known in the Chinook jargon as a "hee-hee" or joke).

Trolling

With the advent of the white man the troll was introduced in salmon fishing and it was found that occasionally ling cod were taken when the spoon or spinner was allowed to fall deeply in the water. This method of fishing is little used commercially but is confined largely to sport fishermen.

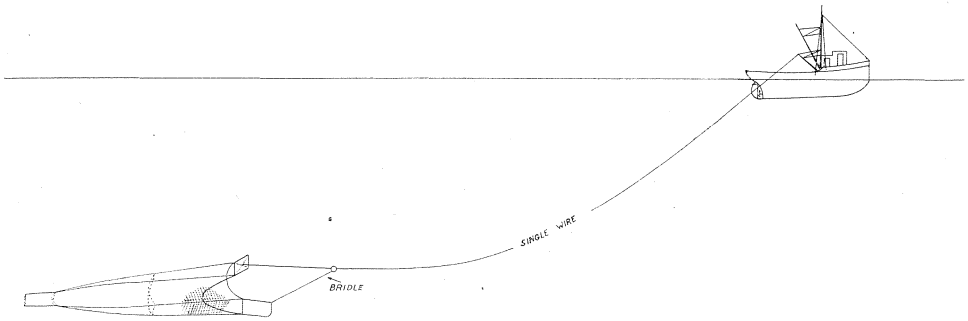

Figure 6. Showing the manner in which the otter trawl is used in obtaining ling cod and other ground fish.

Commercial Methods of Fishing

Commercial fishing methods fall into two chief categories, namely, trawling and jigging. The trawling is carried out mainly by the white fishermen on banks and relatively smooth ground. The jigging is done by the Japanese fishermen in the passes between islands and along reefs.

TRAWLING

Two types of gear are used in ground fishing, the beam trawl and the otter trawl. These were introduced to collect such fish as the gray cod, lemon soles, flounders and skates, but many ling cod are taken, chiefly by the otter trawl.

The beam trawl, while simpler to operate than the otter, has largely been superseded by the latter and of late years its use has become confined almost exclusively to shrimp fishing with ling cod taken incidentally.

The otter trawl requires more skill in handling than the beam, and the size of the vessels required has confined the fishery to a relatively small number of operators, due to the expense involved in equipment, crew, etc.

The boats used in otter trawling range in length from 50 to 80 feet and are

well powered, usually with diesel engines, although some of the vessels still utilize gasoline engines.

The gear consists of a net of 5 and 4½-inch stretched mesh with 4-inch stretched mesh at the cod end. The spread varies with the size of the net and the power of the boat. The float line of the net is supported by corks or glass floats from 4 to 8 inches in diameter. The lower edge of the opening is the lead line and has a series of heavy lead weights to keep the net on the bottom. The lower surface of the net is covered with tangles of loosely frayed rope to protect it from wear on the rough ground.

Otter boards measuring 3 feet by 5 feet by 3 inches are used to spread the net. They are constructed somewhat like kites so that the forward motion of the vessel forces them outward and apart, thus keeping the mouth of the trawl open. The lower edge of each otter board is well shod with iron runners to protect the wooden frame from damage when hauled over rocky ground.

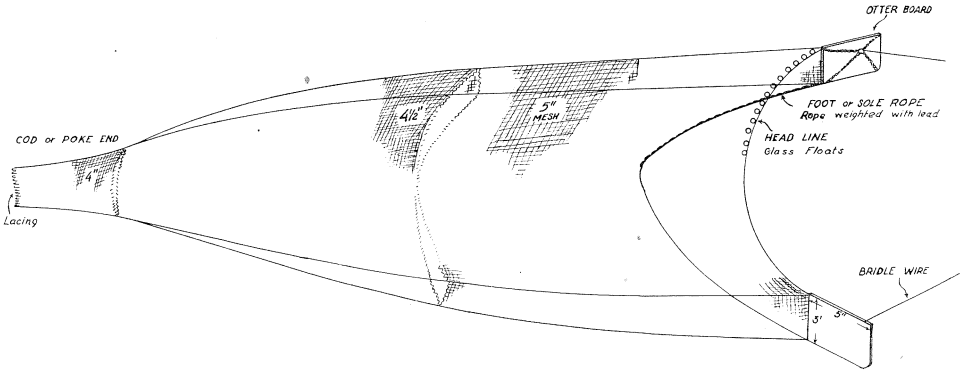

FIGURE 7. Details of otter trawl shown in figure 6. This is the type of trawl used commonly in British Columbia in ground fishing with a mesh sufficiently large to allow the escapement of the immature fish which are too small for market purposes.

A bridle of wire rope attaches the two otter boards to the main line. The latter runs through a block on a short boom which is swung aside as the net approaches the surface. This brings the otter boards alongside the boat and then the net is hoisted by means of a line from the mast so that its contents can be emptied on the deck.

The otter trawl is particularly suited to ling cod fishing in areas which are not excessively rough. The contours of submerged sloping banks from 10 to 50 fathoms below the surface form a rich forage ground for many species of fishes and it is here that the ling cod gather to take their toll of herring, gray cod, whiting, hake and flatfishes.

In order to understand fully the extent and direction of the reefs and banks where ling cod are to be found the fisherman requires a very special training in navigation and skill in the use of the trawl. Not only does he need accurate charts to locate his position but he must be able to interpret by the tugs and jerks on the cable the nature of the bottom, whether it be mud, sand or rock, and by

the angle of the cable in the water and the speed of the boat to estimate the depth at which he is fishing, since in many cases, especially in bad weather, landmarks may be invisible and frequently the banks are only a few hundred yards in width.

Besides the ability to locate a fishing ground by its contour, the nature of the bottom must be studied to estimate the value of the particular area located. Usually a muddy bottom without much plant or animal growth is a poor place to fish but if a haul is made containing rocks heavily encrusted with hydroids it is usually found to be a rich ling cod area.

Owing to the disturbance of the banks by the trawl, it has been found good practice on the part of the trawlers to allow the fishing grounds a rest of a week or ten days in order that normal conditions may be more or less re-established.

FIGURE 8. Miscellaneous catch of ground fish, including ling cod, lemon soles, etc., in an otter trawl.

JIGGING

During the war the Japanese fishermen developed live-bait fishing, which revolutionized the ling cod fishery, as it resulted in the introduction of the live-well type of boat and live-boxes for the storage of the catch.

The live-well is a portion of the hull closed off with bulkheads forming a tank. Several long slots are cut in the side of the hull to allow the circulation of a constant supply of salt water for the impounded fish. There are usually two or three of these wells on each boat.

Live-boxes are of various sizes and shapes. One of the more usual types is made of slats of 1×4-inch boards with spaces between of ¾ inches to 1 inch in

width. The box itself is frequently 3 feet by 5 feet and 8 to 10 feet long. These boxes are submerged by their own weight to float so that the lid only is above the surface.

In live-bait fishing herring have proven to be the most satisfactory bait but the young of rock fishes and flatfishes are frequently used at some seasons of the year.

The herring are taken for bait by means of a herring jig. This consists of a very light line with a small lead weight at the end. Below the weight there is a fine gut leader several feet in length with another small weight at the end. Between the weights 12 to 25 short snoods of fine gut are placed at short intervals,

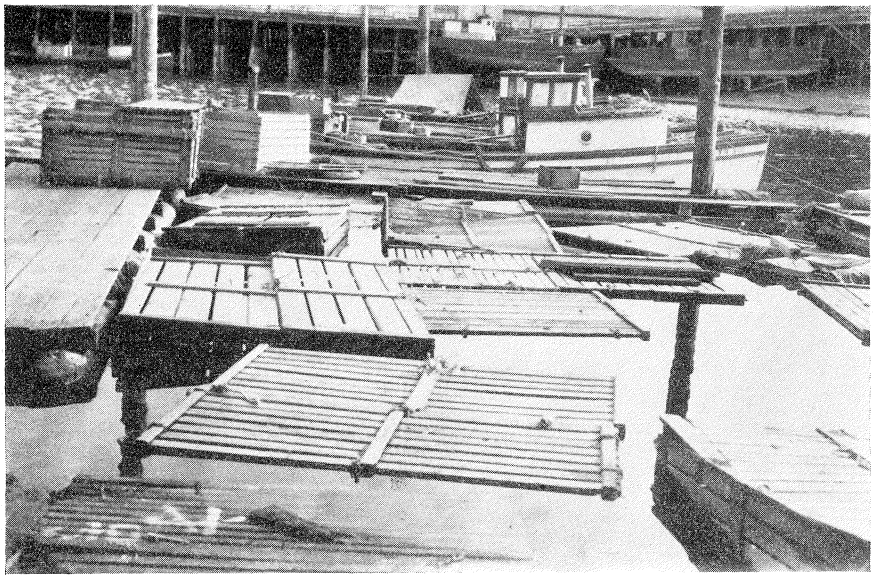

FIGURE 9. Live-boxes such as shown above are used for retaining ling cod for a day or so until sufficient quantities are secured to make a shipment to Vancouver, the chief distributing centre of the industry. In the background are fishing boats with live-wells amidships. Many of the fishermen have canvas awnings, for protection against sun and rain, stretched over the live-wells.

each ending in a small barbless hook. The bait fishing is carried on in the narrow passes where strong currents form whirlpools and eddies which collect the small plant and animal life upon which the herring feed. Here the herring are found in large numbers in the summer months.

The jig is lowered until the bottom weight touches the sand or rock, raised a foot or so and then gently pulled up and down until some herring are snagged. The herring are then hauled up slowly and shaken off carefully into the live-well on the boat. Great care is taken not to touch the herring with the hands or

allow them to come in contact with the side or deck of the boat as the fish are readily injured and considerable losses may result where retention is necessary for several weeks. One dead herring in the live-well or live-box seems to cause the deaths of others through its sloughed scales clogging the gills of the constantly active fish.

When a supply of bait is secured the boats frequently travel several miles to the ling cod grounds. Occasionally the herring are transferred to live-boxes at a central location to be used as needed.

The jig used in ling cod fishing consists of a piece of heavy wire or a light metal bar about three or four feet long suspended in the middle by the main line, approximately three feet above a one- or two-pound weight attached to the end of the line. At each end of the bar is attached a short snood ending in a hook. The hook used is about three inches in length and about one inch across from barb to shank. The hook is passed carefully under the backbone of the herring which is then able to swim freely for some time. Various modifications of the type of jig just described are used, for example, in some cases only a single bait is used and a small weight is suspended from the other end of the bar to keep the bait off the bottom.

The baited jig is lowered to a reef from 10 to 40 fathoms below the surface and then raised a few feet. The line is gently raised and lowered until a ling cod is attracted by the moving bait. It darts upward from the bottom, swallows the bait and is usually well hooked in the process.

In the manner in which the ling cod feeds it greatly resembles the sculpins. The fish lies on the bottom resting on its anal and ventral fins. It remains motionless as the prey passes above it and then with a rapid twist of its body it darts upward behind the victim, seizes it tail first and swallows it promptly.

After it is captured the ling cod is placed in a live-well until a full load is secured and is transferred later to a live-box situated at some base camp until it is taken to market.

DEAD-BAIT FISHING

Large ling cod are taken in Hecate straits and around the Queen Charlotte islands on halibut gear, occasionally in rather deep water. In this fishery, frozen or salt herring are used and fishing is carried on at depths from 45 to 80 fathoms and in some cases between 100 and 200 fathoms. As the ling cod show a marked preference for live food, it is probably a scarcity of food which attracts them to the dead bait. Set-lining for ling cod with dead bait has been tried in the southern waters of British Columbia but the efforts were unsuccessful.

Fishing Season

Owing to the mildness of the climate and the protected nature of the fishing grounds the ling cod fishery is continuous throughout the year except for the closed season in the strait of Georgia area which extends from the end of December to the first of March. Fishing is more intensive in some months than others. A

special effort is usually made in November and December to catch large quantities for winter storage in order to supply the demand for fresh fish throughout the closed season. During the winter months there are very few salmon or other competing fresh fish available and the price for ling cod has a tendency to rise at this time.

Handling the Catch

It has been found through experience that excessive handling of ling cod, especially in hot weather, results in rapid deterioration of the flesh, so preparation for the market is carried on as quickly as possible. As soon as the fish is removed from the water, or live-box, it is killed instantly by a sharp blow on the head.

Figure 10. Type of boat used by Japanese in ling cod fishing in British Columbia. Note live well and jig with lines wound on drums to left of picture.

A deep cut is made behind the head to sever the vertebral column. The fish is then held firmly by the eye-sockets and with a quick snap the tendons and nerves are freed. A knife is then passed around behind the gills and across the isthmus, completely separating the head from the body, but with the viscera still attached. The belly is then slit up from the vent to the isthmus and the viscera are cut away. Great care is taken to remove the kidney material from the backbone and the last remnants are vigorously scrubbed out, since if any blood remains the fish will spoil quickly. Salt water is used sparingly in washing as it tends to soften the flesh.

The loss in dressing is usually estimated at about 30 per cent of the round

weight, the head alone weighing about 20 per cent of the round weight. All fish are bought on the basis of dressed weight. When the head is removed, the total distance from the inner angle of the shoulder girdle to the tip of the tail fin is approximately 26 per cent less than the total length in the round. For all practical purposes, the length of the carcass may be taken as 75 per cent of that of the undressed fish.

After dressing, the fish are weighed and packed at once in boxes with chipped ice. This method is a great improvement over the older one of packing the fish directly in the hold of the boat, since the boxes can be shifted about without disturbing the contents and a better product for the market results.

Upon arrival at the wholesale market the fish are usually repacked in fresh ice for the local trade, especially in the summer months, and for shipment to the interior of the province. Those going to greater distances are frequently lightly frozen and shipped in refrigerator cars.

LIFE HISTORY

Spawning Migration

The spawning season of the ling cod extends from about the middle of December to some time in March, but from the examination of many females during these months, over a period of several years, it is found that the majority have laid their eggs before the end of January.

As the spawning time approaches both males and females come up from the deep water to certain rocky areas where there is a strong tidal current. In most cases examined the site chosen was apparently one which had the maximum sunlight available, that is, on the northern side of the pass. The female selects a crevice between large rocks or slightly under a boulder or rocky shelf from 10 to 30 feet below the lowest tide level where there are few or no marine growths, starfish, etc.

Occasionally egg-masses are laid above the low-tide line but in such cases many of the eggs fail to develop. This may be due to incomplete fertilization, to adverse environmental conditions or to lack of care on the part of the male.

Spawning Fish

The male fish never seem to attain the large size that is found in the females and they also spawn for the first time at a much smaller size. There seems to be a tendency for the very large females, over 40 inches in total length, to lay their eggs before the smaller ones and towards the end of January most of the females that are about to spawn are small fish which are probably spawning for the first time.

Under normal conditions, each ling cod, after reaching maturity, spawns every year. Spawning probably takes place each year since large females taken in December are found to be full of eggs which are practically ripe. On the other hand, very few large females can be found in March containing ripe eggs, and as evidence that they have spawned during the current winter there is usually a

small number of fully developed eggs, seldom more than a few dozen, present in the ovaries not having been extruded at spawning time. It is probable that the case of a large female found with both ovaries full of eggs in April represents an abnormal condition. Through some accident or other the ovaries had slipped past the intestine in such a manner that as the eggs developed the intestine tightened around the oviducts and prevented the normal deposition of the eggs. The fish was 41 inches in total length and weighed 32 pounds in the round. The weight of the eggs was 10 pounds, 14 ounces, and the number amounted to over 518,000.

The eggs are contained in two large ovaries, each of which is attached to a short oviduct. The two oviducts unite just before reaching the outside of the body. The ovaries and oviducts are somewhat muscular and apparently can be emptied in a comparatively short time. In all cases where spent ovaries were examined the eggs for the next spawning were present but very minute.

Spawning Process

It is extremely difficult to make observations on the spawning fish in the winter and at the depths in which they are to be found, owing to poor visibility and the occurrence of low tides at night at this time of year. The actual spawning process has been observed only once, but the egg-mass produced was in no manner different from many others examined from time to time; so it is reasonable to assume that the method is similar in other cases.

The female extruded the eggs directly upon the chosen spot together with a quantity of transparent yellowish highly viscous secretion which, upon contact with the salt water, formed a strong adhesive for attachment of the eggs to the rocks and to one another. This adhesive was somewhat like albumen in appearance but very stringy and sticky.

When a layer of several eggs in thickness had been laid the male swam slowly over the mass and fertilized the eggs with short successive jets of milt. The female then returned and continued to add to the egg-mass and each time that eggs were added the male swam over them and covered them with milt, the surrounding water becoming quite white and almost opaque at times.

The egg-laying process lasted for approximately half an hour. As soon as the female had finished her egg-laying she left and although she seemed to be completely spent she was not captured to verify this assumption. The male, who was much smaller than the female and much darker in colour, remained on guard over the egg mass.

Egg Counts

The number of eggs produced by female ling cod of the same size varies considerably. As a rule, however, the larger fish produce more eggs than the smaller. The following three cases are chosen to indicate the trend of the numbers of eggs produced by females of different sizes:

Standard length (in.)	Total length (in.)	Round weight (lb.)	Dressed weight (lb.)	Egg count
27½	30½	10	7½	60,000±
32¾	36¾	24½	13½	263,000±
35½	41	32	15½	518,000±

The standard length is the measurement from the tip of the lower jaw to the end of the vertebral column and is approximately 12 per cent less than the total length which is the distance from the tip of the lower jaw to the tip of the tail fin.

The count of 60,000 is the lowest that has been found and undoubtedly represents the first spawning of the fish. The other two represent counts from more mature females. Unquestionably egg counts from very large fish will be much greater than 518,000 but this represents the count from the largest ovaries examined. Egg-masses have been observed which were upwards of two feet in length and one weighed over 30 pounds; even allowing for a large amount of absorbed water the number of eggs would probably considerably exceed the largest count given above.

As may be seen from the above data, there is a sharp rise in egg production by the females as they grow older and increase in size. Comparing the egg-counts for each pound of fish, round weight, we have 6,000, 11,000 and 16,000 eggs respectively. The egg-count for each pound of fish, dressed weight, presents a still more startling figure, namely, 8,000, 19,000 and 33,000 eggs respectively. In other words, for each pound in a small fish of 7½ pounds dressed weight, the egg productivity is 8,000 whereas in a fish double that weight the egg productivity is over four times for each pound of dressed weight.

Protection of Eggs

The manner in which the female lays her eggs and the male watches over them is similar to that of many of the sculpins. These latter also lay their eggs in masses and in similar locations. Usually, however, the eggs are almost transparent and brightly coloured as in the case of the red Irish lord, *Hemilepidotus hemilepidotus*, whose eggs are bright pink, or the buffalo sculpin, *Aspicottus bison*, whose eggs are bright orange.

As soon as the female leaves the egg-mass the male takes charge. He keeps stirring the surrounding water with his powerful pectoral fins, actually touching the eggs occasionally until the whole cluster has set into a tough, springy, opaque mass. The eggs become so firmly attached to the rock and to one another that they almost appear to be like sponge rubber when an attempt is made to remove them.

Under natural conditions the male is constantly fanning the eggs with his pectoral fins, keeping the surfaces clear of growths and allowing a continuous change of water to flow over them. He will repel any intruders such as starfish or dogfish, which may come near, attacking them vigorously by biting or bunting

with his head. When a starfish was dropped on one egg-mass the ling cod bumped and pushed at it until it was removed several feet from the eggs. A fish spear put down to detach some of the eggs was viciously attacked and the marks of the teeth were plainly visible on the wooden handle.

The male ling cod stays on guard over the eggs during the whole incubation period and he has been observed to finish his vigil by eating several of the first larvae to hatch.

Incubation Period

When first laid the eggs are about 2.8 mm. of 1/8 inches in diameter and somewhat pinkish in colour. Upon contact with salt water the outer coat of viscous material swells until each egg is about 3.5 mm. in diameter. In a few days the eggs become quite white, gradually changing to a dull light yellowish to greenish brown due to the accumulation of diatoms on their surfaces.

Although the exact time taken for the eggs to mature and hatch is not definitely known, observant Indians and fishermen living in the vicinty of Porlier pass appear to agree that the period is about six weeks.

One interesting feature observed in examining an egg-mass which weighed approximately 15 pounds and measured over two and a half feet across was the fact that while the eggs on the outside of the cluster were in such condition that the shells were disintegrating and allowing the young to escape, eggs in a few layers below were in a much less advanced condition and in some cases the eggs in the centre of the mass were still in various stages of development and not nearly ready to hatch.

Larval Stage

One cluster of eggs was taken with the embryos about to emerge and was brought back to the laboratory. Many of the young emerged en route, others hatched later and some of the survivors were kept alive for 10 days. As yet no ling cod have been observed by the writer between this stage and that of a young juvenile of three inches taken in June.

At the time of hatching the fish are slightly less than ½ inch in length and have a very small yolk sac. This disappears at about the tenth day. At this time the larvae can be recognized readily by their long slender bodies, their large bright blue eyes, their large mouths, together with their bright green gall-bladder and large yellow oil-globule in the region of the liver. The larvae are extremely active and move rapidly along the bottom of an aquarium, hiding under stones and sea-weeds at the approach of fish or the shadow of a hand passed between them and the light.

Juvenile Stage

Between the larval stage of the tenth day and the juvenile of some three inches taken in June nothing is known of the activities of the ling cod. All attempts to secure specimens by trawling and dredging have failed. It is believed

that these fish are extremely rapid swimmers at the approach of danger and that they can hide successfully in crevices on the bottom and thus avoid being caught. The few specimens from the spring hatching obtained in the summer months were taken by fine-meshed beach seines in the shallow water at low tide around eel-grass beds.

Maturity

Ling cod gradually go into deeper and deeper water as they increase in size and at the same time the diet changes from a juvenile diet of crustaceans to one composed almost entirely of fish.

Owing to the fact that an examination of the scales and otoliths of the ling cod has not proven sufficiently trustworthy to admit of age-determination attempts to estimate the age at maturity have had to be abandoned.

Many specimens of both sexes have been examined from year to year and it has been found that the males mature at a much smaller size than the females. Examinations made in December through to April show that in one case only have the males spawned under 18 inches standard length (from tip of lower jaw to end of vertebral column) or about 20½ inches in total length. The round weight at this size is approximately 3 pounds. All specimens over this size were apparently fully mature.

The smallest female found in mature condition had a standard length of 27½ inches (total length 30¼ inches), with a round weight of 9 pounds. All specimens above this weight and length were found to be fully mature.

Maximum Size

The male ling cod do not attain such large proportions as the females. The largest male so far observed measured 32½ inches in standard length (total length, 36¼ inches), and had a round weight of 22 pounds which dressed to 11 pounds.

In catches of from 3,000 to 4,000 pounds taken by jigging it is the exception rather than the rule to find many large males, those over 28 inches in standard length being quite uncommon. The majority of the males taken range in standard length from 18 inches to 24 inches and from 3 pounds to 7 or 8 pounds in the round.

The largest female observed from which actual measurements were taken was 46½ inches in standard length (total length, 52 inches), and had a round weight of 54 pounds which dressed to 33 pounds. This certainly is not the largest ling cod on record as individuals weighing 70 pounds have been taken and one is said to have been 75 pounds in weight. Mr. Thomas Mowat in "*Fisheries of British Columbia*" (1866) reports a specimen 70 pounds in weight and 5 feet in length.

Food

From the early juvenile stage to the oldest adult the ling cod is a voracious feeder. There is considerable variation, however, in the kinds of food utilized

at different ages. In the smallest fish examined Crustacea were more commonly represented with the shrimp-like form, *Neomysis macrops*, and the common commercial prawn, *Pandalus danae*, most abundant. The larger series of juveniles had fed chiefly on young herring and an assortment of other species of small fishes.

In the adult stages almost any live animals seem to be acceptable as food, although certain species seem to be taken in greater numbers than others. Those fishes found to be most commonly taken were: sand lances, herring, various species of flounders, dogfish, young ling cod, gray cod, and whiting in the order named. Besides the fish, crabs, shrimps and squid also are to be found in the stomach contents.

The ling cod is essentially a member of the bottom fauna as can be seen from the occasional stomach content of eel-grass rolled up into balls, gravel, etc. It is probable that in plunging into the vegetation along the reefs and banks it sometimes swallows sea-weeds and hydroids along with its prey since in one case 16 specimens of hydroids of 9 genera were taken from one stomach.

In its feeding habit the ling cod resembles the cottoid fishes very much. Specimens kept in a salt-water aquarium were observed over a period of some months. The fish remains on the bottom most of the time. It rests on its two short ventral fins and its long anal fin balancing itself with its broad pectoral fins which are in constant motion. In this posture the body is at an angle with the bottom of about 15 to 20 degrees. The eyes keep moving from time to time as a small fish swims overhead and then with a swift motion of the tail the ling cod darts upward after the prey and seizes it tail first. If the attempt is unsuccessful it drops slowly down to the same spot and waits for another opportunity.

It was from a study of this habit of taking its food that the method of jigging, mentioned above, was developed by the fishermen.

Associated with the ling cod are certain species of fishes which seem to remain more or less within the limits of certain types of bottom. The ling cod moves from one area to another according to the time of day and the supply of food. In the shallower water bordering on the muddy to sandy bottom the lemon soles, certain flounders, sand lances and whiting abound. In deeper water the flounders are of different species such as the "brill" (*Pleuronichthys*), the slime sole (*Microstomus pacificus*), and the rough sole (*Lyopsetta exilis*), with which are associated dogfish, skates, black cod, etc.

Trawling records indicate that there is a diurnal movement over the banks and as a result the food varies considerably during different parts of the day. Examination of stomach contents shows that when trawling begins at night in shallow water the ling cod are feeding on sand lance as these are found to be in a very slightly digested condition. As the light increases and trawling is carried on in deeper and deeper water during the daytime there is a gradual change in the diet with other species appearing in the food which are practically undigested and the remains of sand lance present are found to be more and more digested as the day advances. In one series of stomachs examined from four

trawl hauls ranging from 10 to over 40 fathoms and from early morning to afternoon it was found that sand lances and flatfishes were more commonly represented in the morning in shallow water while herring and dogfish were more frequently found in the afternoon in deeper water. Perhaps the briefest summary of the food question would be to say, "Follow the herring and there you will find the ling cod".

USES

Flesh

Fully 99 per cent of the ling cod is disposed of on the fresh fish market either immediately or after refrigeration in cold storage. When properly frozen the flesh loses very little of its flavour and is not much changed in texture. The remaining 1 per cent is sold dry-salted or as smoked fillets.

The medium-sized fish, of from 5 to 15 pounds dressed weight, are in the greatest demand by the restaurants and hotels for steaks. The small fish of 2 to 5 pounds are sold chiefly to private homes and the very large fish are usually filleted and sold to the "fish and chips" restaurants. In these restaurants the fillets are usually rolled in flour and fried in fat, the resulting product being of excellent flavour and in keen competition with the halibut.

For some time there was a certain amount of aversion toward the appearance of the green colour in the smaller sizes of ling cod. This prejudice has been largely overcome. The pigment is quite harmless and disappears upon the application of heat in cooking. The flesh is then clear and white and forms a very appetizing addition to the menu, comparing quite favourably with that of salmon and halibut.

The ling cod is at its best when fried, boiled or baked. A small quantity is smoked each year and while the product is very appetizing it does not equal smoked black cod in flavour so the latter retains its preeminent position in the smoked fish market.

Canning has not proven satisfactory since the flesh becomes rather mushy owing to the large amount of water present in the flesh. The resulting product does not have a very attractive appearance although the flavour is quite good.

Liver Oil

The oil content of the flesh is low but the liver, which is between 1 and 4 per cent of the round weight of the fish, contains from 5 to 10 per cent of oil.

Recent work on the liver oils of various fishes at the Fisheries Experimental Station at Prince Rupert, B.C., has demonstrated the fact that the ling cod liver oil is extremely rich in vitamin "A", being 269 Lovibond blue units in a 10 per cent solution of the oil as compared with 294 in the halibut and 12 in ordinary cod liver oils.

In 1929, 4,848,900 pounds of long cod were reported as caught and landed in British Columbia. Since this represents the dressed weights the total weight of fish taken was close to 6,000,000 pounds. As the liver averages about 2 per

cent of the total weight of each fish, this represents over 100,000 pounds of liver. At this time the livers were thrown away as of no value.

Following the publication of the results of the work done on the liver oils of the various fishes studied at Prince Rupert the demand for ling cod livers has caused a rapid increase in their value and in the winter of 1936 the price was over 40 cents a pound. This represents a very considerable addition to the annual value of the fishery, approximately 10 per cent, and has made a very profitable side line for the fishermen, especially when the prices of fish have declined somewhat in recent years. The only preparation required of the fishermen is that he place the livers in a box which is surrounded by ice and leave them for the wholesaler to ship to the pharmaceutical supply houses.

Insulin

The insulin content of the islets of Langerhans in the ling cod is the richest so far discovered in any known species of fish. However, since other sources of this valuable pharmaceutical product have been found which form a more dependable supply, insulin from the ling cod has not been developed as a commercial by-product.

CONSERVATION

In attempting to conserve any species exploited by man, we should first of all consider what degree of utilization will give the largest yield in the long run. In agriculture, where the many factors involved are pretty well understood and can be more or less controlled, it is fairly obvious what measures should be taken to maintain or increase the yield. In the case of fishes, particularly marine fishes, the many factors affecting the supply are so little known and so little susceptible to control that for the present at least chief consideration may well be given to the question—how intensive may the fishery be without endangering the stock, that is, the future supply?

To answer this question for the ling cod is exceptionally difficult, since not only is there lack of knowledge concerning its age, rate of growth and extent of migration, but also there is as yet no known means of determining its age and rate of growth with any degree of certainty, the scales, so useful for this purpose in many fishes, such as the salmon, not being suitable. There are also difficulties to be overcome in determining the extent of its migrations. Until such knowledge can be obtained, it is probably unwise to suggest a definite administrative policy for utilizing the available supply to the best advantage.