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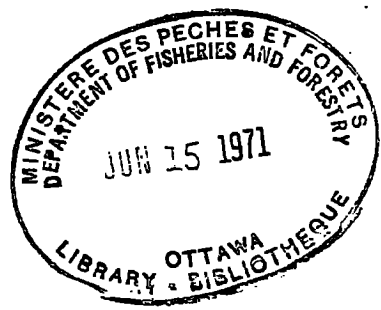
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The swordfish (*Xiphias gladius* L.), its life-history and economic importance in the northwest Atlantic

By S. N. Tibbo, L. R. Day
and W. F. Doucet



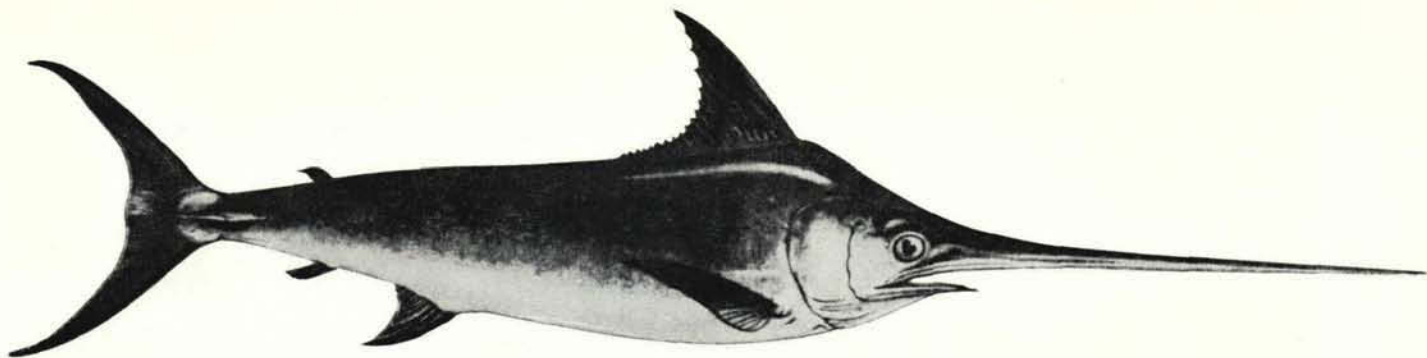
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The swordfish (*Xiphias gladius* L.). Photograph from Nakamura (1955).

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W. E. RICKER
N. M. CARTER

Editors

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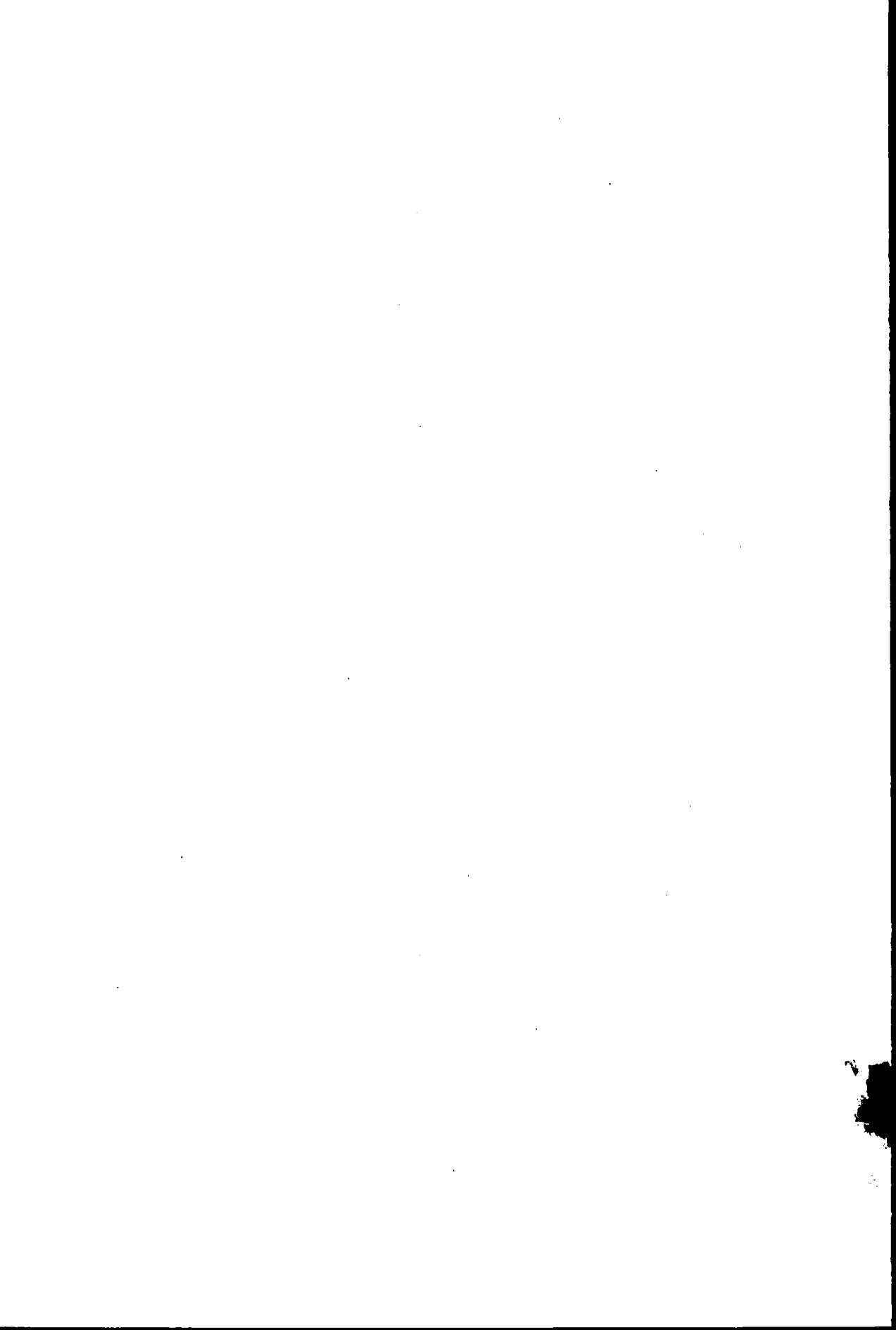
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ABSTRACT

A general account is given of the life-history of swordfish and the development of a fishery for swordfish in the northwest Atlantic. Special attention is given to the Canadian catch which has increased spectacularly in the last decade from about 2 million pounds in 1949 to nearly 7 million pounds in 1959. This increase is associated with a change in the nature of the fishery from a small boat, inshore operation to the use of longliners and draggers that can operate offshore and over a wide area. The prospects for continued expansion of this important industry are discussed.

INTRODUCTION

The swordfish is a powerful, fast, predatory fish of the tropical and temperate open seas. Its fishery is becoming increasingly important on the Canadian Atlantic coast. Swordfish are summer visitors to Canadian waters and the fishery, which is carried on chiefly from June to September, is prosecuted entirely from Nova Scotia ports. Catches in 1959 were approximately 6.7 million pounds with a landed value of nearly 1.5 million dollars. The distribution of swordfish varies throughout a season and from one season to the next. The success of the fishery depends primarily on finding the centers of distribution. While experience is an excellent guide, knowledge of the factors which affect or determine distribution could assist materially in a continued expansion of the fishery and in making better use of the resource.

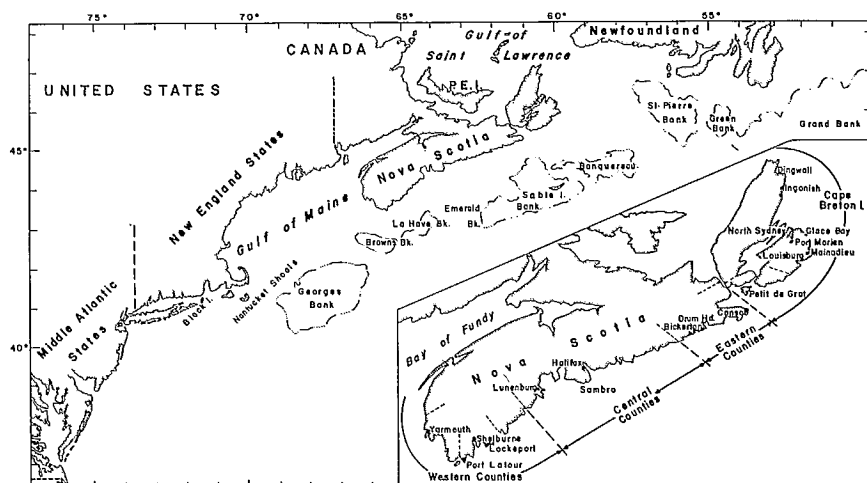


FIGURE 1. Location of swordfish fishing areas in the northwest Atlantic. Principal landing ports and areas of Nova Scotia in inset.

An investigation of the swordfish was initiated in 1958 by the St. Andrews station of the Fisheries Research Board of Canada. Its purpose was to study the biology and ecology of swordfish in order to provide background information for use in evaluating the effect of increasing exploitation of the stock and hence, to furnish a sound basis for whatever management is indicated. Most of the field work and the preliminary reporting was done by student assistants; Mr. G. M. Somerville in 1958 and Mr. B. K. Gilbert in 1959. It is a pleasure to acknowledge their contributions to the study.

This report includes the results of the 1958 and 1959 investigations and some general information obtained from literature surveys and interviews with fishermen. Statistics of fish landings for Canada and the United States are analysed and some of the economic factors which affect the fishery are examined. The swordfish fishing grounds and landing ports in the northwest Atlantic area are shown in Figure 1.

HISTORICAL AND LEGENDARY BACKGROUND

The swordfish has been so well known and for such a long time that it has seldom been confused with other species. Aristotle, the father of zoology, called it *Xiphias* nearly 2400 years ago and it has been known by this name ever since. At the very inception of binominal nomenclature, Linnaeus called it *Xiphias gladius* and only one additional name is included in its synonymy, *Xiphias rondeletii* Leach.

An interesting account of the swordfish is contained in "The Fisheries and Fishery Industries of the United States" by George Brown Goode, published by the United States Commission of Fish and Fisheries in 1884. The following excerpts from this report are of interest.

"The Sword-fish was known to Pliny, who wrote: 'The Sword-fish, called in Greeke Xiphias, that is to say in Latin Gladius, a sword, hath a beake or bill sharp pointed, wherewith he will drive through the sides and planks of a ship, and bouge them so, that they shall sinke withall!'"

"This fish is found in the North Sea and the Baltic, but is rare in those waters. In the Mediterranean, however, it is very abundant. It lives for the most part in the Atlantic, where in winter it is found in mid-ocean. In spring it appears on the coast of Sicily, where its eggs are deposited on the bottom in great numbers."

"Although such large fishes are not usually well flavoured, this one is considered palatable. Pieces of the belly and the tail are especially esteemed, and hence they are expensive. The fins are salted and sold under the name 'callo' . . ."

"The earliest allusion in literature to the existence of the Sword-fish in the Western Atlantic seems to occur in Josselyn's 'Account of Two Voyages to New England', printed in 1674, in the following passage: ' . . . in the afternoon we saw a great fish called the Vehuella or Sword-fish, having a long, strong and sharp fin like a Sword-blade on the top of his head, with which he pierced our Ship, and broke it off with striving to get loose, one of our Sailors dived and brought it aboard!'"

"Another allusion occurs in a communication by Dr. S. L. Mitchill of New York, to the 'American Monthly Magazine': 'an individual of this species was taken off Sandy Hook, by means of a harpoon, on the 19th June, 1817. The next day it was brought to New York market and cut up like halibut and sturgeon for food. The length was about twelve feet, and girth, by estimation, five. . . The stomach contained seven or eight mackerel. The flesh was remarkably firm; it was purchased at a quarter of a dollar the pound!'"

Another early record of the use of swordfish as food is found in the Barnstable Patriot of June 30, 1841, in which it is stated that " . . . fishermen of the island south of Cape Cod capture these fish and that about 200 lbs. a year are pickled and salted at Martha's Vineyard".

Accounts of fishing captains quoted by Goode (1884) give evidence that the fishery came into existence and importance between the years 1840 and 1855 on the south coast of New England. North of Cape Cod, there is no record of fishermen devoting any effort to capturing swordfish until after 1867.

The earliest available references to swordfish in the Canadian area concern the start of the fishery about the beginning of the present century. In the Department of Marine and Fisheries Annual Report for 1903 there is the following statement from A. N. Whitman & Son of Halifax, Nova Scotia:

"Sword fish—A new industry sprang up here this year in the catching of sword fish and quite a number were caught. The catching of these excellent fish has been an industry for a number of years on the coast of the United States, but it has never been followed here. It was discovered here this year that these fish were unusually abundant in our waters and as the price is usually a good one, our fishermen fitted out with harpoons and other appliances to capture them with the result that quite a number were taken and another year will probably see an important business done if the sword fish are as numerous as they were this season. They are among the best of the edible fishes, as all who have tasted can testify. Our fishermen proved adept in the art of catching them, after a very little practice. We predict a good future for the sword fish business."

In the same report (Dept. Marine and Fish., 1903) Mr. John E. Cohoon, Fishery Officer at Canso, Nova Scotia wrote:

"Something new in the fishing industry was reported during the season when swordfish appeared on the coast in good quantities. Swordfish were reported plentiful in September 21, and about 20 fish were landed the week of the 28th."

It was not until 1909, however, that the swordfish fishery became sufficiently important to be recorded separately in the fishery statistics. In the Department of Marine and Fisheries, Annual Report, 1909-10, there are the following statements:

"The amount and value of swordfish caught on the Nova Scotia coast are recorded in the returns this year for the first time, and show a total of 146,611 lbs. in quantity and \$13,695 in value. The swordfish is a huge species of mackerel, having a short shaft of bone protruding from the upper jaw—hence the name—capable of penetrating six inches of solid oak when the great body behind it gathers full momentum."

"Quite a number of these fish [swordfish] were taken on the Atlantic coast this year, which is an unusual thing. The fish weighed from 250 to 500 lbs. each, and are worth \$15 to \$30 each, the usual way of taking them is with a harpoon."

Since 1909 swordfish landings have been recorded regularly in the fishery statistics. For 20 years the growth of the fishery was slow and erratic but afterwards it increased steadily and rapidly from less than 1 million pounds in 1929 to nearly 7 million pounds in 1959.

DESCRIPTION OF THE SWORDFISH

Field trips on commercial vessels in 1958 and 1959 provided an opportunity for studying various other aspects of swordfish biology and the following account deals particularly with these investigations. However, what little is known of the swordfish is scattered through the literature of many countries in an inconvenient and often unavailable form and hence it seems worthwhile including a short summary account of the more important aspects of its biology.

The geological record of the swordfish is incomplete but it has probably been separated from its closest relatives the sailfish, marlin, and spearfish since early Eocene times. Systematically the swordfish belongs to the order Percomorphi which includes a huge number of perch-like fishes. The mackerels, tunas, swordfish, spearfishes, marlins and sailfishes are all included in the sub-order Rhegnopteri (Jordan *et al.*, 1930). There is only one species of swordfish (Family Xiphiidae) but it is sometimes confused with the marlins and sailfishes (Family Istiophoridae) that also possess pointed bills. The swordfish has a broader bill than the marlins or the sailfishes, and lacks pectoral fins. In addition, scales and teeth are found only on young swordfish under 30 inches in length while adult marlins and sailfishes possess distinct scales and teeth.

EXTERNAL FEATURES

The swordfish is characterized by a greatly prolonged upper jaw and snout forming a flat, sharp-edged sword which may amount to one-third of the total length. It has a high first dorsal fin and a small second dorsal, both of them soft rayed. The tail is broad and lunate. There are two separate anal fins and a strong longitudinal keel on either side of the caudal peduncle.

The swordfish, including its sword, is dark above and whitish below, but unlike most mackerel-like fishes, its colours are quite consistently uniform. The upper surface varies from dull blue to purple, dark brown or even black, the belly being dirty white and the flanks bronze. The younger and smaller fish (200 lb) are usually bluish to purple on the back whereas the older and larger fish (400 to 800 lb) are dark brown. The eyes are deep blue.

On July 3, 1959, a swordfish seen in the water by the crew of the *Pubnico Pal* was light blue in colour. When harpooned and boarded, its back was bluish black and the sides of the body and the dorsal fin were a copper-brown colour. Two others that were examined closely were medium brown on the back and sides and only a narrow strip on the ventral surface was whitish.

After death the colours usually fade into a slaty brown above and a dingy white below. Some fishermen describe a type of swordfish which turns 'silver' soon after they come on deck but then revert to a dark colour about 30 minutes later.

SIZE

Swordfish grow to a large size. The largest one recorded by a Canadian fisherman was caught off the northern tip of Cape Breton (date unknown) by Captain Garrison of Sambro, N.S. The dressed weight of this fish was 915 pounds. Practically every fisherman tells a story of landing at least one large fish of 600 pounds or thereabouts (dressed weight) but the average size is much smaller and varies considerably with the season and fishing area.

The world record for rod and reel is currently 1,182 pounds (live weight) taken on May 7, 1953, off the coast of Chile by Lou Marron (Maine Coast Fisherman, August 1958).

Canadian fishermen agree that fish of the early run on Georges Bank in June are different from those on the Grand Bank and on the northern edge of Georges Bank in August. For example, in June the size of swordfish caught on Georges Bank is said to vary from 125 to 175 pounds (dressed weight), whereas in August it varies from 275 to 300 pounds on Georges Bank and from 275 to 350 pounds on the Grand Bank.

The smallest fish landed by a Canadian fisherman was caught off Cape Breton in 1947 by Captain Jule LeBlanc of Middle West Pubnico, N.S. It was just 13

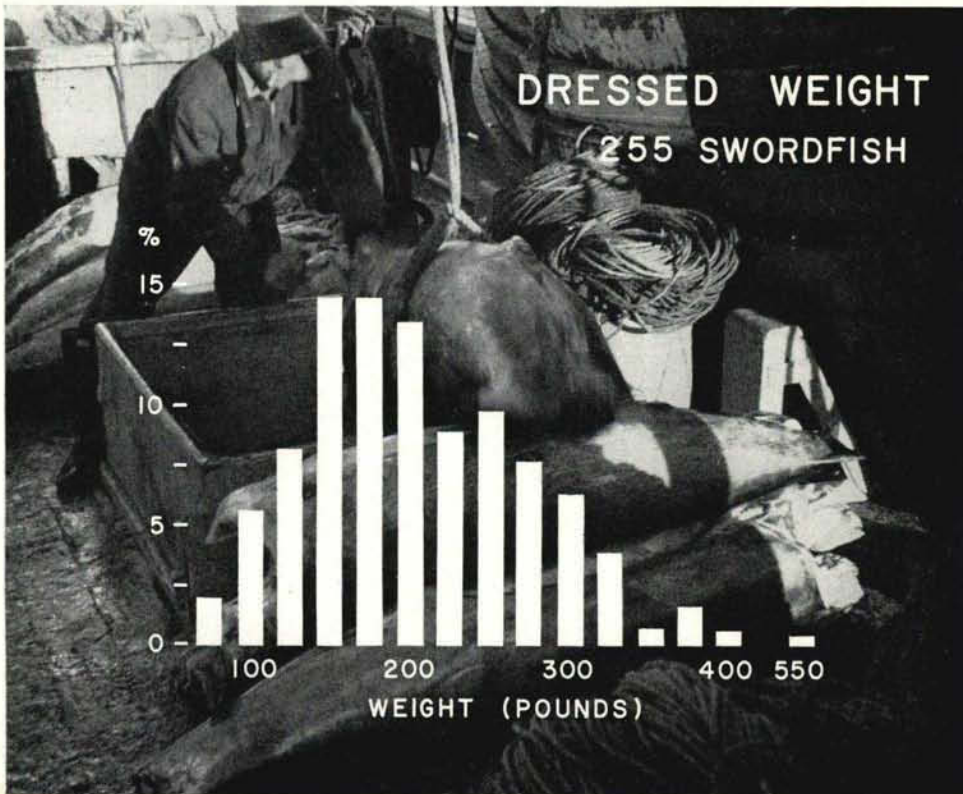


FIGURE 2. Weight distribution of swordfish landed in 1959. (100 lb = 87-112 lb, etc.)

pounds live weight. This fish was kept frozen or on ice for nearly two months and was shown at the Yarmouth County Fisheries Exhibition that year.

On August 15, 1951, the United States trawler *Winchester* hauled up a 5 $\frac{3}{4}$ -pound (live weight) swordfish on the southeast part of Georges Bank (Maine Coast Fisherman, August 1958).

Fishermen report that the fish caught early in the season are not only smaller but are considerably thinner than those caught later. They believe that swordfish probably put on 50 to 75 pounds of 'fat' during their stay in Canadian waters.

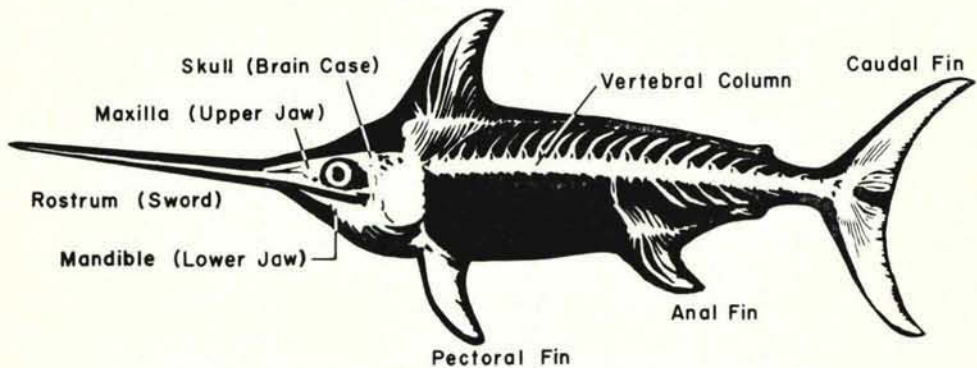


FIGURE 3. Skeleton of the swordfish. Drawn from a photograph in Gregory and Conrad (1937) with labels added.

Figure 2 gives the weight distribution of a sample of swordfish taken during the 1959 season. The weights given are dressed weights, i.e., with head, fins and tail off and guts removed. No attempt was made to convert these weights to 'live' weights because of the lack of an acceptable conversion factor. Swordfish are almost always dressed at sea and live weights are not available except for a few fish. Three fish that were weighed in 1959 both whole and dressed indicated a conversion factor from dressed to live weight of $\times 1.5$ whereas the most commonly used factor in published catch statistics is $\times 1.25$.

INTERNAL FEATURES

The skeletal system of the swordfish is described by Gregory and Conrad (1937). Figure 3, illustrating the skeleton, is taken from their paper. They noted a total of 26 vertebrae, fifteen abdominal and eleven caudal. The ribs are short and poorly developed. The hip or pelvic bones, as well as the fins, are lacking. The skull is about seven times as long as it is deep. It is dominated by the bones of the upper jaw. The most important of these bones are the premaxillaries which form a long pointed beak or rostrum commonly called the sword. The lower jaw or mandible is short in proportion to the length of the skull and the upper jaw. The brain case is wide and shallow. Its roof is strongly built and braced to resist the stresses from the sword. The mouth is small and its bony framework delicate.

Raven and LaMonte (1937) described the digestive tract of the swordfish in considerable detail. The more important aspects are summarized here.

The jaws have no teeth although the mouth and the inside surface of the gill arches are covered with fine backwardly directed denticles which may help in feeding.

The stomach is shaped like a long narrow flask, widest at the middle and tapered toward the ends. It is a long blind pouch with a large tube connecting it to the mouth and a small opening near leading into the intestine. It hangs free in the left side of the body cavity and is capable of extension, when filled with food, back almost as far as the anal opening or vent.

The intestine, which is approximately 10 feet long in a 200-pound fish, forms a series of loops and terminates in a short, thick, downwardly-curved part 8 to 10 inches in length. The spleen lies against the forward part of the intestine. Figure 4 shows the internal organs of a swordfish.

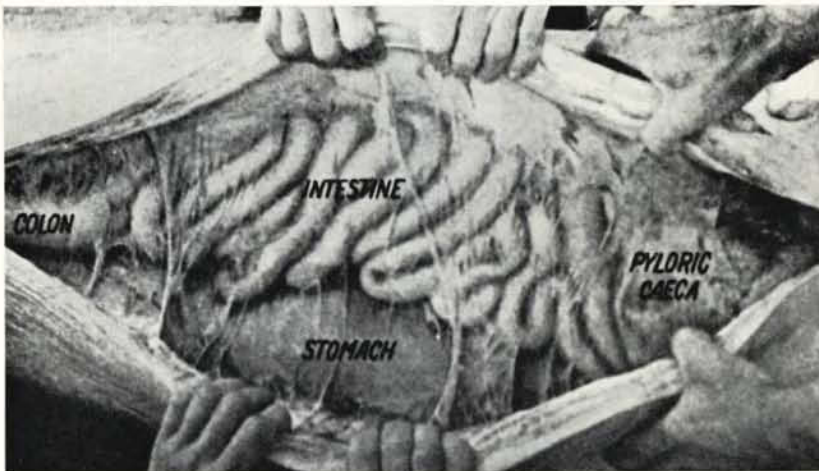


FIGURE 4. Internal organs of a swordfish. Photograph from Raven and LaMonte (1937).

The liver is compact and occupies the bottom and sides in the forward part of the body cavity. The gall bladder is on the right side between coils of the intestine and is far behind the liver.

An enormous digestive gland formed by the pyloric caeca is developed far beyond the stage seen in most fishes (including the mackerel). Hundreds of ducts from the caeca open separately into the intestine rather than uniting into a single intestinal opening as in most fishes with a large number of pyloric caeca.

The most notable aspect of the circulatory system is the size of the heart, which is surprisingly small. The muscular portion is pear-shaped and for a fish weighing 200 pounds is about the size of a pear. The heart lies about mid-way between the angle of the mouth and the end of the gill flap in the angle of the lower jaw. Blood from the ventricle is forced into a flask-shaped vessel, 3 inches long and 1 inch in diameter at its widest point, and flows forward into a narrow artery, the ventral aorta, which breaks up into four pairs of arteries leading to the

gills. From the gills the blood collects in correspondingly paired arteries leading into the dorsal aorta which branches to all parts of the head and body.

When a swordfish is harpooned it is usually very active until the tail is raised and tied to the dory, then it seems to capitulate almost immediately. It has been suggested that the weight of the abdominal contents presses against the heart chamber and stops the action of the small heart, causing almost instantaneous death.

Experienced Canadian fishermen say that the reproductive organs or gonads of all swordfish that they have examined look the same. This raises the question—does only one of the sexes contribute to the fishery? Lee (1942a) examined the anatomy and cell structure of the reproductive organs of 13 swordfish captured off the southern New England coastline during the summer of 1941.

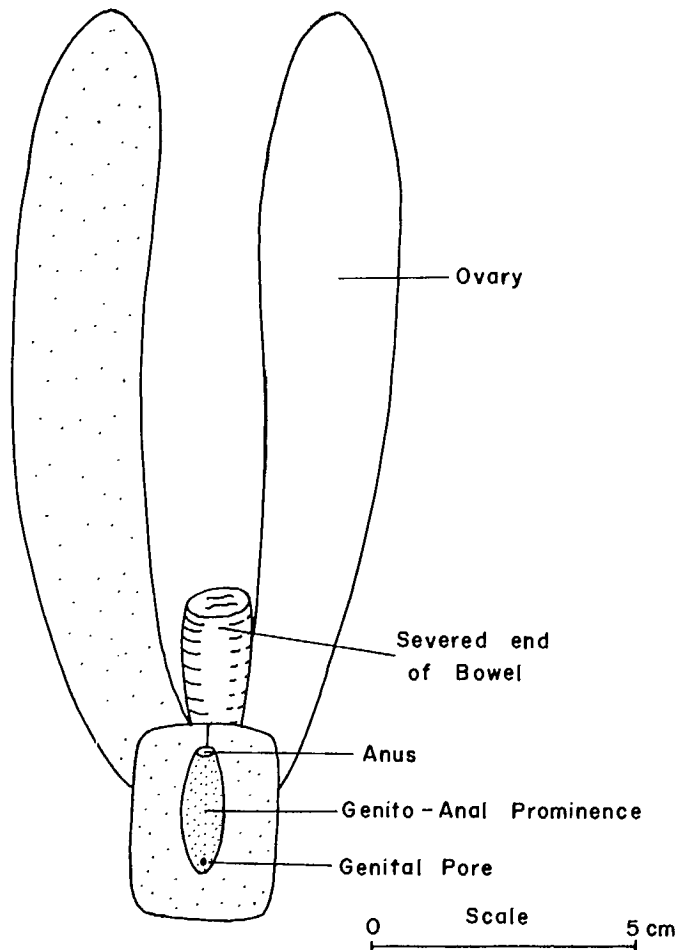


FIGURE 5. Reproductive organs (ovaries) of a swordfish. Redrawn from Lee (1942a).

"The most significant fact revealed by this study of the swordfish gonads [he wrote] is that all of the fish captured throughout the summer from a large fishing area were female. If the swordfish are distributed evenly with regard to the numbers of each sex present, there is only a 0.5¹³ chance [1 in 8,000] of capturing all of any one sex, in 13 individuals. This is far beyond the realm of probability. The absence of any other report on the distribution of the sexes of the swordfish with which to compare the results of the past summer's work prohibits the forming of a definite conclusion, but it seems that some type of sexual segregation or an extremely high ratio of female to male fish exists.

"There are other factors, however, that one must consider and these necessitate extensive research. The methods used in capturing swordfish result in securing only those fish at the surface of the sea. The females may be chiefly surface dwellers in warm weather, with the males remaining in deeper water and seldom approaching the surface. Such a condition is not known to exist; if it does, it would result in an exclusively female catch. Also, many fish are missed by the fishermen, due to a highly elusive or restless nature that makes it impossible for the vessel to approach them on the surface. These fish may be males, too wary to be caught. Such circumstances are extremely unlikely, but at least must be considered, because of the unusual results of the past summer's work. In view of the number of fish obtained, a possible segregation of the sexes of the swordfish in southern New England waters may exist."

Figure 5 is a drawing of the ovaries of a swordfish. Lee (1942a) described the ovaries as relatively long sausage-shaped structures from 15 to 35 cm (6-14 inches) in length and from 4 to 10 cm (1.5-4 inches) in diameter. The size increases with that of the fish. The ovaries lie on either side of the mid-line, and extend backward to fuse with one another in the mid-line at a point in front of the rectum. The eggs in the ovary are microscopic in size. They are extremely numerous.

LIFE HISTORY OF THE SWORDFISH

Although there is no measure of the abundance of swordfish in the northwest Atlantic, there seems to be little reason for concern about the supply. The fish taken are nearly all large adults and only occasionally are small fish caught. There is no evidence of any substantial changes in the abundance of swordfish in recent years. The harpoon method of fishing probably takes only a small fraction of the fish in an area as each individual fish must be the object of a special pursuit. The solitary habits of the swordfish also protect it from wholesale capture as is the case with closely schooled fish.

DISTRIBUTION

On the geographical distribution of the swordfish, Rich (1947) wrote:

"the swordfish is found throughout the tropical and temperate Atlantic; in the Mediterranean; about New Zealand, Hawaii and Japan; and in the South Pacific north to California, probably passing the winter in mid-ocean. On the eastern side (of the Atlantic) it ranges from the vicinity of Cape Town, South Africa, northward in the summer months to the Mediterranean, where it is abundant, and while somewhat less common in British waters, has been taken in the Baltic, the North Sea—and on the coast of Norway up to the North Cape in 71° North latitude. In the western Atlantic and near the North American coast the swordfish ranges from the vicinity of Jamaica, Cuba and the Bermudas, to Cape Breton Island, going well into the Gulf of St. Lawrence, and upon the Grand Banks. In general, it appears on these coasts only during the warmer seasons, but with numerous records for October and November on what is considered the northern part of its range."

Figure 6 shows the areas where swordfish have been seen in the northwest Atlantic.

Very few Canadian swordfish fishermen operate farther south than Latitude 41° N. Occasionally a boat that does not engage in other types of fishing from June to September may go as far as Block Island. Usually the first trip is made to the southeast part of Georges Bank (about Latitude 41° N.) and, as the season advances, the vessels work northward along the edge of the continental shelf. Most vessels make their last trip to Banquereau, although a few boats go to the southeast part of Grand Banks after mid-August. Not one of the fishermen who was interviewed during our investigation had ever seen a swordfish in the inshore areas of the Gulf of Maine, the Bay of Fundy or the Gulf of St. Lawrence, although they do occur there (Fig. 6). Occasionally a few fish are caught on St. Pierre Bank and one fisherman reported catching a single fish on Green Bank.

Little is known of the vertical distribution of swordfish beyond the fact that almost all of the catch is made at or near the surface. There is one record of 5 swordfish caught on a halibut line-trawl set at a depth of 60 fathoms on the northern edge of Georges Bank. Stomach contents suggest that they frequently feed at depths of 100 fathoms or more.

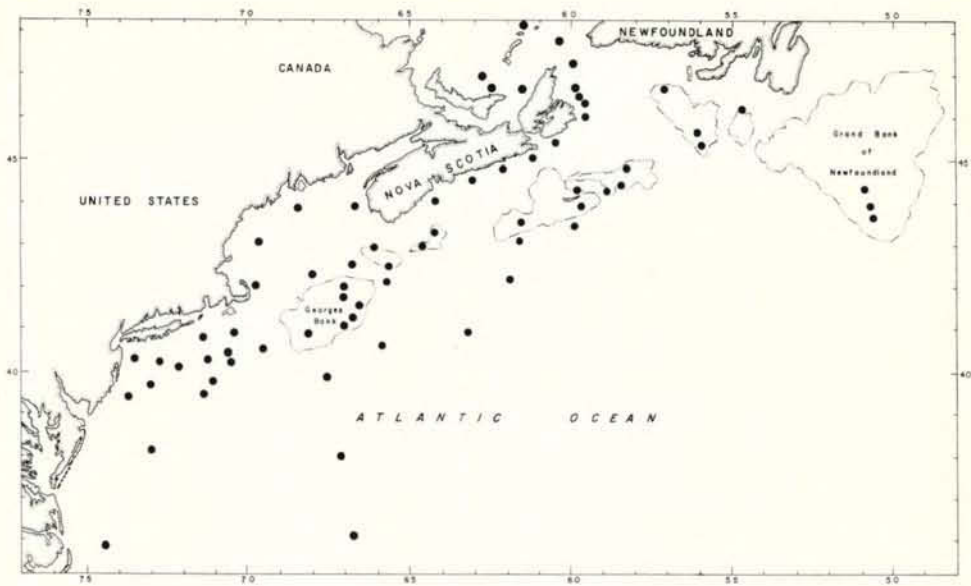


FIGURE 6. Areas where swordfish have been caught or sighted in the northwest Atlantic. Records from various authors.

MIGRATIONS

Many Canadian fishermen believe that swordfish migrate to the north and east along the edge of the continental shelf during the summer and return south and west in the autumn. Others think there are different groups of swordfish which migrate from deep water towards the continental shelf in the summer, and then move off to deep water again in the autumn. In support of the first argument, Captain V. Harpell of Louisburg, N.S., "struck" a swordfish on June 28, 1958, on the southeast part of Georges Bank (Latitude $40^{\circ}30' N.$, Longitude $67^{\circ}27' W.$). The dart broke, part of it remaining in the fish which escaped. On July 20, Captain T. Wilcox of Glace Bay, N.S., caught a swordfish on the southeast part of Sable Island Bank (Latitude $43^{\circ}45' N.$, Longitude $59^{\circ}20' W.$) which had a broken dart in it. Later Captain Harpell and Captain Wilcox met in Louisburg (Mr. Somerville witnessed the meeting) and found that the broken parts of the dart matched perfectly. Although many darts are broken and fish lost and many fish are caught with broken darts in them, it is almost certain that in this case we have an authentic record of a migration of more than 400 miles in 23 days.

In support of the argument for movements from the deep waters to the continental shelf and return to deep water, there are quite obvious differences in the sizes of fish that are caught in the various areas or in the same area at different seasons. For example, the 150-pound (average dressed weight) swordfish caught on Georges Bank in June could hardly be the same group as the 300-pound swordfish caught on the Grand Banks in August.

REPRODUCTION

While there seems to be little information available on the breeding habits of swordfish in the Western Atlantic, this aspect of the life history has been studied extensively in other areas. LaMonte and Marcy (1941) made reference to studies in the Mediterranean from 1910 to 1930 which illustrated and described in detail the collection and examination of adults ripe for reproduction, eggs extracted from females; eggs found floating at the surface, eggs hatched in the laboratory and various developmental stages of the young swordfish. They wrote:

"The height of the reproductive season in those waters [Strait of Messina] is June and July when the adults approach the coast in pairs, a male and a female. The female spawns in several different deposits. Although the maximum extrusion is in July, eggs are found until September. It is generally believed that the swordfish spawns only about twice during its life. The swordfish egg is round, dimly translucent and buoyant. The mature egg, from 1.82 to 1.87 mm [about 0.07 inch] in diameter hatches in about 2½ days. Eggs and young were taken off Messina and larvae were brought to the thirteenth day out of the egg in the laboratory."

With the single exception of the Messina run, the finding of eggs and young of the swordfish has been sporadic and does not establish the breeding places of the various schools. Marie Poland Fish (1926) reports the finding of a swordfish with partially matured eggs off Stonington, Connecticut, on July 24th, 1924. This fish weighed 150 pounds and contained ovaries weighing 3.15 pounds. The number of ova was estimated at about 16 million.

Ernest Hemingway thought the broadbill swordfish must breed off Cuba. In *American Big Game Fishing*, he wrote: ". . . for the fish are often taken in pairs full of milt and spawn and I have seen female broadbill [swordfish] so full of roe that the eggs would be expelled in the boat when the fish was moved".

Larvae of the swordfish have been picked up in isolated cases in various locations throughout the area of adult distribution. A sufficient number of very small swordfish have been reported from the Gulf Stream off Florida and Cuba to make this area worthwhile investigating as a possible breeding ground.

BEHAVIOUR

Swordfish are commonly found at the surface and their behaviour there is easy to observe. Many accounts of this aspect of swordfish biology appear in the literature and there is considerable agreement among the various writers. Practically nothing is known of their sub-surface activities except what is inferred from food found in their stomachs.

The swordfish is truly pelagic and is not dependent on either the coast or the bottom except perhaps as related to its food supply. It is a warm-water fish and is most common where temperatures exceed 60° F.

Figure 7 shows typical surface temperature conditions for the month of August throughout most of the swordfish fishing areas. The major part of the catch is made along the edge of the continental shelf between the 61° F and the

64° F temperature lines. During one cruise to Banquereau in August, 1959, detailed temperature records were kept. Of 104 fish caught, 92 were taken when temperatures were 60° F or higher and only 12 when temperatures were less than 60° F.

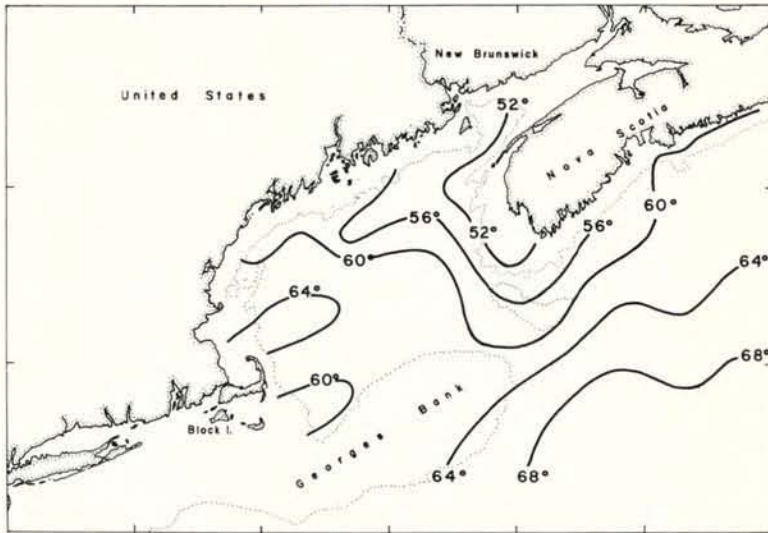


FIGURE 7. Typical surface isotherms in the northwest Atlantic for the month of August. Data from D. F. Bumpus, Woods Hole Oceanographic Institution (personal communication).

Although commonly referred to as schooling fish, swordfish are seldom seen close together and even when extremely plentiful, are usually 30 or 40 feet apart. Occasionally 2 fish are seen swimming together but such records are very rare.

Most fishermen believe that swordfish come to the surface only during the daylight hours and our records show that fish are seldom seen before 10 AM or after 6 PM. On calm days they either lie quietly at the surface or swim lazily, with the tip of the first back fin and the tip of the tail out of the water. It is claimed that fishing is best about the time of the full moon.

Frequently the swordfish is seen jumping or "breaching" as the fishermen describe it. This is most common among the smaller fish. They often jump 3 or 4 feet out of the water and 2 or 3 times their length horizontally. The larger swordfish seldom jump out of the water. The reason for this leaping is not known. It may be an attempt to get rid of external pests such as remoras or lampreys. It could also be associated with surface feeding, since the falling back into the water must stun large numbers of small fish, thereby making them more easily captured for food.

Perhaps the most discussed aspect of swordfish behaviour has been its pugnacity. The earliest records tell of the sides and planks of ships having been pierced by swordfish. The frequency of the records suggest that this is a very

common occurrence although it is perhaps chiefly associated with fishing and occurs most often after a fish has been harpooned. During Gilbert's trip on the *Pubnico Pal* in August 1959, two swordfish punched holes through the bottoms of dories. One of the fish rammed its sword more than a foot through the planks and remained stuck until the protruding section of the sword was sawed off and the stump driven out with an axe. The crewman who hauled the fish said that he felt the line go slack just before the fish hit the boat. This seemed to be a deliberate attack by the fish although in many other cases it appears accidental, with the fish rushing around in all directions as it is being hauled.

Both Somerville and Gilbert made detailed observations of the behaviour of swordfish before and after they had been "ironed". During three cruises they noted that, with few exceptions, the fish were easy to run on. The striker was usually able to wait until the bowsprit was directly over the fish before he struck. The fish either did not see the boat or did not fear it.

Swordfish are not always so easy to capture. Crews of both the *Fanny Faye* and the *Pubnico Pal* said that fish are often so "wild" that the striker must throw his "pole" far ahead of the boat, almost to the end of the retrieving line, in order to stand a chance of striking the fish.

After they are "ironed", some swordfish continue to swim slowly as though nothing has happened, although the dart has been driven at least a foot into the back. In most cases, however, the fish swim quickly along the surface for a short distance and then disappear. In 1958 and 1959 no fish were observed to thrash violently on being "struck", although many did when an attempt was made to drag them aboard. A few fish were so severely injured by the dart that they could be hauled aboard with hardly a struggle.

GROWTH

The literature contains many references to the capture and examination of very young swordfish. Arata (1954) examined and described 33 specimens, $\frac{1}{4}$ to $7\frac{1}{2}$ inches long, caught off the Atlantic coast of Florida and in the Gulf of Mexico. Other descriptions are contained in papers by Cuvier and Valenciennes (1831), Sanzo (1922), LaMonte and Marcy (1941) and Nakamura *et al.* (1951). In spite of these records and the long-term and wide-spread interest in swordfish, almost nothing is known of their growth rate. In the Mediterranean, where the species is best known, young fish from $\frac{1}{2}$ to 10 pounds taken in the winter and early spring, are thought to have been hatched during the previous summer. Fish of 20 to 50 pounds may be completing their first year of life. Beyond this no attempt to even guess at a size-age relationship seems to have been made.

Canadian fishermen say that swordfish are thin at the beginning of the season (June) and grow fatter and heavier as the season advances, adding 50 to 75 pounds. This does not seem unreasonable, considering the enormous amounts of food found in swordfish stomachs, but it contributes little to an understanding of long-term growth.

FOOD AND FEEDING HABITS

Food and feeding habits may have considerable effect on the distribution of swordfish. Accordingly, attention was given to this aspect of their biology during the 1958 and 1959 investigations.

The swordfish belongs to a warm-water tribe and, other things being equal, it might be expected to remain in comparatively warm water. It presumably invades the region of Georges Bank and the Nova Scotia banks during the summer months to feed on the fish found there. When it has fed, it presumably seeks the warmest water available and digests its meal there.

The literature contains many references to the food of swordfish. In the northwest Atlantic the diet consists chiefly of mackerel, menhaden, silver hake, butterfish, herring, argentine and squid. However, Bigelow and Schroeder (1953) state:

"It is not unusual for swordfish taken on the offshore banks to contain deep-sea fishes of one kind or another in their stomachs, and many such instances have been recorded. Since these so-called "black fish" live around the edge of the continent mostly below 150 fathoms, this is good evidence that the swordfish found on the banks that front our Gulf do some of their foraging at considerable depth farther out at sea. It also seems that they sometimes strip lines set out for halibut of the fish already caught, for they are sometimes brought up tangled in the line."

Our observations on food and feeding habits were mostly made during a trip in 1958 on the *Fanny Faye*, and in 1959 during two trips on the *Pubnico Pal* and two on the *Lister*. Additional information was obtained from preserved material brought ashore by the captains of other swordfish vessels. Observations included the number of each species present in the swordfish stomachs and evidence of mutilation by the sword. The identification of species was always confirmed by preserving small samples for subsequent examination at the St. Andrews station.

Most of the stomachs examined were full of food. Occasionally a swordfish would vomit everything from its stomach before it was boarded, and sometimes would even eject the stomach.

For evidence of mutilation by the sword only those fish which were in a fresh condition were examined, so as not to confuse the damage resulting from digestion with actual evidence of slashing. Fishermen generally agree that the swordfish's normal manner of feeding is to strike into the schools of smaller fishes, first disabling them with its sword and then picking up the victims. Swordfish do this by suddenly rising from below, even coming completely out of the water with the speed of their rush. They then fall back among the fish at the surface where they slash from side to side with their two-edged sword, killing and injuring the closely schooled fish. In the five field trips made in 1958 and 1959, however, no feeding at the surface was observed nor was there much evidence that fish commonly found near the surface made up any substantial part of the swordfish's diet.

From July 25 to 28, 1958, Somerville examined the stomach contents of 14 swordfish while he was on board the *Fanny Faye*, fishing near Sable Island Bank

and Banquereau. He counted 564 individual food items in all stomachs. There were 411 scaled lancetfish, 108 lanternfish, 22 squid, 15 redfish, 7 argentine and 1 silver hake. Lancetfish and lanternfish occurred in all but three of the stomachs examined, one of which contained 8 redfish, another contained 4 argentines and the third contained 1 argentine.

During a trip south of Nantucket Shoals from June 19 to July 6, 1959, on the *Pubnico Pal*, Gilbert examined the contents of 25 stomachs carefully and many others superficially. Silver hake occurred in more stomachs than any other species and in greatest numbers. Squid, lancetfish and lanternfish were also very common, but present in smaller numbers.

From July 9 to 20, 1959, during a trip on the *Lister* to the south of Sable Island Bank, Captain C. J. Bayers found that silver hake made up about 85% of the swordfish stomach contents. Squid, redfish, lancetfish, lanternfish, haddock, pollock and billfish made up the remaining 15% with only a few of each of these species being found.

From August 8 to 22, 1959, Gilbert made a second trip on the *Pubnico Pal*, this time to the vicinity of Banquereau. A total of 36 stomachs were examined and most of them were full of food. Lancetfish were found in 20 of the 36 stomachs and this species made up over half the total food in all stomachs. Lanternfish were found in 11 stomachs and made up about one third of the total food content. Redfish, argentines, squid and silver hake occurred less frequently.

During a second cruise on the *Lister*, fishing on Browns Bank from August 31 to September 4, 1959, Bayers found that herring made up about 65% of the stomach contents, with silver hake making up most of the remainder.

Of the species which occurred most frequently in swordfish stomachs, argentine, lancetfish and lanternfish are considered to be deep-water forms, while redfish, silver hake and squid are believed to range more or less independently of depth. This with the fact that most of the stomachs were full of food suggests that, after foraging at considerable depths, swordfish rise to the surface to rest or sleep as other animals do after feeding.

The above studies indicate that the diet of the swordfish is varied and depends on the species present in an area. The following species were found in stomachs in substantial numbers: scaled lancetfish (*Paralepis* sp.) lanternfish (*Myctophum* sp.), redfish (*Sebastes marinus*), argentine (*Argentina silus*), silver hake (*Merluccius bilinearis*), squid (*Illex illecebrosus*), stomias (*Stomias ferox*), butterfish (*Poronotus triacanthus*), herring (*Clupea harengus*) and salmon (*Salmo salar*). Some stomachs also contained large numbers of euphausiids (*Meganyctiphanes norvegica*).

There is conflicting evidence on the use of the sword for feeding purposes. Some of the stomachs examined contained fish that were in excellent condition, with no indication of having been struck by the sword, while other fish had ugly gashes deep in the flesh. Somerville's observations in 1958 indicated that few food items had been struck with the sword. The remains of a number of lancetfish and

argentinines that had apparently been mutilated before being swallowed were observed but 533 out of 564 showed no injuries and had been engulfed whole. In 1959 Gilbert examined 145 freshly ingested fishes of various species and found that 141 or 97% had definite slashing injuries. For example, one stomach contained 5 large argentine with the scales still intact. Two of these fish had deep slashes in the bodies while the other three were cut cleanly into two pieces. There can hardly be any doubt that the swordfish uses its sword to kill at least some of its food. Table I lists the species examined for evidence of slashing during a cruise on the *Pubnico Pal*, August 8 to 22, 1959. Figure 8 is a photograph of the contents of a swordfish stomach in which all the food items showed evidence of having been but with the sword. Figure 9 shows a lancetfish (*Paralepis* sp.) taken from a swordfish stomach. This fish too was badly injured before being eaten.

TABLE I. Stomach analyses of 36 swordfish indicating use of the sword in feeding. Data from *Pubnico Pal*, August 8-22, 1959.

Species	Total number	Number slashed	Remarks
Scaled lancetfish..... (<i>Paralepis</i> sp.)	72	70	Badly mutilated—some slashed twice
Lanternfish..... (<i>Myctophum</i> sp.)	31	31	Mostly cut in two
Argentines..... (<i>Argentina silus</i>)	28	28	21 cut in two; 7 cut deeply
Redfish..... (<i>Sebastes marinus</i>)	8	8	1 with skull crushed; 2 with heads dangling
Squid..... (<i>Illex illecebrosus</i>)	5	3	1 cut length of body
Silver hake..... (<i>Merluccius bilinearis</i>)	1	1	Cut in two

PARASITES

Swordfish are usually very heavily parasitized and many species are involved. Some hang on the gills, some hand on the body, others fasten themselves to different parts of the alimentary tract—the oesophagus, the stomach and the intestines—and still others bore into the flesh.

The following parasites were found during the 1958 and 1959 investigations:

A sea lamprey (*Petromyzon marinus*) was captured by one of the fishermen on the *Pubnico Pal* in 1959. He gaffed it while it was still attached to the swordfish. Many swordfish have marks of lampreys on them but few have open wounds. The marks consist mostly of longitudinal scratches along the side of the body and would suggest that the swordfish is fairly successful in ridding itself of these pests. One fish seen 'breaching' (leaping out of the water) and caught later on August 16, 1959, had fresh, longitudinal scratches which suggested that a lamprey had just been shaken off.

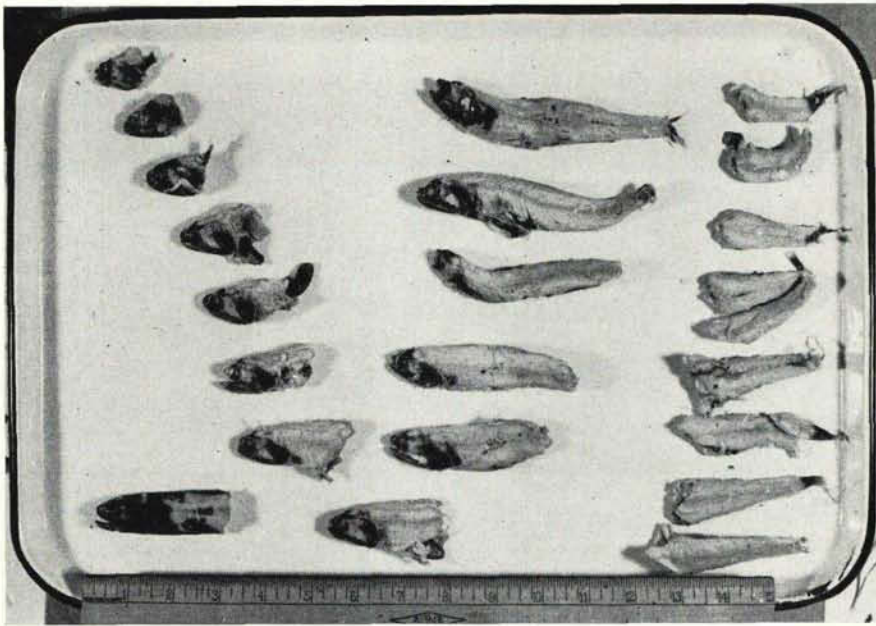


FIGURE 8. Food from a swordfish stomach. All of these fish were cut by the sword before being eaten by the swordfish. (Scale in inches.)

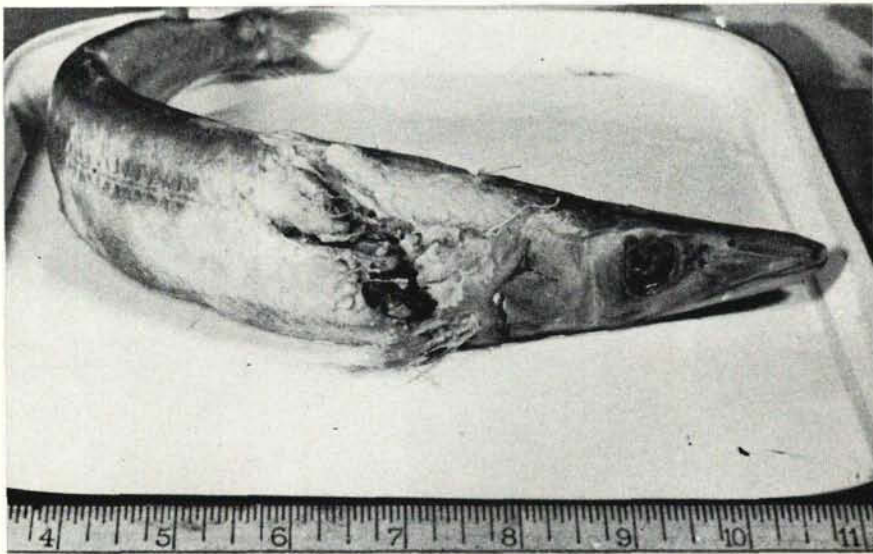


FIGURE 9. A scaled lancetfish (*Paralepis* sp.) from a swordfish stomach. Note the deep sword cut on this fish. (Scale in inches.)

Although the remoras are not true parasites, they can be included here. Fishermen frequently report seeing 'suckers' clinging to the swordfish; sometimes several of them on one fish. These are almost certainly remoras and most likely the swordfish sucker (*Remora brachyptera*). Gilbert collected one remora from a swordfish taken by the *Pubnico Pal* on June 2, 1959. Mr. W. C. Schroeder of the Museum of Comparative Zoology, Cambridge, Massachusetts, identified it as *Remora brachyptera*.

Both Somerville and Gilbert made frequent reference to a parasite found attached to the belly, sides, back and fins of the swordfish. This parasite is partly imbedded in the tissues and cannot be pulled out. The outside portion has a leathery covering and is tipped with a fan-like appendage resembling an artist's brush. Specimens were preserved and later identified as a copepod belonging to the Family Pennellidae, probably *Pennella filosa*.

Two species of internal parasites were found in or associated with the digestive tract. One species was a round worm found in the stomach. Specimens varied from 1 to 5 inches in length and in some stomachs there were literally hundreds of them. This round worm was identified by Dr. T. W. M. Cameron of the Institute of Parasitology, Macdonald College, Que., as *Contracaecum incurvum* R. It has been observed in swordfish from various parts of the world including the Woods Hole region of Massachusetts (Linton, 1901a, b). The other internal parasite was an unidentified worm found in the wall of the intestine. Specimens were present in only 2 of 14 fish examined and were not present in large numbers. They measured 50 to 60 mm (2-2½ inches) in length and about 3 mm ($\frac{1}{10}$ inch) in diameter.

OTHER ENEMIES

Known natural enemies of the swordfish are few. Young swordfish would presumably be preyed upon by any sufficiently large predacious fish. Sperm and killer whales, tuna and large sharks are perhaps the only species capable of making trouble for an adult swordfish. Of these, the shark is the only one ever seen in actual combat with a swordfish. Bigelow and Schroeder (1953) report the finding of a good-sized swordfish in the stomach of a mako shark. They also refer to a report of a fisherman who described seeing two large sharks bite or tear off the tail of a 350-pound swordfish which he afterwards harpooned.

Enmity between swordfish and sharks may explain the wariness of swordfish in approaching each other. It is universal testimony of fishermen that two fish are rarely seen swimming close together. In the schools they ordinarily keep at least 30 to 40 feet apart. If two fish came close together—especially if the approach is made head on—they will dart away with every appearance of panic. This also occurs in their encounters with porpoise and other large fish. Fishermen say that if porpoise are swimming near the bow of the boat, swordfish will be scared away before the fishermen get close enough to 'stick' them. It is amazing to see how suddenly this huge fish disappears from sight when alarmed.

THE SWORDFISH FISHERY

We do not know when fishermen in the northwest Atlantic first set out to seek swordfish as a source of food. The literature contains many references to swordfish being caught and eaten in the United States early in the 19th century. In Canada, however, swordfish apparently were not used for food until the beginning of the 20th century, and the first official records of Canadian commercial catches date back to only 1909. Undoubtedly swordfish were regarded as sufficiently useful to be sought at an earlier date by Canadian fishermen. However, since official records were not kept, it is supposed that little time was spent on the swordfish chase prior to the end of the 19th century. If an occasional fish were captured as fishermen pursued the traditional fisheries, it is presumed that it was more for the pleasure of the hunt than for the sake of the fish. No market outlet for swordfish was developed in Canada before the turn of the present century.

Figure 10 gives the landings of swordfish in Canada and United States from 1909 to 1959. Table II gives the landings and landed values for the same period by four area divisions in Canada (Cape Breton Island, Eastern, Central, and Western Counties of Nova Scotia (Fig. 1)) and two in the United States (New England States and Middle Atlantic States (Fig. 1)).

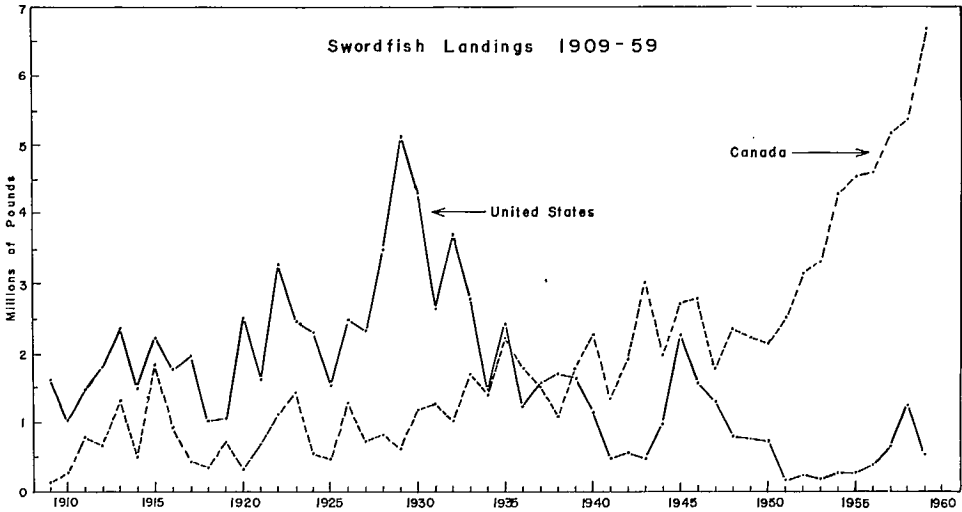


FIGURE 10. Swordfish landings in Canada and the United States, 1909 to 1959.

The United States already had a well-established fishery in 1909, with landings approximately 1.5 million pounds annually. The fishery there reached a peak in 1929, when more than 5 million pounds were landed. Since that time there has been a steady decline, and the average United States catch during the 1950's was

less than 0.5 million pounds. By contrast, the Canadian fishery, which had a late beginning and developed slowly, is still expanding. Catches reached 2 million pounds for the first time in 1935 and remained at about that level through the 1940's. In the last decade, catches have increased about threefold, from 2.2 million pounds in 1950 to 6.7 million pounds in 1959.

The cause of the decline in the United States swordfish catches appears to be a decrease in fishing effort. The expansion of the Canadian fishery, while influenced by a growing market, is principally attributable to the development of an offshore fleet designed primarily for the groundfish fishery. The experience of the last decade has shown that the economic performance of these vessels can be greatly improved by a seasonal diversion to swordfish operations.

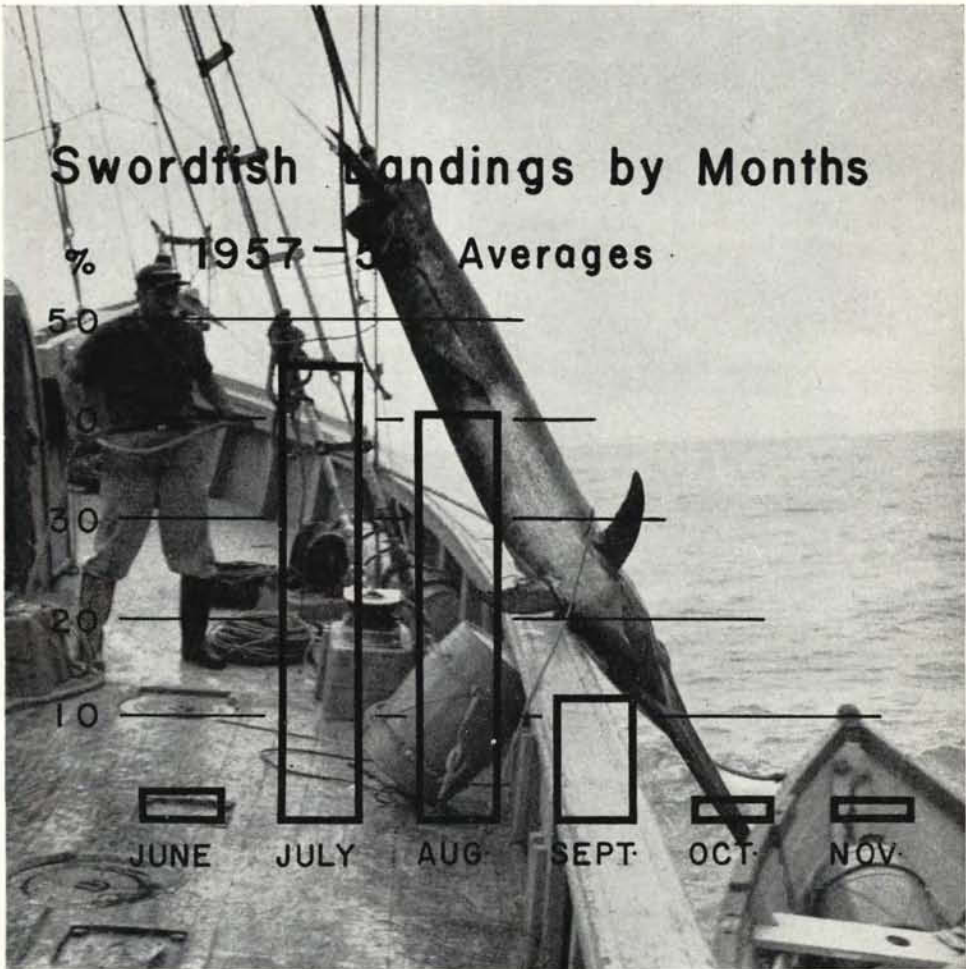


FIGURE 11. Average (1957-59) landings of swordfish in Canada by months.

TABLE II. Landings in pounds (dressed weight) and landed values in dollars of swordfish in the north-Fisheries, Branch

Year	Cape Breton Island ^a		Eastern Counties ^b		Central Counties ^c		Western Counties ^d		Canadian Totals	
	Pounds	\$	Pounds	\$	Pounds	\$	Pounds	\$	Pounds	\$
1909	2,600	520	68,600	4,800	13,500	947	61,800	7,428	146,500	13,695
1910	41,900	2,763	57,800	2,890	143,900	9,941	28,900	2,657	272,500	18,251
1911	128,500	7,306	61,400	3,070	481,700	19,738	121,900	7,670	793,500	37,784
1912	53,000	2,750	289,900	14,206	205,300	10,223	109,500	5,320	657,700	32,499
1913	142,100	4,639	647,800	19,276	413,600	15,710	128,700	6,917	1,332,200	46,542
1914	112,700	4,263	242,400	9,566	48,900	2,199	94,200	6,924	498,200	22,952
1915	428,400	15,445	602,200	24,088	649,900	31,722	172,200	10,295	1,852,700	81,550
1916	301,400	15,686	321,800	12,872	229,800	11,054	75,400	5,081	928,400	44,693
1917	67,600	4,294	291,200	11,648	25,100	1,255	49,900	5,393	433,800	22,590
1918	153,700	19,759	186,400	26,126	3,500	428	20,900	3,051	364,500	49,364
1919	390,300	54,562	318,600	37,384	13,200	1,371	19,000	2,700	741,100	96,017
1920	262,700	32,350	47,900	4,780	8,000	960	16,500	3,156	335,100	41,246
1921	416,000	41,139	144,100	15,096	15,300	1,580	109,700	16,230	685,100	74,045
1922	595,500	42,569	358,400	21,043	113,900	11,356	48,600	6,142	1,116,400	81,110
1923	936,400	59,302	303,700	23,628	192,400	11,544	1,800	216	1,434,300	94,690
1924	469,800	52,206	60,100	5,257	25,200	2,870	2,400	302	557,500	60,635
1925	376,600	57,438	58,600	7,776	9,800	1,192	10,100	1,370	455,100	67,776
1926	659,400	80,047	491,500	49,150	130,000	15,410	12,700	1,809	1,293,600	146,416
1927	537,600	66,601	139,800	15,115	31,700	3,250	20,800	3,124	729,900	88,090
1928	585,600	81,227	181,800	24,957	32,700	4,910	8,700	1,149	808,830	112,243
1929	509,500	57,806	107,900	9,622	9,500	1,275	6,700	910	633,600	69,613
1930	1,045,000	123,524	134,300	13,719	6,800	900	7,200	1,002	1,193,300	139,145
1931	1,218,500	133,650	19,600	2,164	3,600	408	21,200	3,817	1,262,900	140,039
1932	921,800	30,846	48,000	1,516	18,600	1,001	47,500	6,069	1,935,900	39,432
1933	1,546,700	104,235	79,600	4,833	42,400	2,861	45,000	5,673	1,713,700	117,602
1934	1,256,400	100,785	44,700	3,290	14,900	1,543	93,100	11,999	1,409,100	117,617
1935	1,983,100	126,199	105,100	7,175	37,400	2,168	108,300	12,859	2,233,900	148,401
1936	1,285,500	104,039	386,600	29,865	14,600	1,151	98,600	15,219	1,785,300	150,274
1937	1,033,100	98,348	46,800	3,780	7,900	490	414,200	67,580	1,502,000	170,198
1938	992,800	83,621	9,900	1,087	6,000	556	84,200	16,265	1,092,900	101,529
1939	1,545,400	144,478	27,900	2,643	10,800	1,439	204,300	37,186	1,788,400	185,746
1940	2,146,800	227,679	44,000	4,981	3,800	478	95,500	20,393	2,290,100	253,531
1941	1,272,600	201,793	6,900	1,149	1,900	306	64,900	14,582	1,346,300	217,830
1942	1,873,200	430,376	17,000	3,000	2,000	460	41,300	12,140	1,933,500	445,976
1943	2,985,000	809,689	14,700	3,270	1,400	420	19,800	6,507	3,020,900	819,886
1944	1,913,500	593,366	3,400	890	2,900	795	69,200	21,428	1,989,000	616,479
1945	2,296,200	867,555	19,000	6,068	5,400	1,700	396,500	154,925	2,717,100	1,030,248
1946	2,060,500	672,071	2,400	888	122,800	48,005	590,000	260,440	2,775,700	981,404
1947	1,065,000	396,000	0	0	700	280	726,300	305,320	1,792,000	701,600
1948	1,544,000	506,500	4,000	1,400	32,000	14,500	776,000	336,600	2,356,000	859,000
1949	1,016,000	311,600	4,000	900	7,000	2,200	1,206,000	409,700	2,233,000	724,400
1950	1,158,000	347,300	17,000	5,300	58,000	20,300	921,000	332,600	2,154,000	705,500
1951	1,149,000	409,000	88,000	41,000	446,000	182,700	860,000	364,800	2,543,000	997,500
1952	979,000	262,800	207,000	57,000	526,000	134,900	1,444,000	433,500	3,156,000	888,200
1953	1,311,000	371,100	174,000	52,700	757,000	313,000	1,082,000	368,300	3,324,000	1,105,100
1954	1,132,000	253,100	375,000	108,200	1,450,000	388,300	1,341,000	388,400	4,298,000	1,138,000
1955	1,356,000	286,500	505,000	117,500	1,280,000	312,800	1,405,000	373,500	4,546,000	1,090,300
1956	1,086,000	253,100	556,000	148,700	1,128,000	313,300	1,842,000	580,000	4,612,000	1,295,100
1957	1,237,000	302,600	512,000	124,700	1,631,000	424,500	1,800,000	489,100	5,180,000	1,340,900
1958 ^e	1,410,957	357,311	743,191	199,704	1,503,502	412,994	1,719,664	469,123	5,377,314 ^e	1,439,132 ^e
1959 ^e	1,589,187	300,697	893,739	176,466	2,191,322	453,167	2,027,258	452,901	6,701,506 ^e	1,383,231 ^e

^a Inverness, Victoria, Cape Breton, Richmond Counties.

^b Guysborough County.

^c Halifax, Lunenburg Counties.

^d Queens, Shelburne, Yarmouth Counties

^e Figures for Canada are preliminary and may be revised.

^f Data converted to dressed weight (conversion factor, dressed to round weight, X1.25).

west Atlantic 1909-1959. Data from Fisheries Statistics of Canada and U.S. Bureau of Commercial of Statistics.

New England States ^a		Middle Atlantic States		United States Totals		Grand Totals ^f		Year
Pounds	\$	Pounds ^f	\$	Pounds	\$	Pounds	\$	
1,637,156	158,529	h	h	1,637,156 ⁱ	158,529	1,783,656	172,224	1909
1,039,091	141,432	h	h	1,039,091 ⁱ	141,432	1,311,591	159,683	1910
1,502,630	108,854	h	h	1,502,630 ⁱ	108,854	2,296,130	146,638	1911
1,809,840	162,699	h	h	1,809,840 ⁱ	162,699	2,467,540	195,198	1912
2,380,920	195,877	h	h	2,380,920 ⁱ	195,877	3,713,120	242,419	1913
1,499,844	177,669	h	h	1,499,844 ⁱ	177,669	1,998,044	200,621	1914
2,238,967	221,559	5,890	756	2,244,857 ^j	222,315	4,097,557	303,865	1915
1,772,312	238,279	h	h	1,772,312 ^j	238,279	2,700,712	282,972	1916
1,973,518	292,169	h	h	1,973,518 ^j	292,169	2,407,318	314,759	1917
1,034,091	223,192	h	h	1,034,091 ^j	223,192	1,398,591	272,556	1918
1,060,800 ^f	294,827	h	h	1,060,800 ^k	294,827	1,801,900	390,844	1919
2,531,669	494,202	h	h	2,531,669 ⁱ	494,202	2,866,769	535,448	1920
1,597,645	318,406	35,892	9,125	1,633,537 ^j	327,531	2,318,637	401,576	1921
3,281,748	447,016	h	h	3,281,748 ^j	447,016	4,398,148	528,126	1922
2,455,419	448,119	h	h	2,455,419 ^j	448,119	3,889,719	542,809	1923
2,305,771 ^f	527,726	h	h	2,305,771 ^k	527,726	2,863,271	588,361	1924
1,527,180	385,929	h	h	1,527,180 ^k	385,929	1,982,280	453,705	1925
2,441,679	492,629	48,647	11,391	2,490,326 ^j	504,020	3,783,926	650,436	1926
2,330,906 ^f	529,941	h	h	2,330,906 ^k	529,941	3,060,806	618,031	1927
3,492,738 ^f	779,138	h	h	3,492,738 ^k	779,138	4,301,538	891,381	1928
4,854,824 ^f	908,497	259,307	34,471	5,114,131	942,968	5,747,731	1,012,581	1929
4,108,038 ^f	876,584	187,312	37,887	4,295,350	914,471	5,488,650	1,053,616	1930
2,568,603 ^f	591,999	84,906	22,717	2,653,509	614,716	3,916,409	754,755	1931
3,638,680 ^f	485,390	55,925	8,291	3,694,605	493,681	4,730,505	533,113	1932
2,705,117 ^f	404,647	82,053	12,569	2,787,170	417,216	4,500,870	534,818	1933
1,463,493	265,849	h	h	1,463,493 ⁱ	265,849	2,872,593	383,466	1934
2,388,480 ^f	423,872	34,080	8,850	2,422,560	432,722	4,656,460	581,123	1935
1,242,710	260,544	h	h	1,242,710 ⁱ	260,544	3,028,010	410,818	1936
1,494,400 ^f	290,940	87,200	20,216	1,581,600	311,156	3,083,600	481,354	1937
1,670,000 ^f	350,100	41,200	9,591	1,711,200	359,691	2,804,100	461,220	1938
1,598,160 ^f	323,328	47,760	11,486	1,645,920	334,814	3,434,320	520,560	1939
1,069,840 ^f	230,088	73,760	18,561	1,143,600	248,649	3,433,700	502,180	1940
474,535	138,831	h	h	474,535 ⁱ	138,831	1,820,835	356,661	1941
549,440 ^f	178,458	10,880	5,365	560,320	183,823	2,493,820	629,799	1942
458,480 ^f	150,368	6,800	3,334	465,280	153,702	3,486,180	973,588	1943
941,600 ^f	280,702	32,560	15,243	974,160	295,945	2,963,160	912,424	1944
2,119,360 ^f	644,275	137,680	60,100	2,257,040	704,375	4,974,140	1,734,623	1945
1,484,240 ^f	1,108,654	87,280	57,597	1,571,520	1,166,251	4,347,220	2,147,655	1946
1,245,280 ^f	628,530	50,880	38,160	1,296,160	666,690	3,088,160	1,368,290	1947
752,720 ^f	375,776	36,320	25,000	789,040	400,776	3,145,040	1,259,776	1948
755,360 ^f	339,735	17,600	10,975	772,960	350,710	3,005,960	1,075,110	1949
709,360 ^f	324,914	19,120	11,775	728,480	336,689	2,882,480	1,042,189	1950
159,840 ^f	96,638	1,680	1,155	161,520	97,793	2,704,520	1,095,293	1951
241,360 ^f	112,361	880	515	242,240	112,876	3,398,240	1,001,076	1952
193,600 ^f	81,000	800	1,000	194,400	82,000	3,518,400	1,187,100	1953
273,600 ^f	105,000	2,400	2,000	276,000	107,000	4,574,000	1,245,000	1954
283,200 ^f	107,000	1,600	1,000	284,800	108,000	4,830,800	1,198,300	1955
382,400 ^f	164,000	11,200	7,000	393,600	171,000	5,005,600	1,466,100	1956
636,800 ^f	262,000	10,400	5,000	647,200	267,000	5,827,200	1,607,900	1957
1,174,400 ^f	432,000	77,600	45,000	1,252,000	477,000	6,629,314 ^c	1,916,132 ^c	1958
442,490 ^f	162,971	100,080	50,714	542,570	213,685	7,244,076 ^c	1,596,916 ^c	1959

^a Major ports only for 1909-18, 1920-23, 1925, 1926, 1934, 1936 and 1941.
^h Data not available.
ⁱ Data incomplete—major New England ports only.
^j Data incomplete—major New England ports and Middle Atlantic States.
^k Data incomplete—New England States only.
^f Data incomplete for 1909-28, 1934, 1936 and 1941.

During the 1959 season, fishing log books were supplied to some of the swordfish vessels. The completed records accounted for only about 9% of the total catch for that year and the records are undoubtedly biased in favour of the more successful and co-operative fishermen who were selected for this study. An analysis of the data obtained from the records, however, gives some indication of the effort involved in the swordfish fishery and the number and weight of fish caught (Table III).

TABLE III. Summary of information from fishing log records kept by representative Canadian swordfish fishing vessels, 1959.

	June	July	August	September	Total
No. of log records	4	14	18	4	40
No. of days at sea	61	193	212	62	528
No. of days fished	47	152	145	50	394
No. of fish seen	292	2,107	1,156	276	3,831
No. of fish caught	226	1,548	934	197	2,905
Weight of fish caught (lb)	45,000	307,200	182,000	46,100	580,400
Av. no. fish caught per day at sea	4	8	4	3	6
Av. no. fish caught per day fished	5	10	6	4	7
Av. no. fish caught per trip	56	111	52	49	73
Av. weight each fish (lb)	199	198	195	234	200
Av. weight each trip (lb)	11,250	21,940	10,110	11,530	14,510
Principal fishing areas	Georges Bank	Georges Bank Sable Island	Sable Island Banquereau	Sable Island	

The number of days fished (Table III) includes searching for fish on days when no catch was made. The difference between days at sea and days fished is accounted for by (a) the time spent steaming to and from landing ports and (b) the days lost because of bad weather. More than 25% of the total time at sea is not productive of fish. However, the efficiency of capture is relatively high, in that more than 75% of the fish seen were caught. The average weight landed per trip is small but because of a high unit value (20.6 cents per lb in 1959) the average gross receipts per trip are nearly \$3,000.

SEASONAL CHARACTERISTICS

Swordfish usually appear in Canadian fishing areas in early June and remain until mid-September. A few catches have been made in late October and early November. Figure 11 gives the average landings by months for 1957 to 1959.

Table IV shows that most of the early and late landings are made in the western areas, especially at the ports of Halifax, Lockeport and Yarmouth (Fig. 1). Fishing during these periods is largely confined to Georges Bank. As the season advances the fish move north and east, and landings then occur at ports near the fishing grounds. For example, catches on Banquereau are usually landed at eastern Nova Scotia ports such as North Sydney, Louisburg and Glace Bay (Fig. 1). The landing ports used in August and September suggest a westerly migration of swordfish.

The seasonal pattern of landings shown in Table IV is fairly typical of the Nova Scotia swordfish fishery. This is confirmed in Figure 12, which gives the proportion of each month's catch taken in eastern and western Nova Scotia.

TABLE IV. Monthly Canadian landings of swordfish in pounds by ports for 1957. Data compiled from records kept by captains of fishing vessels.

Ports	June	July	Aug.	Sept.	Oct.	Nov.
<i>Eastern Nova Scotia</i>						
Alder Point.....	...	1,200	5,500	2,100	...	...
Bickerton.....	...	338,500	126,600	31,400	...	...
Canso.....	...	3,600	200	...	...	...
Dingwall.....	...	...	3,500	...	...	...
Drum Head.....	...	25,400	5,400	...	...	...
Glace Bay.....	...	100,900	109,900	73,700	...	...
Ingonish.....	...	400	1,300	...	...	...
Louisburg.....	...	49,600	275,300	14,000	800	...
Mainadieu.....	...	18,800	22,900	600	...	...
North Sydney.....	...	190,900	342,200	110,000	...	...
Petit de Grat.....	...	3,100	...	...	...	...
Port Morien.....	...	13,700	6,900	...	...	...
<i>Western Nova Scotia</i>						
Clark's Harbour.....	16,400	86,300	46,200	23,400	200	300
Halifax.....	21,400	455,700	87,900	95,700	...	...
Lockeport.....	32,300	188,900	111,400	53,700	1,000	...
Lunenburg.....	...	400	4,600	...	...	...
North West Cove.....	36,600	151,200	164,300	74,500	300	...
Port Latour.....	18,300	...	300	400	...	500
Port Mouton.....	...	20,500	14,400	100	...	...
Sambro.....	...	438,200	87,600	102,900	...	...
Shelburne.....	...	92,200	9,600	5,000	...	...
Woods Harbour.....	...	12,900	...	...	...	...
Yarmouth.....	40,300	221,900	251,700	142,600	1,100	300
Total.....	165,300	2,414,300	1,677,700	730,100	3,400	1,100

AREA OF CAPTURE

Swordfish are captured in both inshore and offshore waters. For inshore fishermen, the main grounds are along the eastern shore of Nova Scotia, particularly off the coast of Cape Breton Island. Offshore fishermen venture as far west as Block Island and as far east as Grand Bank (Fig. 1).

The principal fishing areas include the offshore parts of the Nantucket Shoals region, Georges Bank, the deep channel between Georges and Browns Banks, Browns Bank, La Have, Emerald and Sable Island Banks, the banks off the eastern coast of Cape Breton, Saint Pierre Bank, and the southeast edge of Grand Bank (Fig. 1). Figure 13 shows the principal fishing areas and the distribution of catches during the 1959 season. The catch record is based on a small sample of the 1959 fishery (9%) and is probably biased in favour of vessels fishing from eastern Nova Scotia ports.

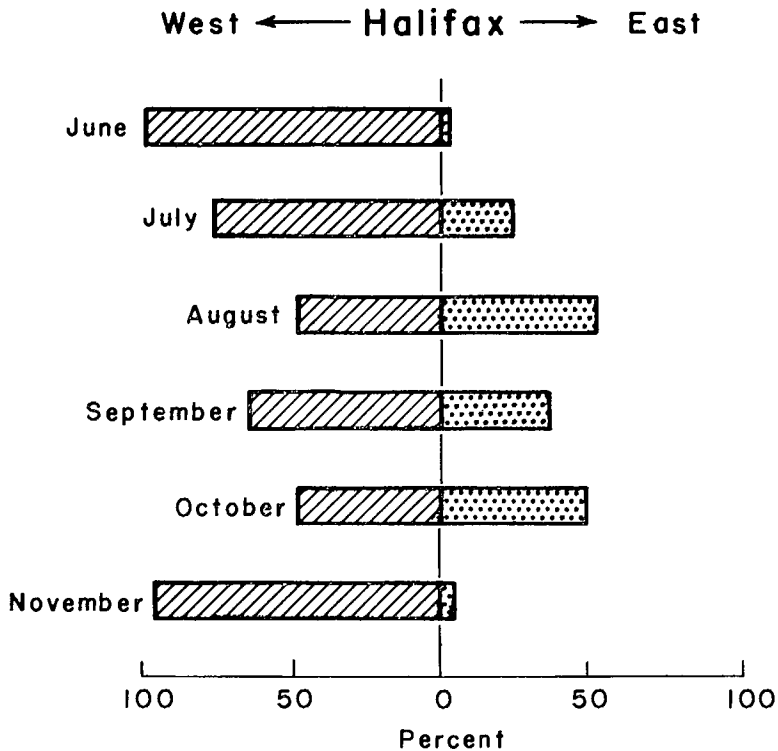


FIGURE 12. Proportion of swordfish landings made east and west of Halifax. Data averaged for 1950 to 1959.

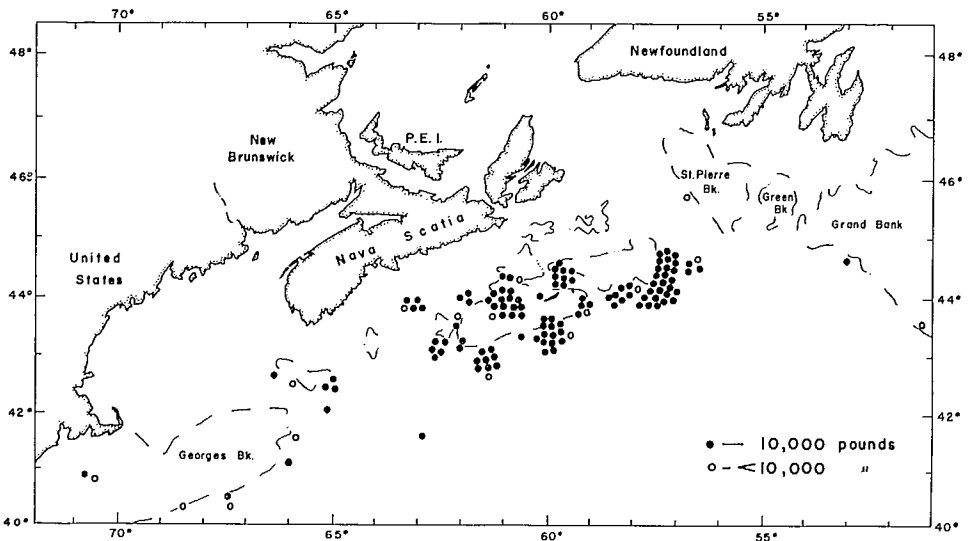


FIGURE 13. Distribution of swordfish catches in 1959.

FISHING GEAR

Swordfish are taken almost exclusively by harpooning or spearing. The equipment (Fig. 14) is simple in the extreme, consisting of a pike pole, a dart, a warp (line) and a buoy. The pike pole is made of wood or aluminum about 15 feet long. It is shod with a 2-foot rod of iron which fits into a socket on the back of the dart. This dart is sometimes called a 'lily iron', perhaps because of some fancied resemblance to a lily. It is a double-headed arrow point with broad flanges set at a slight angle to the main axis. Once the dart has been lodged into the flesh of a fish, the strain on the line which is attached to it causes the sharpened edges of the flanges to cut and hold in an oblique direction to the strain and, hence, produce a firmer grip in the flesh.

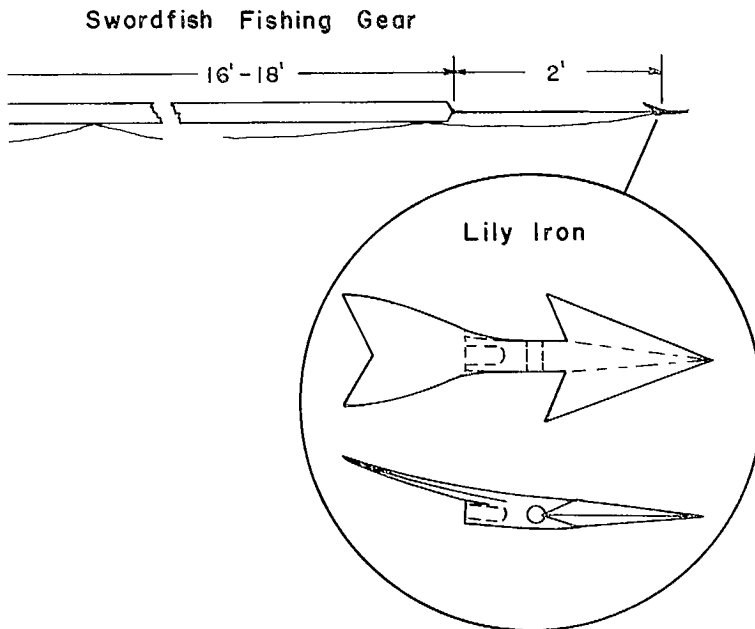


FIGURE 14. Swordfish fishing gear. Drawing by P. W. G. McMullon.

Along the back of the dart is a thick rib, the after part of which is hollowed out to receive the point of the pike pole. A hole is bored through the central part of the dart, between the barbed heads, and the warp is made fast to it.

The warp consists of 40 to 80 fathoms of rope $\frac{3}{4}$ inch in circumference. This is tied lightly to the pike pole, allowing enough strain to hold the dart in place. The warp is fastened by slip knots, which pull clear with the rush of a stricken fish, at the "stand"—where the harpooner is perched to spot his prey—and again just behind the fore rigging of the vessel. The remainder of the warp lies in a coil on the deck of the vessel and is attached to a small barrel-shaped keg or buoy.

METHOD OF FISHING

The swordfish is not known to surface except in moderate weather. On sunny, calm days it can be found basking in the sun, or what fishermen call "finning". It moves along easily with its dorsal fin and the upper lobe of its tail showing above water. In a fresh wind, the swordfish is usually 2 to 10 feet below the surface, where it can be identified as a bluish spot in the green water.

While a vessel cruises in search of fish, the "lookout-men" are perched in the rigging of the foremast (Fig. 15). There they sit or stand watching for fish that are submerged, leaving the search for fish at the surface to other members of the crew on deck. The dories are placed on the port side of the deck. The starboard side is left free for fishing, except for buoys and spare pike poles that are placed along the rail in readiness for instant use.

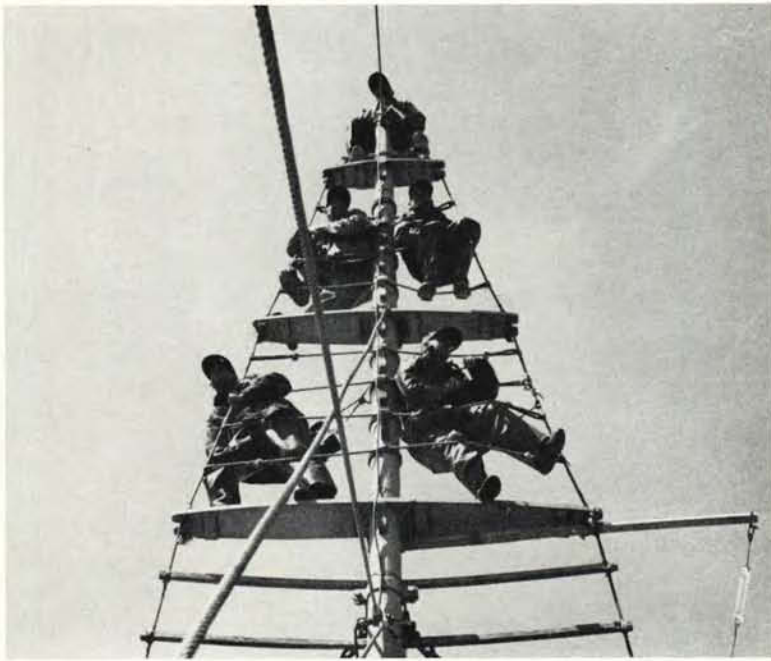


FIGURE 15. Searching for swordfish. Photograph by G. M. Somerville 1958.

When a fish is sighted all the crew, except the "striker" at the end of the bowsprit (Fig. 16) and the captain at the wheel, stand by to put the dories over the side and to handle the fish after it is "ironed". The vessel is directed to the fish by the "masthead-man" (Fig. 15). The "striker" is in readiness in his stand—a skeleton iron frame set upright on the tip of the bowsprit—with his pike pole lying across the rim of the stand. The "striker" is indeed a key member of the crew and is chosen because of his strength and skill in handling a pike pole.

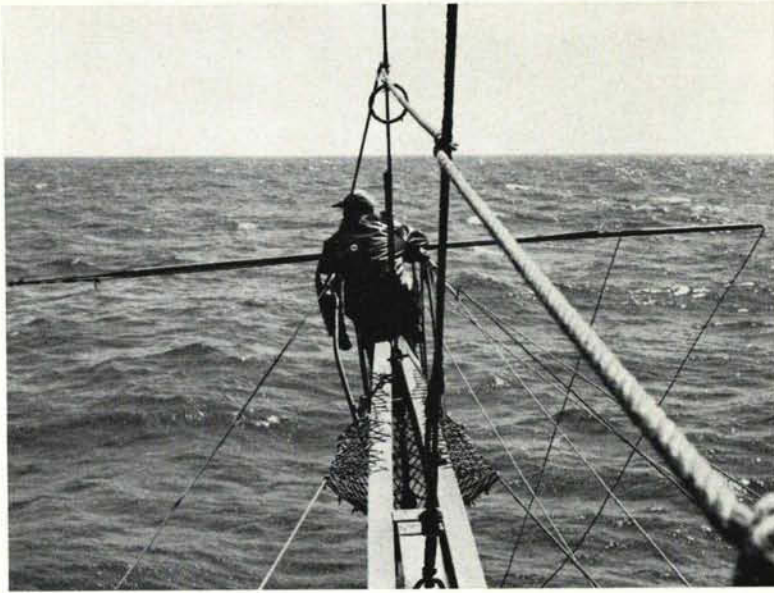


FIGURE 16. The 'striker' in his stand. Photograph by G. M. Somerville 1958.

Once the vessel is within the proper distance of the fish, the "striker" drives his pike pole into the back of the fish, as close as possible to the large dorsal fin. Some "strikers" throw the pike pole (Fig. 17, *left*) while others merely thrust or stab after careful aim (Fig. 17, *right*).

After a fish is "struck", the pole is pulled back by means of a retrieving line. The barb is now embedded in the flesh, and the fish rushes away towing the warp and the buoy, which have been thrown overboard by a crew member. The doryman immediately takes to his craft, picks up the buoy and begins to haul in his prize. Occasionally this results in an extremely exciting and rapid ride before

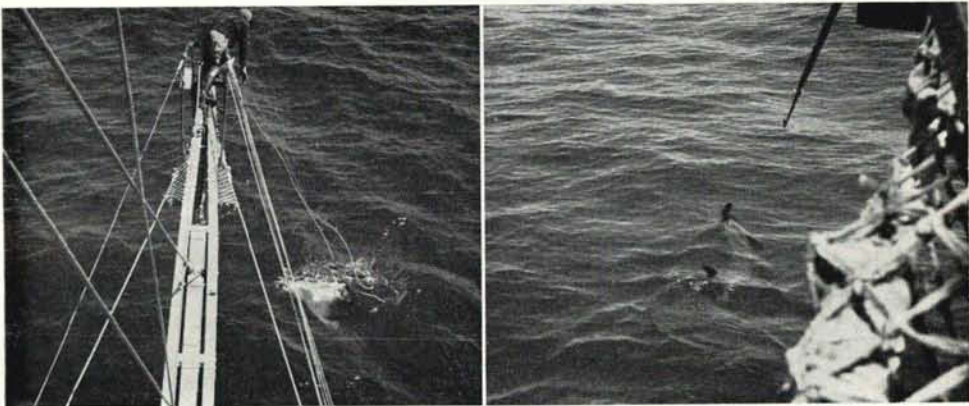


FIGURE 17. Harpooning swordfish. Photographs by G. M. Somerville 1958.



FIGURE 18. A swordfish tied to a dory. Photograph by G. M. Somerville 1958.



FIGURE 19. Hoisting a swordfish to the deck of the vessel. Photograph by G. M. Somerville 1958.

the fish becomes exhausted. A large fish will usually battle 20 minutes or more, although the length of the battle depends largely upon the fisherman's skill at hauling. Many fish are hit so hard that there is little fight left in them. Regardless of the fight, the fish is finished off with a lance which cuts into the gills and causes it to bleed to death. Once dead, the fish is made fast to the side or stern of the dory (Fig. 18), with a strap around its tail, and the doryman is picked up by the vessel and his victim hauled up on deck (Fig. 19).

The sword, fins and tail are cut off immediately as each fish is hoisted on the deck of the vessel. The remainder of the dressing—cutting off the head, scrubbing the body cavity with wire brushes, washing with sea water, wiping with burlap cloths to remove loose filmy tissue, and icing—is done at the end of the day's fishing. This method of fishing applies generally throughout the swordfish fleet although there are some variations. Each crew will operate a little differently depending on experience, weather conditions and the abundance of fish.

The average duration of a trip is about 2 weeks, varying between 10 and 18 days. There are recorded instances of swordfish being caught by other methods—ordinary hand-lines, long-lines, seines, nets and drags. However, swordfish thus caught are a result of accident rather than design and are often more of a vexation than a boon to fishermen.

In 1959, one swordfish vessel, the *Terry and Gail*, experimented with an electric harpoon for catching swordfish. With some modification, this new device may prove more efficient than the conventional method of capture, since the fish can be killed instantly and much time, therefore, can be saved in getting it on board the vessel. Presumably, too, fewer crew members and no dories would be required. This would result in higher monetary returns to fishermen.

Gilbert saw the electric harpoon gear at Louisburg, N.S., and one of the crewmen explained its operation to him. Gilbert reported that:

"Since they had used it (the electric harpoon) only a few times not much could be said at the time about its success or failure. However, of the fish that had been landed at that time, none took more than 3 minutes to bring aboard. By comparison, I found that, on the *Pubnico Pal* the time required to land 18 swordfish varied from 20 to 80 minutes with an average of 43 minutes for each fish."

The chief points in the operation of this new gear were as follows: the "pole" is armed with a modified dart to which an insulated, electric cord is attached. This transmission line which replaces the "warp", carries the current from a compact metal box located on the front of the wheel house to the dart. The electric cord, which is about 10 fathoms long, carries no current until the mechanism is tripped by the pulling of the "struck" fish. The fish can be electrocuted manually before it takes out all the line by pulling on the cable at the point where it enters the control box. The fish receives 250 volts as it completes the circuit between the "live" dart and a ground plate mounted on the hull of the boat below the waterline. Apparently the fish is killed instantly and can be hauled aboard without the use of a dory. There were three separate lines fastened to three darts coming from the control box, so that a maximum of three fish could be struck, one after another in a very short time.

The most obvious advantages of the new gear are a reduction in crew, as no dories need be launched to retrieve the fish, and a great saving in time in bringing in the fish. The cost of this equipment was reported to be about \$2,200.

In his diary, Gilbert described a typical day aboard a swordfish vessel during a period of good fishing. This record was for the *Pubnico Pal* fishing on Georges Bank at approximately Latitude 40°08' N., Longitude 68°47' W., on June 24, 1959.

"Two swordfish which remained on deck for the night were iced at 9 AM. Nine boats visible in the area. Shortly after 9 AM (before engine was started for day) a swordfish was sighted off the bow. Gave chase and ironed it fair. When struck, it made no extraordinary motions but stayed on the surface. We steamed past it preparing to throw the keg over but when the swordfish remained on the surface the crew hauled back on the line and pulled it on deck, where they hacked off its sword and lanced its gills. Only then did it flop around a bit but the crew tied its tail down. Ironed second swordfish at 9:10 AM. Eighteen boats visible, many with dories out. Ironed third swordfish at 9:26 AM. Hauled second swordfish at 9:45 AM. Twenty to twenty-five boats visible from deck. Ironed fourth swordfish at 10:21 AM. Striker missed the next one. Ironed fifth and sixth at 10:45 AM. We lost No. 6 when line fouled in the propeller. Seventh and eighth ironed at 11:40 and 11:45 AM respectively. Twenty-two boats now visible. At noon, we passed an ironed swordfish which was leaping at the surface. Temperature of fish hauled aboard at 12:42 PM was 55.6°F (surface water temperature 58.0°F). Ironed fish at 1:00 PM, 1:45 PM, 1:50 PM. A swordfish hauled aboard at 1:55 PM was the third fish of the day which was ironed completely through the body. Ironed



FIGURE 20. Swordfish are iced below decks at the end of the day. Photograph by G. M. Somerville 1958.

another swordfish at 2:10 PM. It dove about 5 seconds after being hit. Another, ironed at 2:20 PM dove almost immediately. At 2:25 PM dory alongside without his fish. Hauled swordfish aboard at 3:05 PM. Ironed swordfish at 3:25 PM. Some porpoises off the bow. Swordfish hauled aboard at 3:45 PM. The weather was excellent, clear and calm all day. Most of the fish were not finning but were sighted underwater and fairly close to the boat. Had they been finning, a far greater number of fish would have been seen and presumably more caught. From the number of boats reporting good catches (M.V. *Foam* got 12, M.V. *Shirley and Arthur* 18, and M.V. *Lister* 17) there must be a large body of swordfish in this area. Four swordfish hauled aboard; 2 at 5:20 and 2 at 6:30 PM. Fishing over for the day. Total catch 16 swordfish."

VESSELS

There are two types of fishing craft engaged in the swordfish fishery; (a) inshore boats, which confine their operation to only short distances from shore, and (b) offshore vessels, capable of searching for fish over very wide areas.

The boats that make up the inshore fleet are small, measuring from 30 to 40 feet in length. They are quite broad for their size and have a flat stern. The end of the stern is open and the wheel house is situated approximately amidships. Each boat has a small stand for the "striker", but few are equipped for masthead observations. Each boat carries one dory and a crew of two or three men.

Nearly all of the inshore fleet is based in Cape Breton Island. Landings are usually small, with only a few boats catching more than one or two fish during an entire season. During the 1957 season, Somerville inspected 46 of these boats. It was his impression that the owners were all having a rather "tough time" as the

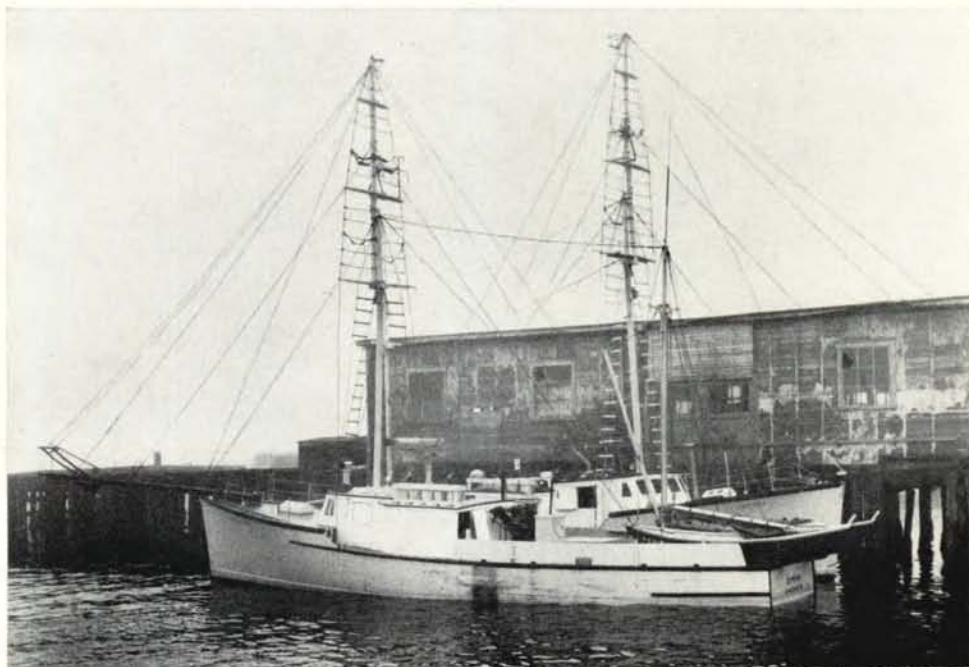


FIGURE 21. A swordfish fishing vessel, Longliner type. Photograph by P. W. G. McMullon 1960.

boats were so poorly maintained. None of them had been painted recently, and the equipment was old and rusty.

In 1957, the offshore fleet consisted of 85 longliners (Fig. 21), 24 schooners (Fig. 22), 14 draggers (Fig. 23), and 43 unspecified types of vessels. The longliners have a crew of five or six and carry 2 or 3 dories. Most of these vessels are of recent construction, fitted with modern navigational aids and in good condition. In general, the schooners are very old but are kept in good repair. They carry a crew of nine or ten and have from 3 to 5 dories.



FIGURE 22. A swordfish fishing vessel. Schooner type. Photograph by G. M. Somerville 1958.

The sizes of vessels vary considerably but, in general, the longliners are less than 60 feet, the draggers 60 to 70 feet and the schooners 80 to 100 feet. The offshore vessels may fish all the way from Block Island to the Grand Banks, and account for more than 90% of the recent swordfish landings. The size of the offshore fleet has been increasing steadily since 1945.

Although many vessels are engaged in the swordfish fishery for successive years, many others fit out for a single season or for part of a season. Most fishermen involved participate in other fisheries. Even during the swordfish run, normally from June to October, the fisherman's time is divided between hunting swordfish and fishing other species.

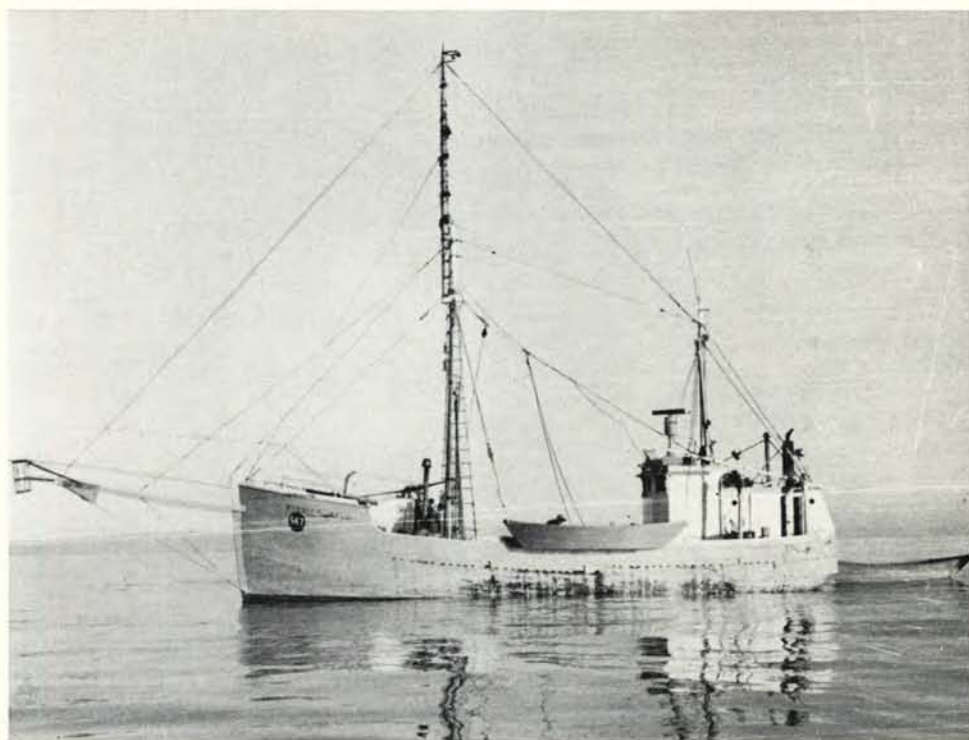


FIGURE 23, A swordfish fishing vessel. Dragger type. Photograph by G. M. Somerville 1958.

SWORDFISH LANDINGS AND MARKETING

TRENDS IN PRODUCTION

The development of a commercial swordfish fishery in Canada proceeded at a slow pace (Table II). The value of landings in 1909, the first year of official records, was \$13,696. As late as 1940, the value of landings was only \$254,000; in 1950 it was \$705,000, and in 1959, \$1,383,000. The averages for the periods 1930-39, 1940-49, and 1950-59 were \$204,500, \$665,000 and \$1,138,000 respectively.

This slow development can be attributed to a number of factors. Foremost among them are the short season and the traditional method of fishing employed. The fishing season is confined to the summer and early fall. As such, it is characterized by a great degree of uncertainty (of returns) and hence does not provide much attraction for many fishermen. At the same time the method of fishing employed is more dependent upon the weather than most Canadian fisheries. Combined with the limitations of a short season, this serves to discourage the application of expensive, specialized capital or the formation of large-scale swordfishing enterprises. For these reasons, until recent years most Canadian fishermen have sought swordfish only in inshore waters, using the same small, inexpensive boats employed in other inshore fisheries. The results have been a much smaller catch than if the movements of this "demon of the deep" had been followed more intensively in his offshore habitat.

Another factor which deterred normal expansion of this fishery was marketing, particularly up to about 1930. Swordfish, like many other fat fishes, is not ideally suited to the traditional types of cures; moreover, consumer preference has always been for the fresh or frozen product. Because of this the development of the market, especially in the United States, required adequate refrigerated transportation. It was only in the 1930's that such facilities were developed.

It is also obvious from Table II and Figure 10 that Canadian swordfish landings were somewhat sporadic for a considerable portion of the fishery's documented history. During the first 20 years of this period the pattern of landings is not too well defined, although there were definite peaks during the years 1913, 1915, 1922, 1923 and 1926. From 1930 to 1948, a cycle of 2 to 3 years is discernible, with peaks in 1931, 1933, 1935, 1940, 1943, 1946 and 1948. Since 1948, however, landings have increased in every year except 1950; and even in that year, the decrease was only fractional and likely due to less intensive fishing effort.

While this pattern of landings is not consistent, it is possible that particular oceanographic conditions recur periodically with adverse effects on the catch.

Since there are many factors which can affect the catch—such as weather conditions, price, etc.—further research into the oceanographic environment would be necessary before it could be isolated as a separate factor affecting the fish supply.

The changes which have taken place in the swordfish fishery since 1945 merit special mention. During this period, the modernization of the Atlantic coast fleet, particularly the introduction of a larger type of longliner, enabled a number of fishermen to combine fishing for swordfish and other species with considerable success. The development of longlining was notably rapid and extensive in western Nova Scotia and resulted in a phenomenal increase in swordfish production in that area. This is shown in Figure 24 which also portrays the shift of emphasis in this fishery from eastern to western Nova Scotia fishing ports.

The increase in swordfish landings by longliners is especially striking from 1952 onwards. John Proskie (1957, 1959) ascribes it to the increase in the capital

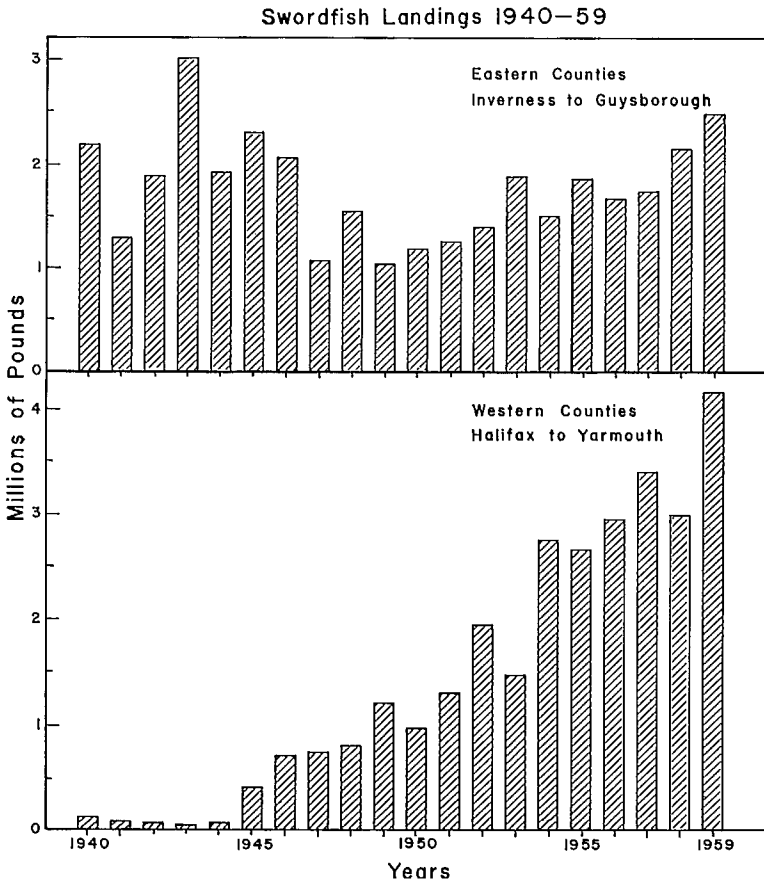


FIGURE 24. Swordfish landings in the eastern and western counties of Nova Scotia 1940-1959.

and operating costs associated with longlining. According to this analysis, increased costs forced longliner operators, who until then had concentrated on the capture of groundfish species, to seek species more rewarding in price and to turn to swordfish. Table V, which is based upon Proskie's sample study of swordfishing longliners (about 68% of vessels 50 to 60 feet in length) gives a measure of the increase in swordfishing by these vessels during the period 1952 to 1959.

TABLE V. Days fished and output of swordfish by Canadian longliners (50-60-foot class). Data from Proskie (1959), with 1959 added.

Year	Average number of days fished	Average landings	Average value
		<i>pounds</i>	\$
1952.....	24	16,469	4,172
1953.....	39	25,026	7,420
1954.....	39	27,425	7,519
1955.....	41	38,580	8,963
1956.....	39	37,654	10,265
1957.....	39	37,916	10,025
1958.....	56	42,264	11,552
1959.....	44	47,423	9,497

Average swordfish landings of these longliners increased threefold during the 8-year period, 1952 to 1959. The average money value received by fishermen more than doubled during the same years of comparison; and in 1958 it was nearly three times the landed value registered in 1952.

The significance of the increased contribution to landings by the 50-60-foot longliner class is more clearly demonstrated by reference to the increase in total swordfish landings which occurred during the 1952-1959 period (Table VI).

The increased share of swordfish landings by longliners during this period was accompanied by the disappearance of a number of boats from the swordfish fleet. As recently as 1945 the swordfish fleet consisted of 373 vessels and boats,

TABLE VI. Percentage increases over 1952 in total and average landings of swordfish by Canadian longliners (50-60-foot class). Data as in Table V.

Year	Increase in total landings	Increase in average landings
	%	%
1952.....	0.0	0.0
1953.....	5.3	52.0
1954.....	36.2	66.5
1955.....	44.0	134.3
1956.....	46.1	128.6
1957.....	64.1	130.2
1958.....	64.2	156.6
1959.....	112.3	188.0

the majority being Cape Island and other inshore type boats. By 1952 the number had declined to about 280 and by 1958 (the last official record year) the number stood at only 214, even though approximately 100 longliners were added to the fleet. It is indeed significant that while the number of boats declined by 159 during the last 15 years, the volume of the catch nearly tripled, from 2.7 million pounds in 1945 to 6.7 million pounds in 1959. While the possibility of an increase in fish abundance must be admitted, an improvement in vessel efficiency is apparent.

MARKETS

The chief market for Canadian swordfish is in the United States. Upwards of 90% of the catch is exported there. Most of the fish is sold in the fresh state, although some is frozen before shipment. Fresh fish are dressed before sale—heads, tails and entrails removed—and are usually shipped in wooden boxes, packed in ice.

Only a small portion of the swordfish catch is disposed of on the domestic market (Table VII). This is largely because the markets in the United States have been adequate, until now at least, to absorb the bulk of available supplies at acceptable prices. However, this situation may not continue. Average export prices in the United States dropped from 40.5 cents in 1958 to 34.9 cents in 1959, coinciding with an increase in Canadian swordfish landings of about 1.5 million pounds. Whether this market reaction was due to the increase in Canadian supplies or to the strength of foreign competition, or whether it was simply part of the general pattern of declining prices for fishery products in the United States in 1959 is not known. Certainly more searching market inquiry is required before the possibility of expanding swordfish sales in the United States can be competently assessed.

TABLE VII. Canadian swordfish landings, exports to United States, and prices received in cents per pound, 1955-1959. Data from Fisheries Statistics of Canada.

Year	Landings		Exports		Average values	
	<i>pounds</i>	\$	<i>pounds</i>	\$	Landed <i>cents/lb</i>	Exported <i>cents/lb</i>
1955.....	4,546,000	1,090,000	4,437,000	1,334,000	24.0	30.1
1956.....	4,612,000	1,295,000	4,494,000	1,707,000	28.1	38.0
1957.....	5,180,000	1,341,000	4,766,000	1,824,000	25.9	38.3
1958.....	5,378,000	1,439,000	4,416,000	1,787,000	26.8	40.5
1959.....	6,702,000	1,383,000	6,625,000	2,313,000	20.6	34.9

In addition, the margin between the price received by fishermen (landed values) and exported values has widened steadily during the last 5 years. In 1955, for example, the spread was 6.9 cents while in 1959 it was 14.3 cents, an increase of over 100%. The reasons are not obvious. They may be rising costs of handling, transportation, merchandising, etc. Detailed studies are needed to isolate these factors and to assess their importance for the future development of the swordfish industry.

PROSPECTS FOR EXPANSION OF THE FISHERY

In any attempt to evaluate the prospects for the swordfish fishery on the Canadian Atlantic coast, one is confronted with the need for more research, particularly of a biological and economic nature. There has been considerable expansion of this fishery during the past 10-15 years. Is this trend to continue? Some of the more important factors which must be considered, before this question can be answered intelligently, are examined below.

SWORDFISH STOCKS

Perhaps the greatest and most obvious gap in our knowledge concerns the size of the swordfish population. Research is needed to determine at least the approximate extent to which exploitation of the resource can be increased without fear of economic depletion. At present, there seems to be little reason for concern about the supply. Catches have been increasing rapidly for the past 10 years, yet fishermen consider the present rate of exploitation to be low. This may well be so, since fishing is restricted seasonally and is confined to surface waters. Light and weather conditions are also limiting factors. One mystifying aspect of the fishery is that most, if not all, of the present catch is of females. There may be a differential vertical distribution of males and females, so that the males could be in the same areas as females but would not appear at the surface where they could be harpooned. Assuming that both males and females are in the same general areas, more efficient methods of capture that would take equal numbers of both sexes might double the present catch.

SWORDFISH MIGRATIONS

There is need for research in this field. Existing knowledge is almost entirely confined to what has been acquired from contacts with fishermen, from recorded or orally transmitted versions of their observations and experiences.

SUCCESS OF FISHING OPERATIONS

Fishing success is greatly affected by the abundance and availability of swordfish. Economic research is needed to establish the optimum rate of exploitation of existing supplies, in terms of net yield per unit of capital invested, and to determine whether expansion of the fishery is warranted.

SHIFT FROM OTHER FISHERIES

The degree of expansion of the swordfish fishery will also be influenced by fishermen's alternative sources of fishery income, i.e., the success with which they can exploit other fish species. The recent past has seen a considerable shift

of emphasis from other species to swordfish, largely because of the price advantage. What the future will bring in this direction can best be assessed from an analysis of the production and marketing factors which affect the various fisheries of the Atlantic coast.

MARKET POTENTIAL

No advance in swordfish production can be considered without reference to the potential of the market both in Canada and in the United States. Marketing in the United States is subject to strong competition, especially from Japan. It is not known with what success Canadian producers will meet this competition in the future. The domestic market, however, is largely untapped. Gains might be made in this market if an aggressive merchandising policy were developed.

JELLIED SWORDFISH

Each year a small number of swordfish caught are "jellied". The flesh is a thick, watery or jelly-like mass and is unmarketable.

The causes of this "jellied" condition are unknown although a great many theories have been advanced. There is no outward indication of any abnormality. "Jellied" fish are usually large, appear to be in good physical shape and as a rule put up an exceptionally good battle when "ironed". It is somewhat curious that very few small fish are "jellied". "Jellied" fish are found most frequently late in the season and in the northern part of the area of distribution.

M'Gonigle and Leim (1937) suggested that the "jellied" meat resulted from bacterial infection. Tsuchiya and Tatsukawa (1954) and Tsuchiya and Kudo (1957) found that "jellied" meat contained a large amount of moisture with relatively little fat. They also detected the presence of large amounts of water soluble nitrogen. They suggested that the condition may occur after the fish is caught and recommended freezing and cold storage immediately after catching to prevent it.

It is generally agreed that "jellied" swordfish flesh has no objectionable taste or odor and is not harmful to humans.

This condition, unless remedied, will continue to have an adverse effect upon the market. Scientists are already engaged in research on "jellied" flesh in other fish species.

METHOD OF FISHING

Because of the short fishing season, the traditional method of fishing which is still employed in the swordfish fishery is not conducive to the formation of large-scale fishing units. Major future expansion is not likely unless new and more efficient methods of fishing are devised.

The longline method of fishing is now being employed successfully by Japanese fishermen. This technique might be adopted by our Canadian fishermen.

The use of an electric harpoon has also been tested, and its successful application could contribute greatly to fishing efficiency. At present the swordfish catch is dependent on individual sightings by members of the crew perched in various parts of the rigging. This would appear to be inefficient, especially on foggy days or when seas are choppy. The use of electronic equipment to find swordfish might help increase catches substantially. In addition, experimental gear research might contribute to a more successful swordfish fishery by developing new and more efficient methods of fishing.

These factors indicate the type and scope of research required to make an intelligent appraisal of the future prospects for the swordfish fishery.

SUMMARY

1. The swordfish fishery on the Canadian Atlantic coast is becoming increasingly important. Landings have increased from about 2 million pounds in 1949 to nearly 7 million pounds in 1959.

2. Swordfish are summer visitors to Canadian waters and the fishery is prosecuted entirely from Nova Scotia ports.

3. Swordfish investigations were carried out in 1958 and 1959 with emphasis on distribution, habits and food.

4. Although swordfish were undoubtedly known and caught by Canadian fishermen before the turn of the century, it was not until 1909 that swordfish became sufficiently important to be recorded separately in fishery statistics.

5. The swordfish belongs in the mackerel-tuna-spearfish group of fishes and is characterized by a greatly prolonged upper jaw and snout forming a flat, sharp-edged sword which may amount to one third of the total length.

6. Swordfish grow to a large size. The world record by rod and reel is currently 1,182 pounds (live weight). The average size in the Canadian commercial fishery is about 300 pounds (live weight). The rate of growth is unknown.

7. Noteworthy aspects of the internal features of swordfish include: jaws entirely devoid of teeth; a large well-developed digestive gland, the pyloric caeca; and a heart which is quite small relative to that in other fish species.

8. The swordfish is distributed widely throughout the tropic and temperate seas but is fished extensively only in the northwest Atlantic, the Mediterranean and the south Pacific.

9. There are conflicting views on the migrations of swordfish. Some fishermen believe they winter in mid-ocean and move into coastal regions during the summer. Others believe that the migratory path is northeast and southwest along the edge of the continental shelf.

10. Breeding seasons and areas are practically unknown except in the Mediterranean where spawning occurs in June and July. Isolated cases of larval occurrence have been reported throughout the area of adult distribution.

11. Studies of swordfish behaviour have been limited to surface areas where they are caught while apparently resting or sleeping after feeding. The most discussed aspect of behaviour has been their pugnacity especially in unprovoked attacks on vessels.

12. The results of food studies indicate a varied diet consisting of both deep-water forms and forms that range more or less independently of depth. Considerable use is made of the sword to maim or kill food fishes before eating.

13. Swordfish are usually heavily parasitized. The most common forms are: (a) a copepod (*Pennella filosa*) found chiefly on the belly, sides and back and (b) a roundworm (*Contracaecum incurvum* R.) found in the stomach.

14. The Canadian swordfish fishery started about the beginning of the present century but developed slowly until about 1950. In the last decade catches increased threefold from 2.2 million pounds in 1950 to 6.7 million pounds in 1959.

15. Mean value of Canadian swordfish landings increased fivefold from \$204,500 in 1930-39 to \$1,138,000 in 1950-59.

16. Canadian swordfish landings are made chiefly in July and August although some catches are made from June to November. Practically all the fish are caught with hand-operated harpoons.

17. Most of the Canadian swordfish catch is made in offshore areas along the edge of the continental shelf from Block Island to the Grand Bank. A small inshore fishery is carried on off the coast of Cape Breton Island.

18. The offshore swordfish fleet consists of longliners, druggers and schooners that are involved in other fisheries (chiefly groundfish) during part of the year. Inshore boats are small, poorly equipped and maintained, and only moderately successful in catching swordfish.

19. Increased landings of swordfish by Canadian fishermen coincided with a modernization of the Atlantic coast fleet which started about 1946. The introduction of a larger type of longliner enabled many fishermen to combine swordfishing and other fisheries with considerable success.

20. The chief market for Canadian swordfish is in the United States, where nearly 90% of the catch is exported. Most of the fish is sold fresh although some is frozen before shipment.

21. The longline method of fishing now employed successfully by Japanese fishermen and the use of electric harpoons now in the testing stage are suggested as new and improved methods of capture for Canadian fishermen.

22. Further expansion of the Canadian swordfish fishery appears possible. At present, basic knowledge of the biology of the stocks and an economic appraisal of fishing operations are necessary for an assessment of the potential.

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