

**CIHM
Microfiche
Series
(Monographs)**

**ICMH
Collection de
microfiches
(monographies)**



Canadian Institute for Historical Microreproductions / Institut canadien de microreproductions historiques

© 1996

Technical and Bibliographic Notes / Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming are checked below.

- Coloured covers /
Couverture de couleur
- Covers damaged /
Couverture endommagée
- Covers restored and/or laminated /
Couverture restaurée et/ou pelliculée
- Cover title missing / Le titre de couverture manque
- Coloured maps / Cartes géographiques en couleur
- Coloured ink (i.e. other than blue or black) /
Encre de couleur (i.e. autre que bleue ou noire)
- Coloured plates and/or illustrations /
Planches et/ou illustrations en couleur
- Bound with other material /
Relié avec d'autres documents
- Only edition available /
Seule édition disponible
- Tight binding may cause shadows or distortion along
interior margin / La reliure serrée peut causer de
l'ombre ou de la distorsion le long de la marge
intérieure.
- Blank leaves added during restorations may appear
within the text. Whenever possible, these have been
omitted from filming / Il se peut que certaines pages
blanches ajoutées lors d'une restauration
apparaissent dans le texte, mais, lorsque cela était
possible, ces pages n'ont pas été filmées.
- Additional comments /
Commentaires supplémentaires:

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

- Coloured pages / Pages de couleur
- Pages damaged / Pages endommagées
- Pages restored and/or laminated /
Pages restaurées et/ou pelliculées
- Pages discoloured, stained or foxed /
Pages décolorées, tachetées ou piquées
- Pages detached / Pages détachées
- Showthrough / Transparence
- Quality of print varies /
Qualité inégale de l'impression
- Includes supplementary material /
Comprend du matériel supplémentaire
- Pages wholly or partially obscured by errata slips,
tissues, etc., have been refilmed to ensure the best
possible image / Les pages totalement ou
partiellement obscurcies par un feuillet d'errata, une
pelure, etc., ont été filmées à nouveau de façon à
obtenir la meilleure image possible.
- Opposing pages with varying colouration or
discolourations are filmed twice to ensure the best
possible image / Les pages s'opposant ayant des
colorations variables ou des décolorations sont
filmées deux fois afin d'obtenir la meilleure image
possible.

This item is filmed at the reduction ratio checked below /
Ce document est filmé au taux de réduction indiqué ci-dessous.

10x		14x		18x		22x		26x		30x	
							/				
	12x		16x		20x		24x		28x		32x

The copy filmed here has been reproduced thanks to the generosity of:

National Library of Canada

The images appearing here are the best quality possible considering the condition and legibility of the original copy and in keeping with the filming contract specifications.

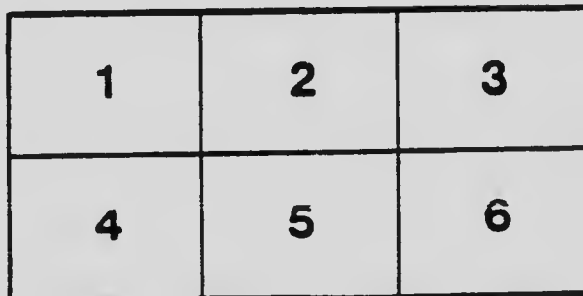
Original copies in printed paper covers are filmed beginning with the front cover and ending on the last page with a printed or illustrated impression, or the back cover when appropriate. All other original copies are filmed beginning on the first page with a printed or illustrated impression, and ending on the last page with a printed or illustrated impression.

The last recorded frame on each microfiche shall contain the symbol \rightarrow (meaning "CONTINUED"), or the symbol ∇ (meaning "END"), whichever applies.

Maps, plates, charts, etc., may be filmed at different reduction ratios. Those too large to be entirely included in one exposure are filmed beginning in the upper left hand corner, left to right and top to bottom, as many frames as required. The following diagrams illustrate the method:



:



L'exemplaire filmé fut reproduit grâce à la générosité de:

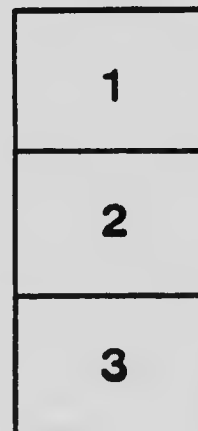
Bibliothèque nationale du Canada

Les images suivantes ont été reproduites avec le plus grand soin, compte tenu de la condition et de la netteté de l'exemplaire filmé, et en conformité avec les conditions du contrat de filmage.

Les exemplaires originaux dont la couverture en papier est imprimée sont filmés en commençant par le premier plat et en terminant soit par la dernière page qui comporte une empreinte d'impression ou d'illustration, soit par le second plat, selon la cas. Tous les autres exemplaires originaux sont filmés en commençant par la première page qui comporte une empreinte d'impression ou d'illustration et en terminant par la dernière page qui comporte une telle empreinte.

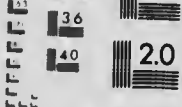
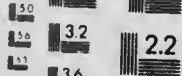
Un des symboles suivants apparaîtra sur la dernière image de chaque microfiche, selon le cas: le symbole \rightarrow signifie "A SUIVRE", le symbole ∇ signifie "FIN".

Les cartes, planches, tableaux, etc., pouvant être filmés à des taux de réduction différents. Lorsque le document est trop grand pour être reproduit en un seul cliché, il est filmé à partir de l'angle supérieur gauche, de gauche à droite, et de haut en bas, en prenant le nombre d'images nécessaire. Les diagrammes suivants illustrent la méthode.



MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



APPLIED IMAGE Inc

1653 East Main Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phone
(716) 288 - 5989 - Fax

CA.FS.483

RA-6-3

Bulletin of the Biological Board of Canada No. 3

Histories of New Food Fishes

III. The ANGLER

By

C. J. CONNOLLY, Ph. D.

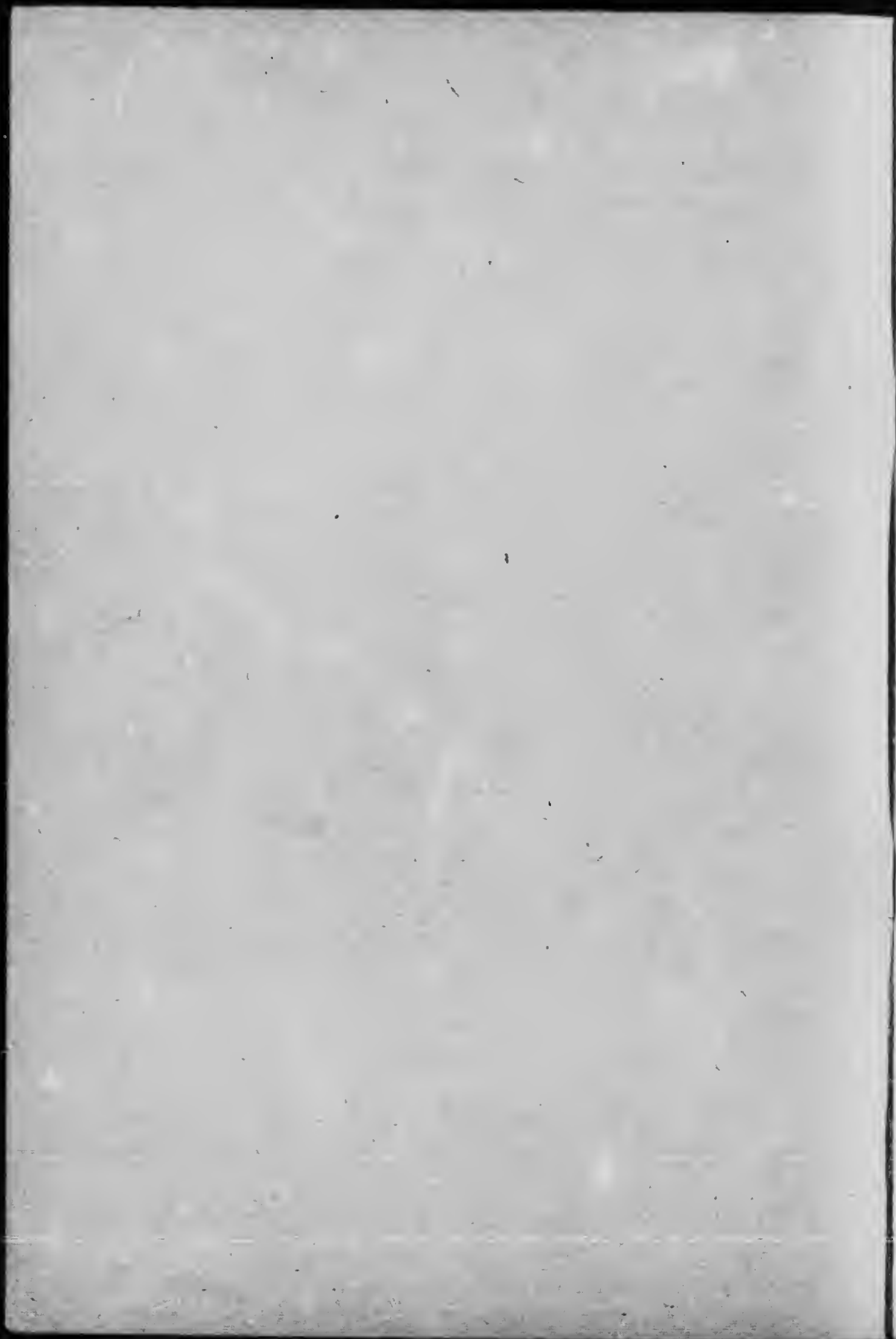
Professor of Biology at St. Francis Xavier's College,
Antigonish, Nova Scotia



LIBRARY OF THE
BIOLOGICAL BOARD OF CANADA
JUN 20 1960
Office of Conservation of
Wildlife

OTTAWA
THOMAS MULVEY
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1920

DDN 8236645



BULLETIN of the BIOLOGICAL BOARD of CANADA. No. 3

Histories of New Food Fishes

III. THE ANGLER

By

C. J. CONNOLLY, Ph. D.

Professor of Biology at St. Francis Xavier's College.
Antigonish, Nova Scotia



OTTAWA
THOMAS MULVEY
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY

1920

0000000000

THE BIOLOGICAL BOARD OF CANADA.

- Professor E. E. PRINCE, Commissioner of Fisheries, Chairman.
Professor A. P. KNIGHT, Department of Naval Service.
Professor L. W. BAILEY, University of New Brunswick, Fredericton, N.B.
Professor A. H. R. BULLER, University of Manitoba, Winnipeg.
Rev. Canon V. A. HUARD, Laval University, Museum of Public Instruction, Quebec, P.Q.
Professor W. T. MACCLEMENT, Queen's University, Kingston, Ont.
Professor J. P. McMURRICH, University of Toronto, Toronto.
Dr. A. H. MacKAY, Dalhousie University, Halifax, N.S.
Professor R. F. RUTAN, McGill University, Montreal.

INTRODUCTION.

THE Biological Board of Canada has begun a progressive movement to bring about a more intensive development of the fisheries. Its policy is, among other things, to disseminate in a popular form knowledge concerning the various fishery problems. In this way it is hoped to make available practical information obtained from a scientific study of the food-fishes.

In view of the food situation, during the war and since, it seems natural that the first problem to be considered should be the making use of hitherto unutilized food-fishes. In the first bulletin of the Biological Board of Canada, Dr. Huntsman, Curator of the Atlantic Biological Station, has dealt with an important food-fish—the Canadian plaice. At his suggestion I undertook to study the angler-fish, and while the quantity obtainable was not at first so abundant as was expected, the results seemed sufficiently important to be brought to the attention of those interested in the fisheries. It is not suggested, of course, that a special fishery should be developed for the capture of this fish. It is not abundant enough for that. But in the fishery of the present marketable varieties, thousands of tons of fish which are considered non-edible are thrown back into the sea. The total loss annually amounts to hundreds of thousands of dollars. Some of these fish, it is true, are not good fish, but they could be used for other purposes such as sources of oil, fertilizers, etc. Others again are excellent food-fishes, and to this group belongs the angler.

NAME.

The scientific name of this fish is *Lophius piscatorius* and it aptly refers to two striking characteristics. The first part of the name, *Lophius*, is from a Greek word meaning crest and refers to the spiny ray on his head. The second word, *piscatorius*, is a Latin word meaning, pertaining to the angler, and suggests the habits of the fish which is said to use the filament-like ray just referred to, as a bait to lure other fishes into its enormous mouth. The name formerly given to the fish on this side of the Atlantic was *Lophius americanus*, or the American angler, for it was believed that it was a species distinct from that found in European waters, but there is now no doubt that the American and European forms are identical.

The fish is known by many common names. In English speaking countries it is called the Monk fish, Angler, Frog-fish, All-Bellows, All-Mouth, Fishing-Frog, Toad-fish, Nass-fish, Sea-Devil, Devil-fish, Wide-Gap, Kettle-Maw, Goose-fish, Molligut,

etc. The oldest name is Frog-fish which is the equivalent of the name used by the Greeks and Romans. Both Aristotle and Cicero refer to it, the former, indeed, making some observations upon its internal structure which were verified only during the latter part of the nineteenth century. In Scotland it is called Keethe, Keghie, and Keithok. The French name for it is Baudroie, also Poisson-pecheur. It is likewise known by many names on the continent. In Germany it is called See-Teufel and Angler; in Norway and Denmark, Bredflab, Havtaske; Flanders and Holland, Zeediuvet; and in Sweden, Merulk.

The name *angler* though not usually used locally by the fishermen is common to all English-speaking countries, and as it corresponds to its scientific name and suggests its most striking characteristics, it is the proper name to apply to this fish.

DESCRIPTION OF FISH.

The angler is so distinctive and bizarre in appearance, that it can easily be recognized and indeed cannot possibly be confused with any other fish found on our coasts. (Fig. 2.)

The adult fish is about three feet long, possessing a large head and a tapering conical body. It is entirely devoid of scales. In colour it is a mottled chocolate-brown above and white below. The pectoral fins situated on each side of the anterior surface of the body as well as the tail or caudal fin are much darker and at the tips of the fins almost black. The fins on the lower surface of the body, the ventrals, are reddish.

The head forms almost one-half the entire body and is very wide and flat. The skull itself, however, is rather narrow, the great breadth of the head portion being due to the spreading out of the gill supports, and the lengthened supports of the pectoral fins. The latter feature gives the pectorals an arm-like appearance so different from most fishes where the pectoral fins seem to spring directly from the sides of the body. It is a characteristic found in a group of fishes called Pediculates. Another characteristic of this group is that the gill-opening is reduced to a circular aperture which is situated just behind the pectorals.

The surface of the head is very uneven and is especially spiny in the young. The mouth is large, terminal, and almost as wide as the head. The lower jaw projects considerably beyond the upper jaw. Both jaws bear four rows of teeth directed inwardly. Some are curved and conical, others straight and acute. Most of the teeth are depressible so that the victims of the angler find no obstruction in their passage into its enormous mouth. Two teeth-bearing areas are also present on the upper surface of the mouth.

On the lower jaw and extending in a straight line along the sides of the body back to the tail is a fringe of barbels or appendages which look very much like the tips of seaweeds. The leaf-like processes forming the fringe are of various sizes, large processes being intermingled with smaller ones. The line of appendages is somewhat interrupted by the pectoral fins on which are found only a few of these processes. They are best developed on the lower jaw where some of them attain a length of two inches.

The large and prominent eyes on the upper surface of the head look upwards and outwards. On the upper anterior surface are situated three isolated spines, the first two being movable and when at rest are recumbent on the surface of the head. These spines together with three smaller ones which form a continuous finlet farther back, are really much modified portions of the first dorsal fin. The first dorsal spine has a fleshy, pendant tip, which, it is believed, serves as a bait to lure other fishes into its mouth. On either side of this spine are short cylindrical stalks. These are the sensory-olfactory lobes or nostrils. The second spine bears no pendant tip, and is sometimes, though not usually, longer than the first. The third spine is embedded in the skin for about half its length. Farther back three delicate spines form the supports for a continuous finlet. The second dorsal fin is situated near the tail, and is very similar in size and shape to the anal fin directly below.

The pectoral fins are large, but from their soft yielding structure it can be seen that they are not efficient organs for swimming. In the posterior axils of these fins are situated the gill-openings or branchial apertures. The ventral fins are handlike structures and undergo, as we shall see later, a remarkable development during the life-history of the fish. They, too, show that they are not well adapted for swimming; indeed the entire structure of the fish reveals at once its sluggish habits. The angler is a bottom-loving fish adapted rather for crawling than swimming, and possesses in its enormous mouth well armed with teeth, the fringe of lobes so similar to tips of seaweed, the baited filament and the colour of the body, characters strikingly adapted to its habits and environment.

DISTRIBUTION.

The angler has a very wide range of distribution, being found on both sides of the North Atlantic. It is a common fish in the Mediterranean and on the western coast of Europe extending northward along the Scandinavian coast to the Færoe islands. Its northern limit on the eastern side of the Atlantic is about the 70th parallel, and it occurs as far south as the Cape of Good Hope.

In Europe according to Fulton, "it is common both in inshore waters and in the greatest depths at which trawlers work, but it seems to be most abundant in water of moderate depth."

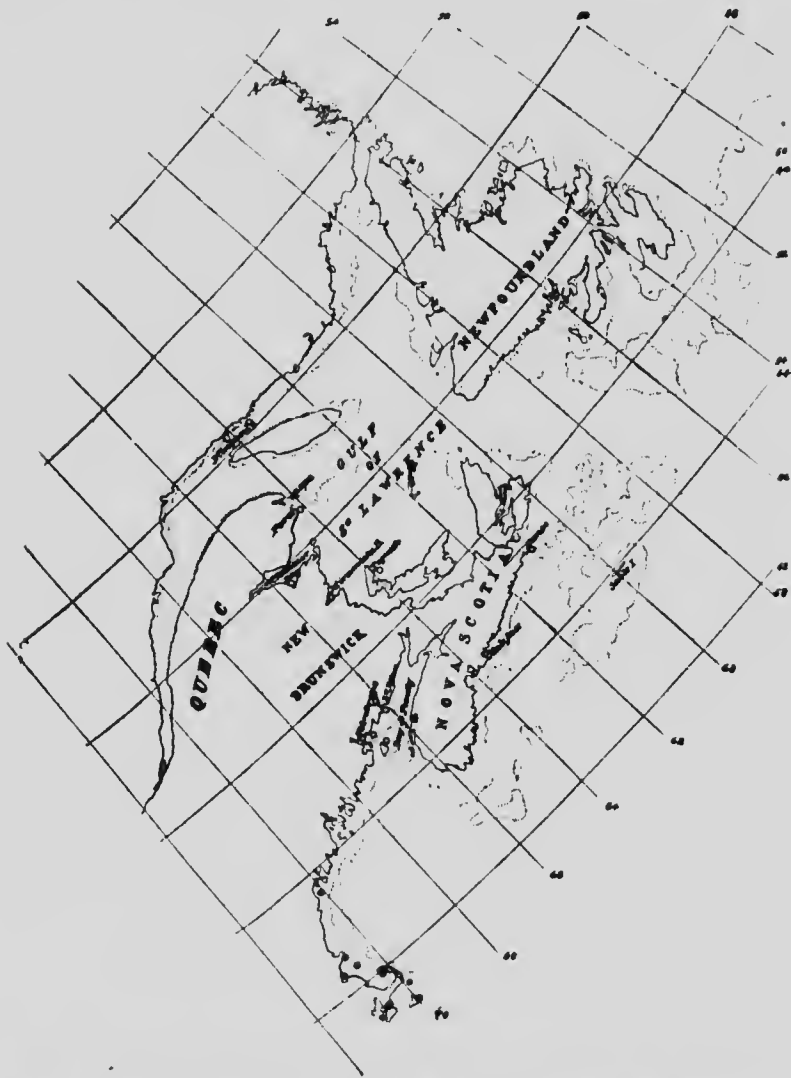


Fig. 4.—Chart showing distribution of Angler. The circles indicate where adults were captured. The areas marked by dotted lines have depth of less than 50 fathoms. The Angler is found on all the banks off the south coast of Nova Scotia and in the deeper water between the banks and the coast.

On our side of the Atlantic, it extends from Newfoundland to cape Hatteras at moderate depths (Jordan and Gilbert), and in deep water as far south as the Barbados (Jordan and Evermann). On account perhaps of its peculiar appearance, large size, and the fact that it has often been left stranded on the beach by the tide, it has been frequently recorded. It appears to be abundant all along the shores of the northeastern coastal states of the Union—New Jersey (Fowler), New York (Bean), Massachusetts (Smith, Goode and Bean), and Maine (Kendall).

There are also many records of its occurrence in our own Canadian waters. In the Bay of Fundy it is frequently found, usually on the more exposed shores as at the west islands, but specimens are occasionally taken in Passamaquoddy bay and the St. Croix river. Two specimens examined in the summer of 1918 were caught off Wilson's Beach. Elsewhere it has been taken at Long Beach above Great Salmon river, N.B., (Perley), and in the Annapolis basin, N.S. In July, 1919, specimens were obtained by the fishery officers at Richibucto, N.B., and Harborville, Kings Co., N.S., and in September, 1919, two specimens were taken by the writer at St. Mary Bay, N.S.

On the outer coast of Nova Scotia, it has been reported from St. Margaret's bay and Halifax by Jones and from Canso by Cornish. In the gulf of St. Lawrence there are records for Tignish, P.E.I. (Cornish), Miramichi bay and Bathurst, N.B. (Cox); also for Gaspé, P.Q. (Stafford), and Percé, P.Q. (Taverner), on the south shore, and for Anse des Dunes and Long Point near Mingan, P.Q. (Fortin), on the north shore. There are no records of its having been found in the St. Lawrence estuary.

It has been recorded for the banks of Newfoundland, but it is doubtful whether it occurs any farther northward. Its northern range on this side of the Atlantic is approximately limited by the 50th parallel. It is true that Weiz has listed *Lophius laevigatus* from Okak, Labrador, but we can not be sure what fish he meant. *Peterophryne gibbo*, a fish living in the floating *Sargassum* of the Gulf Stream, was at first placed in the genus *Lophius*, and later had the name *laevigatus* given to it by Cuvier, but this species can hardly have reached Labrador.

Pennant in 1784 reported the angler from Hudson bay, but according to Richardson the basis of this report was an Indian description of the Thutinameg or "Windfish". Lower, however, has found that the Anotimek or "Windfish" of the Indians is a sculpin, (*Icelus hamatus*).

On the American coast, the angler is limited as a shallow-water form to the Acadian zone and the northern part of the Carolinian zone, but its range as we have already noted, extends much farther south, where it is to be found in deep water.

ABUNDANCE.

It is difficult to make an estimate of the relative abundance of this fish. As the fishermen dislike handling it, and do not retain the specimens caught but throw them back into the sea, only very inexact statements could be obtained as to the frequency with which it is met. It does not appear, however, to be abundant in inshore waters. Perhaps if the fishermen once became accustomed to handling it, a surprising amount might be forthcoming. The steam-trawlers, especially, which work in areas of considerable depth might bring in a goodly number. Captain Hansen, of the steam-trawler *Orontes* operating out of Mulgrave, N.S., says: "There are plenty of them on all the banks of Nova Scotia. As a rule it is a deep-water fish and found in places that we call "dead ground," which means that there are no haddock or codfish there. In the winter months you will find them all around Sable island in from 60 to 75 fathoms of water. At least 2,000 pounds could be landed weekly by one trawler working on these banks. It is a good fish to eat and there is a great market for them in France and Belgium."

It may be of some interest to the reader to give the total weights of anglers landed in different countries from the various fishing areas in northeastern Europe, here mentioned. The statistics given are from the last available "Bulletin of the Fisheries of North-eastern Europe." The quantities are given in pounds:—

North Sea: England, 2,028,778; Scotland, 2,287,166; Germany, 563,807.

Skagerak: Germany, 357,658; and from Cattegat, 4,708.

Iceland: England, 400; Scotland, 6,372; Germany, 92,118.

Faeroes: England, 61,133; Scotland, 13,076.

Rockall: England, 4,694; Scotland, 559; Belgium, 132.

West Scotland and North Ireland: England, 607,191; Belgium, 550; Germany, 13,306; Scotland, 87,119.

South England: England, 480,121; Belgium, 9,372.

West England: England, 14,437; Belgium, 4,532.

West Ireland: 1,789.

South Ireland: 322,682; Belgium, 12,892.

Bay of Biscay: England, 20,339; Belgium, 616.

Morocco: England, 11,064; Germany, 418.

North Atlantic and White Sea (mixed regions): Germany, 45,489.

CAPTURE.

The angler is usually caught on the hooks of long set lines or baited trawls. Most of the specimens captured during the summer of 1918 were taken in depths ranging from 35 to 65 fathoms where



Fig. 1. The Angler. After W. von Wright in Smith.

- Fig. 5. Cross section of the Ovary, showing the germinal wall with the egg-pouches arranged in a single layer. The covering membrane has been raised by a hook.
- Fig. 6. Single egg of Angler, 0.02 mm. in diameter, showing clusters of oil globules around the germinal vesicle.—After Fulton.
- Fig. 7. Nearly mature egg removed from the mucous substance, showing oil globules and yolk granules.
- Fig. 8. Three eggs embedded in the gelatinous membrane in which they are laid.—After Agassiz.
- Fig. 9. Embryo just hatched: y—yolk; o g—oil globule; a—anus.—From Prince.
- Fig. 10. Embryo of fifth day, with dorsal process and paired fins: a—anus; o g—oil globule; p f—pectoral fin; v f—ventral fin; s p—sorsal spine. From Prince.
- Fig. 11. Young Angler.—From Agassiz.
- Fig. 12. Young Angler, thirty millimetres long, side view and dorsal view. From Agassiz.
- Fig. 13. 13a. Dorsal and ventral views of young Angler four and one-half inches in length, from the Bay of Fundy.

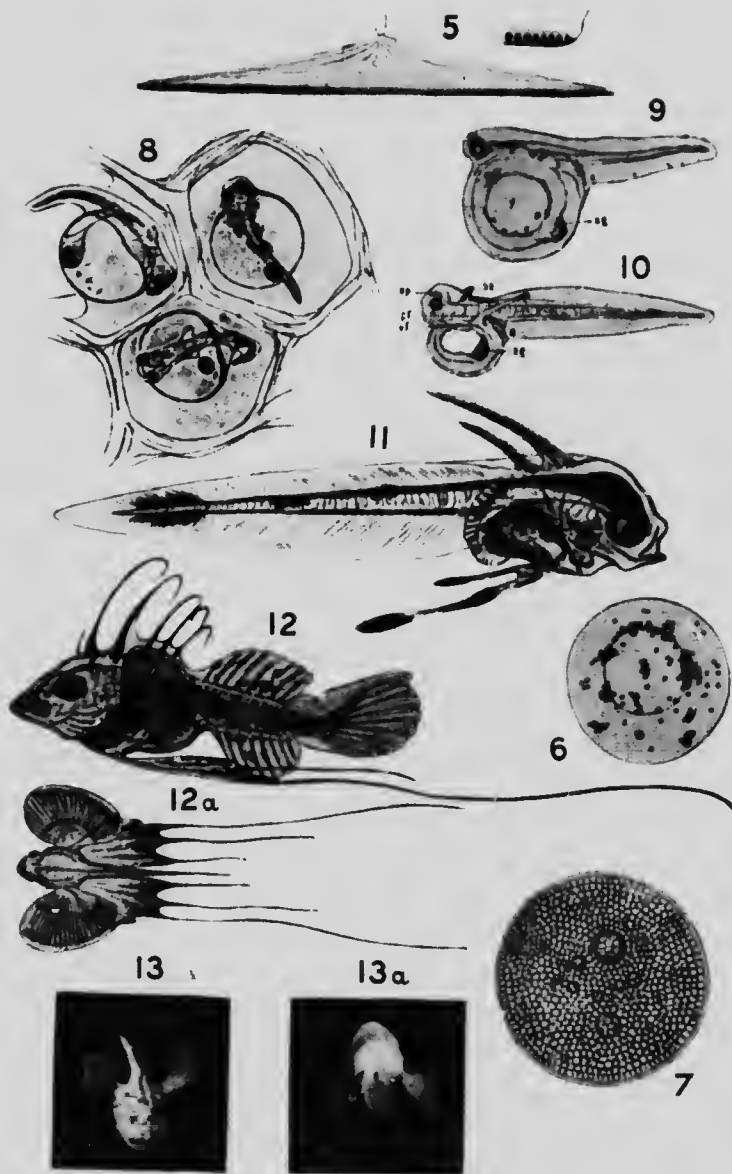




Fig. 2. Adult Angler, thirty-three inches long, from the Bay of Fundy.



Fig. 3. Angler, caught near Bathurst, New Brunswick, June 13, 1914.
Photographed by H. W. Jones.

the fishermen happened to be working. The month of July was the most favourable season in the Bay of Fundy and during this time they came in with the hake, which seems to be their favourite food. They are known also to follow shoals of herring. In inshore waters, therefore, the amount taken in the course of fishing for the staple varieties will fluctuate according to the presence or absence of other fish and in some months, none would be obtainable in these waters. But at greater depths where the steam-trawlers work the supply would be more constant, and it is from this source that we must look for sufficient quantities to supply the market.

Young fish are very seldom caught either on the set line trawls or by the beam or otter trawl. The reason is that the young seek greater depths after hatching, and frequent rocky bottoms where trawlers do not usually operate.

SIZE AND WASTE.

The average size of the adult angler captured during the summer of 1918 was about three feet, but the fish is said to attain a length of five feet; the average size was forty-two inches. A fish of average size weighs about twenty-eight pounds, and of this weight about ten pounds are marketable. There is thus a considerable waste on account of the very large head. But if the head of the fish were cut off on being caught, the remainder could be very easily handled, and the great bulk of it consists of good meat. The flesh on either side of the backbone is entirely free of bones and can very conveniently be cut into steaks.

PALATABILITY.

There is no doubt whatever that the angler is a good food-fish. The several investigators at the Atlantic Biological Station have eaten it during the summer of 1918 and all pronounced it good. The flesh is firm and white and especially suitable for frying. It has been a staple food-fish for many years in European countries and is considered excellent, in some countries being even regarded as a delicacy. It was introduced into the New York market during the summer of 1918 and found a ready sale.

SPAWNING.

The spawning period varies considerably according to the depth and temperature of the water which the fish inhabits. In Europe, according to Fulton, the spawning period extends "from March to the beginning or middle of July and perhaps into August, and probably mostly in May." Along the New England coast the angler spawns during May and June (Edwards), and during these

months the spawn is often found floating or accidentally attached to lobster traps in Vineyard Sound, but farther south it seems to spawn much later, towards the end of summer. Off Rhode Island the period extends from June to August. While the angler usually spawns in shallow water, there are indications that it does so also in deep water, and this seems to be the case as we go south, for here the angler would obtain in deep water the temperature found favourable in shallow water in northern latitudes.

The spawn has been found occasionally in the Bay of Fundy, but I have been unable to find any records of its occurrence on the Atlantic coast of Nova Scotia or elsewhere in Canadian waters. It may be said generally, that the spawn of the angler is unknown to our fishermen and its occurrence must therefore be rare in our waters, for it is so conspicuous that, if common, it would surely be remarked.

The eggs which I had the opportunity to examine at the Atlantic Biological Station, were taken on June 24, 1910, by the Indians at Pleasant point at the entrance of Passamaquoddy bay, and preserved in formalin. The spawn filled one and a half tubs, and was thought by the Indians to be ambergris. When taken, it was noted that it had a pink shade due to the oil globules present in the eggs.

The eggs of the angler are embedded in a continuous sheet of mucous substance from thirty to forty feet in length and one-half to a foot or more in width, which floats near the surface of the water. The mucous band is violet-grey in colour and the specks in the eggs due to the developing embryos give the entire substance a purple colour, so that it has been aptly called the "purple veil." The number of eggs contained in a band shed by a single angler is enormous. Fulton estimated the number of eggs in roe 36 feet in length and 6 inches wide at the ends, to be 1,345,848. The weight of this was $10\frac{1}{2}$ pounds, about 20 per cent of weight being due to eggs and the rest to the mucus. In bands of greater length, the number of eggs has been estimated as high as 3,204,400.

During the process of ripening, the eggs increase in volume, and according to Fulton, who has made a study of the young ovarian egg, this is due to the entrance of a watery fluid from the surrounding tissue. This increase in volume is not so great as in other eggs which float singly in the water. They are now lighter than in the earlier stages but not sufficiently light to float when separated from the mucous band. On being shed, the eggs float by reason of the buoyancy of the mucous substance in which they are embedded.

When the egg is very young and immature there are many small globules surrounding the germinal vesicle or nucleus in the centre of the egg, (fig. 6), but as the egg matures the globules fuse

together forming fewer and larger globules. When almost ripe and separated from the mucoid substance, the eggs are spherical and 1.7 mm. or almost one-sixteenth of an inch in diameter. The egg has a very thin capsule or covering membrane, and has a whitish granular appearance owing to the large number of yolk granules which form the greater part of its contents. (Fig. 7.)

DEVELOPMENT.

The living matter or protoplasm of the egg gradually collects at one pole to form the germinal disc, and the division of this disc into minute cells gives rise to the embryo fish. The yolk, which makes up the remaining and larger portion of the egg, supplies food to the embryo and furnishes material for its growth.

The plate-form germinal disc, consisting of numerous minute cells gradually grows over and incloses the yolk. Before it has half covered the yolk, its edge becomes thickened, and at one point of this thickened margin a little elevation soon appears. This elevation grows forward towards the centre of the plate, becoming a thickened band extending from the edge of the plate to its centre and finally beyond the centre to the other side of the egg sphere. This thickening in the living matter covering the yolk is the first indication of the embryo. One end of this band develops rapidly and forms the head on which the eyes soon appear. At the opposite end of the band the tail is formed, and in the angler it is freed from the surface of the yolk at a very early period. Soon a continuous median fin arises. It begins behind the head and extends back around the tail and forward on the lower surface, until it meets the yolk sac, where it splits, the two divisions spreading over the surface of the yolk. The fin membrane is remarkably wide in the angler. Patches of colouring matter appear on the surface of the young fish, and at this stage are much more abundant than in most fishes.

The young fish in the early stages of development is contained within the egg membrane, (fig. 8) but by its movements it eventually bursts open this membrane and henceforth leads an independent existence in the sea. It is estimated that the period of development before hatching occurs lasts from two to three weeks according to the temperature of the water. At the time of hatching, the yolk which serves as nourishment for the developing fish and consequently decreases in bulk with the growth of the fish, still forms about one-half the entire bulk (fig. 9). It disappears rapidly after hatching occurs. There is no tendency at this stage toward the vertical flattening of the head so pronounced in the adult. On the contrary the head is flattened laterally and to a greater extent than is the case with those fish which, unlike the

angler, are laterally flattened in the adult. Characteristic of the angler, too, are the blunt anterior surface of the head and the rounded trunk and tail.

At the time of hatching, two circular folds of skin are present just above the yolk. The higher, anterior one is the rudiment of the pectoral fin, and the lower one posterior to it is the rudiment of the ventral fin. According to Agassiz and Williamson the rudiment of the dorsal spine is already apparent when the embryo hatches, and five days afterwards is a stout finger-like process (fig. 10). In this later stage the pectoral fins appear as a pad on each side and the ventral fins have developed into rod-shaped structures. The yolk has already decreased appreciably in bulk. About this time a second spine appears as a small papilla.

Gradually the head flattens and lengthens, and henceforth increases in size in proportion to the body, while in most other fishes there is a gradual decrease in the size of the head compared with the rest of the body.

When the embryo is about fifteen days old, a second ray of the ventral fin appears as a bud at the base of the first and continues rapidly to lengthen. The pectorals also become comparatively large. By this time a third dorsal spine appears behind the second. The lower jaw projects considerably beyond the upper one. Teeth have appeared on the lower jaw. The young fish is now about 9 mm. or one-third of an inch in length. Following this stage, the fins and dorsal spines increase rapidly in size, and a third ray appears on the ventral fin. The head becomes much larger, pigment spots become more numerous, and the caudal or tail fin begins to be differentiated from the embryonic fin fold.

Up to this stage there is no marked difference in the development of the American angler, as figured by Agassiz, and that of the European form, as described by Prince and Williamson, except that in the former the second branch of the ventral develops earlier than in the latter. For according to Agassiz's figures, when the young angler possesses two spines and the rudiment of a third, the second ray of the ventral is already more than half the length of the first ray (fig. 11), while it is a mere bud in the European specimen. But in the oldest stage figured by Agassiz there is a remarkable difference when compared with the slightly younger European specimens. So great is the difference that Prince doubts whether the British angler "really passes through the surprisingly grotesque stages figured by Agassiz."

The most striking figure of the last stage figured by Agassiz (fig. 12) is the enormous length of the first ventral ray which is about twice the length of the body of the fish. There are two smaller rays interior to this, and all three are connected by a membrane reaching almost to the base of the tail, so that when

seen from above the ventrals look more like wings than fins. There is, however, a tendency in development at this stage leading to adult features. This is shown in the vertical flattening of the head now increased much in size. The front part of the head slopes more gradually, thus forming with the lower jaw a smaller angle than is present in previous stages. Accumulations of colouring matter or pigment spots have become quite dense over the head and trunk. The pectorals have become very large and their rays well developed and lined with pigment spots. The tail fin is clearly outlined and the embryonic median fin has given rise to a posterior dorsal fin above the trunk and an anal fin below, both being connected with the tail fin by the unmodified part of the median fin fold. The anterior dorsal fin is shown in the figure to consist now of five rays with a sixth forming in front of the ray which was the first to develop. This would seem to be abnormal, for the ray which arises first continues to hold the lead in size in other young anglers that have been observed.

It will be recalled that in the adult angler, the first three rays are isolated from one another, the third ray being partly embedded in a fold of the skin and the next three connected by a membrane forming a finlet, the six rays taken together forming the first or anterior dorsal fin. This condition is approached in the stage just described.

At this stage the young angler must seek greater depths for its further development, or perhaps conceal itself among the seaweeds of rocky bottoms at moderate depths, for specimens in the post-larval stages up to four or five inches in length have rarely been observed.

RATE OF GROWTH.

Owing to the scarcity of the young angler for the reasons just mentioned, very little is known concerning its rate of growth. According to Fulton, who has studied the rate of growth in the European foru, one of the smallest specimens found was five inches long. Young anglers are also very rare on this side of the Atlantic, but I have fortunately been able to examine a few specimens of a size apparently rarely met with, and they will furnish some clue as to their rate of growth.

To calculate the rate of growth it is of course necessary to begin with the spawning period. This, as we have seen, extends through the months of June, July and August. Eggs in the earliest stages of embryonic development were obtained at the entrance of Passamaquoddy bay during the last week of June as we have already noted. In the cold waters of that place and season, the period of development before hatching would take about three weeks. The young fish spends several weeks more in the larval condition before it assumes the form of the adult fish.

The young angler caught on August 12 (1910) and preserved in formalin at the Atlantic Biological Station, St. Andrews, N.B., had an extreme length, measured from tip of lower jaw to the extremity of tail, of $4\frac{1}{2}$ inches and weighed 15.7 grams, or about half an ounce (fig. 13).

This specimen evidently belonged to the previous year and is approximately one year old. The pectoral fins are membranous, wing-like structures and comparatively wide— $1\frac{3}{16}$ inches when expanded. The ventrals are long, narrow structures running back parallel to the axis of the body. They are $1\frac{5}{16}$ inches in length. The head is about one third the extreme length of the body.

In the Provincial Museum at Halifax, are some interesting specimens of young anglers which Mr. Piers, the curator, kindly permitted me to examine. Though not all are preserved in perfect condition, they throw considerable light on the early stages of growth.

The largest of the young specimens were caught in Halifax harbour and measures $5\frac{1}{4}$ inches. It belongs, like the St. Andrews' specimen, to the previous year, but is somewhat older than the latter. This is quite apparent in the further development which it has undergone. The most pronounced change is in the appearance of the fins. The pectorals have become flipper-like structures looking more like crawling than swimming appendages. The ventrals have become broader and their rays strongly developed. They are now directed backwards and outwards, crossing over the axils of the pectorals. Three rows of depressible teeth curving inwards are present. The specimen weighs $34\frac{1}{2}$ gr. or $1\frac{1}{2}$ ounces. The head is one-third the length of the body.

Another specimen has an extreme length of not quite three inches. This one has fins similar in appearance to those of the St. Andrews' specimen, but the rays are softer and have a less rigid and flaring appearance. It weighs 5.2 gr. or about $\frac{1}{2}$ of an ounce. Unfortunately there is no record of its exact date of capture, but it is quite evident that it was spawned in the same year, and is only a few months old.

The third Halifax specimen has a total length of but $2\frac{3}{4}$ inches and is the youngest and most interesting of the three specimens. It is not, however, in a good state of preservation. Mr. J. M. Jones has given a detailed description of it in a report of the Nova Scotia Institute of Science (Vol. II, 1871). This specimen is obviously only two or three months old.

From a consideration of these young specimens, we learn that the angler attains a length of about five inches at the end of the first year. This is a somewhat slower growth than that calculated by Fulton for the European forms, but the colder water of the Bay of Fundy, which never rises above 52° F., would perhaps account

for the difference. Fulton computes the average increment in a year to be a little over six inches.

During recent years much has been learned concerning the growth of fishes by examining the zones of growth on the scales. The formation of zones is due to the fact that there is a slow growth in autumn and winter and a rapid growth in spring and summer. The successive periods of rapid growth consequently become marked off from one another and the age of a fish can be determined by counting the annual rings.

As the angler has no scales we must have recourse to another method of determining its growth. The vertebrae or segments which together form the backbone also show zones of growth on their concave surfaces at both ends. In the older specimens it is somewhat difficult to determine the exact number of rings, but in the younger specimens the rings of growth are quite distinct. From an examination of the vertebrae the ages of specimens of various lengths were estimated as follows: A specimen of about 4½ inches in length is one year old; 18 inches, four years; 29 inches, eight years; 31 inches, nine years; 37 inches, ten years; 40 inches, twelve years. The average yearly increment is therefore about four and a half inches in the younger angler, and the yearly increment gradually decreases as the fish grows older.

AGE AT MATURITY.

A sufficient number of specimens of different ages was not obtained to make it possible to determine the age at which maturity is reached. The specimen having a length of eighteen inches, however, was not yet mature, while all specimens over thirty-one inches in length were mature. According to Fulton's calculation, when three years old the angler will measure approximately twenty-one inches, and when four years old about twenty-six or twenty-seven inches. "The information as to the size at which maturity is first attained is not extensive, but males may be found ripe at the time stated. Females probably do not become mature as a rule until over thirty inches in length, and the facts point to the males first reaching maturity when four years of age and the females when five years."

FOOD.

The angler will eat almost anything. It is known to have swallowed the wooden buoys attached to lobster traps and has been caught with a boat anchor for a hook. In the stomach of one examined by the writer, a cod twenty-three inches long and weighing three and three-quarter pounds was found, together with a smaller fish in great part digested. But this does not give an

adequate idea of its voracious appetite, for it is said to swallow other fish as large and as heavy as itself. It is able to do this because its stomach is distensible to an extraordinary degree. Its favourite food in our regions seems to be the hake, the schools of which it follows, but its fare is made up of a great variety of forms such as soles, flounders, dog-fish, herring, cod, haddock, skates, sea-ravens, sculpin, crabs, and squid.

Though its meals are indeed heavy, they are probably not frequent, for the stomachs of a large percentage were found to be empty. The digestive powers of the stomach seem to be exceedingly slow and fishermen are known to have sold to unsuspecting buyers, fish that were taken from the stomach of the angler. In one case three quarters of a hundred were obtained from one angler and sold.

HABITS.

From the earliest times, writers have made mention of the peculiar habits of this fish. Cicero, for instance, says (*De Nat. Deorum* II-49) that fishing-frogs are wont to bury themselves in the sand and to move in close proximity to the water; and that the fish which approach them, as if for food, are destroyed by the fishing-frogs and consumed.

As we have seen, its structure suggests much concerning its habits. Its flat form with eyes on the top of the head and looking upwards indicate that it is a bottom-dwelling fish. Its hand-like ventral fins and the long arm-like supports of its pectorals show that it is adapted rather for crawling on the bottom than for swimming. Its brown colour harmonizes with the seaweeds, and the fringe of appendages, so much like small fronds of seaweed, increases the similarity with its surroundings. This feature affords some compensation for its poor swimming ability; for by means of this protective colouring, it can the more easily conceal itself while lying in wait for prey. In addition to this protection it possesses the dorsal filaments, the first of which is movable in all directions and is provided with a bait-like appendage, which no doubt is a lure to other fish, and for this reason, as we have seen, the name angler has been given to it. But it is more probable that the angler uses this structure as a sense organ to learn of the presence of other fish. Other names also suggest its habits. It is called the goose-fish, for instance, because it is known to have swallowed geese which were floating on the surface of the water. Seven wild ducks are said to have been found in the stomach of one angler and six coots in another.

While the angler is normally a bottom fish, it occasionally comes to the surface and fishermen say that it does so especially during a storm.

In Europe the belief is prevalent among the fishermen that the appearance of the angler presages a storm and the belief is shared by the fishermen on the Atlantic coast of Canada. According to Storer a current saying among the fishermen of Massachusetts is: "When you catch a goose-fish, look out for an easterly storm."

CONCLUSION.

The angler, though not common in inshore waters, is frequently caught at certain seasons as a by-product of other fisheries. As it is a good food-fish, it should not be thrown back into the sea. There should be no hesitation in using this fish for food, as it has long been tested in Europe where it is considered excellent, and during the past year has been sold in the New York markets. As the angler is to some extent destructive of other fish, we have an additional reason why it should be retained when captured.

It is a common fish on the banks of Nova Scotia, and while no estimate can be given of the quantity annually available, there is every reason to believe that marketable quantities can be obtained.

