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Fishery biology of the swordfish, Xiphias gladius Linnaeus (Teleostomi: Xiphiidae), in Cuban waters

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FOREWORD

Among the several traditional short range fisheries conducted in Cuba, one of the most productive is that of big fishes and open sea sharks which are so abundant along the North-West coast of Cuba. Among these the sword-fish (Xiphias Gladius) constitutes one of the most interesting biological enigma presently faced by maritime studies, due to the fact that its migratory habits make it difficult to obtain the necessary data to make a general table of its life cycle. Therefore, the cooperation of all countries interested in this species would be very useful in order to cope with such an important problem. With this idea in mind we have prepared this modest research plan, the results of which are offered in this paper, hoping that the large number of existing gaps could be filled by knowledge attained in other latitudes as well as by a more intense study on the phases taking place in our waters.

This research was conducted during two consecutive years in a 10-mile area from Puerto Esperanza, Province of Pinar del Rio (latitude 22 47N, longitude 83 44' W) to Cojimar, Province of Havana. Traditionally the swordfish which is a local fish has been caught from Santa Fe in the West, to the beaches of Santa Maria del Mar and Guanabo, to the East of Havana. Lately, the fishing area has been extended from Puerto Esperanza to Matanzas with very satisfactory results.

Besides statistical data obtained from the commercial swordfish fisheries, direct data were obtained from controlled fisheries. Each time the weather permitted fishing with the Cuban drifting line and depth pre-set hooks was carried out. This type of fishing was pursued for one year by professional fishermen and it provided the basic data used for the vertical distribution. Also a monthly sortie to the area between Jaimanitas and Havana Bay was made by a vessel equipped to take vertical temperature and salinity data, aiming to discover the relation between these and swordfish concentrations. In the area between San Antonio Cape and Havana Bay plankton net towing was performed to catch swordfish in the larva stage. At the very beginning, sorties were made from 2400 to 0700 and later from 0700 to 1200. Temperature was taken /2 by inversion (sic!) (immersion) thermometers and salinity was determined by the Knudsen method. A plankton net No. 00 of 50 centimeter diameter was towed to catch larvae.

Fishes caught by the vessel used in this project were subject to the following process. First the species was determined; the fish were measured with a yardstick (with up to 1 centimeter accuracy) from the lower jaw to the back center of the caudal fin (Rivas 1956); sex was noted; specimens were weighed entire and cleaned (without fins and heads, and eviscerated) to find out the conversion ratio of the two weighings. At the end of each sortie, fishermen gave one pattern specimen on which the date of catch; relative depth, estimated by the length of the line immersed; estimated current; phase of the moon and gear immersing and lifting hours were registered.

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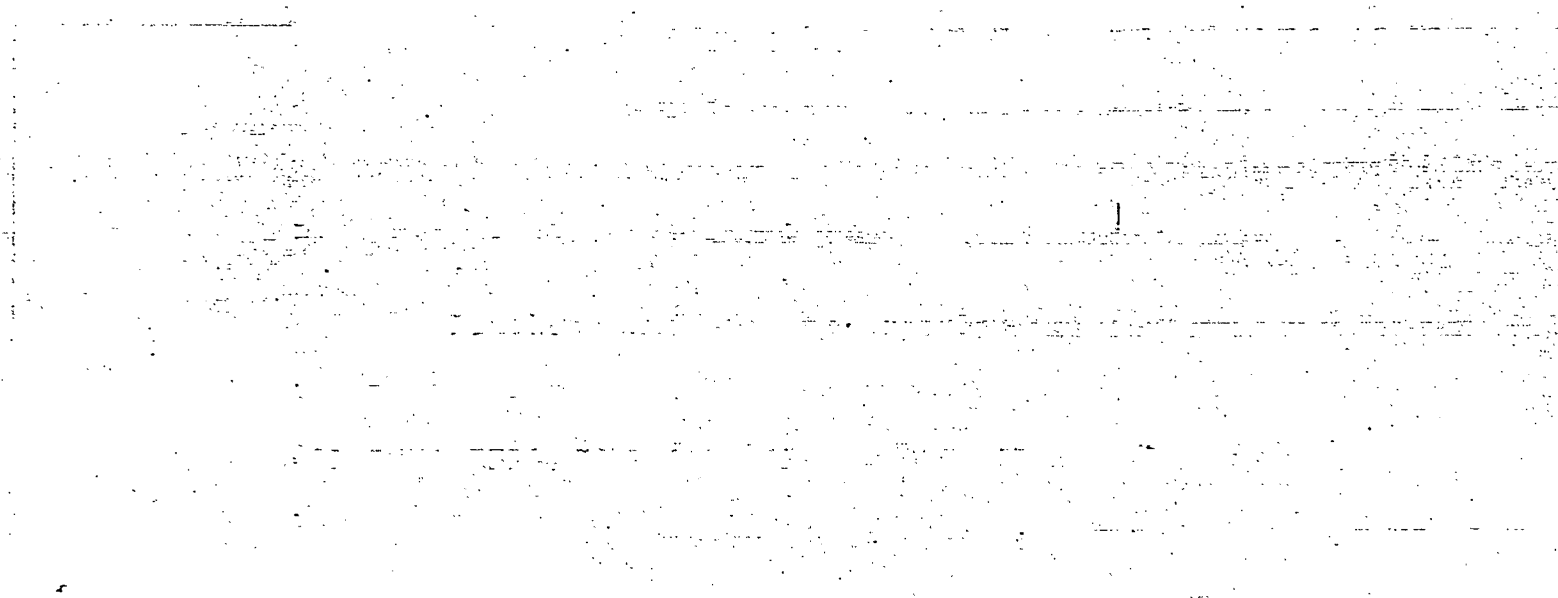
The following process was followed in order to determine swordfish feeding habits: during February and March of 1961, stomachs of specimens caught were taken out, the ends of which were previously tied before cutting the digestive tract: they were carried to the laboratory where they were longitudinally cut to verify their contents. During the remainder of the months of research, stomachs were occasionally collected to verify the existence of a new group in the feeding regime.

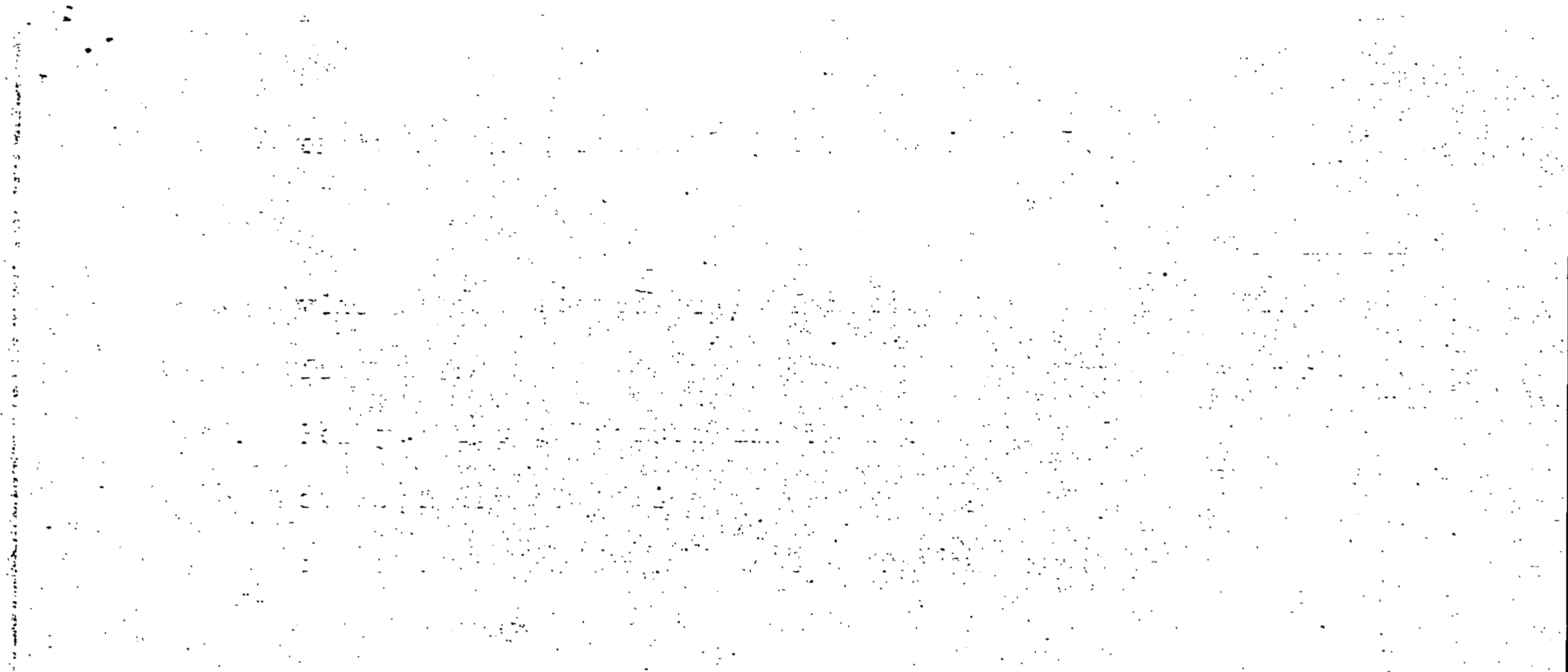
Finally, and based on results obtained during the two years of research, a new type of long drifting line, Japanese type, was developed. This type is more appropriate to our local fishing conditions.

Plate 1 and Figure 2 were drawn by Orlando Jambu and other illustrations by Luis Roura Gonzalez. Francisco Fernandez Conejero was in charge of photography with the exception of picture V-3 done by Justo F. Ondarza.

This type of work would have been impossible without the cooperation of professional drifting line fishermen, the members of the cooperative fisheries of Pelayo Cuervo Navarro and Manuel Ascunce Domenech, both at Cojimar, who fully understanding the importance of this scientific research, supplied the necessary data for the statistical part. We also wish to express our thanks to Enrique Segura, Vicente Granda, Antonio Paez, Oscar Secades and Rafael de los Huertos, members of the Pelayo Curvo Navarro Cooperative, who contributed to the project with all their experience of many years and performed perfectly the fishing experiments entrusted to them.

PLATE No. 1





Swordfish (Xiphias gladius L.) Above: adult. Below: Young.

BIOLOGICAL ASPECTS

Morphology

The swordfish is a large animal the population of which in our waters is characterized by an average full length of 160 cm and a weight of 59 kg. It does not present sexual dimorphism; Youngs and adults differ in some external characteristics and for this reason we are offering a brief description of both stages.

Adult. Strong and fusiform body; scaleless skin; large head, more than one fourth of the full length; big eyes, at one fifth of the head length, almost circular and located forward on the mouth commissure; long flat and sharp edged beak or sword reaching one third of the body length; the first dorsal fin, located at the vertical of the branchial openings, is very high, three-fifths of the head length, and hooked; the second dorsal fin is very small, rudimentary and almost opposite to the second anal fin which is almost identical; the first anal fin looks somehow similar but not as high and hooked; narrow pectoral fins, smaller than the dorsal fin; no ventral fin; very strong caudal fin with identical lobes and a broad quill around the edges; color, upper part deep blue with silver glares on the operculum and bronze glares on other parts of the body; the lower part is white-creamy; when the animal dies the blue becomes charcoal or black.

Youngs. Young and adult specimens are very much alike, except that in the young both first and second dorsal and anal fins are joined, while in adults they are

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completely separated. These joints gradually disappear as young specimens grow, first in the anal fins and later in the dorsal fins; the skin shows rudimentary scales.

GROWTH: Very little is known about the larval evolution and growth of the swordfish. According to some authors the full reproductive phase of the swordfish (spawning, larvae, youth and adults) takes place in summer on the Sicilian and Southern Italian coasts. From the Atlantic, north of the Equator, we only have fragmentary information on the larval development and limited reports on young specimens.

The study of material collected to date, shows, that three different forms (larva, young and adult) can be considered. It is understood that this division into stages is arbitrary, mainly due to the small amount of specimens compared; but, even so, it helps to locate growth stages which up to the present are unknown in Atlantic specimens.

Fig. 1. Swordfish larva (Xiphias Gladius with a full length of 30.5 cm. Copied from "Histoire Naturelle des Poissons", by Curvier and Valenciennes (1831) Plate No. 225.

LARVA - The larva, which in its first stages is entirely different than the adult, is characterized by a continuation of the dorsal, caudal and anal fins which later will become independent. Specimens illustrated by Lütken (1883), Cuvier and Valenciennes (1831, Arata (1954) and Fanning (1955) are good samples of this phase in the different stages of growth.

YOUNGS - The young swordfish is, generally speaking, very much like the adult. The uninterrupted anal fin has split in two but the dorsal fin still forms only one fin. This change occurs when the full length passes from 30.5 cm to 111.8 cm, this conclusion being reached after comparing the drawings of Cuvier and Valenciennes, (Fig. 1) probably represents one of the latest larval forms, compared with our smaller specimen which according to the definition is already a young form.

ADULT - In this phase the dorsal fin has split in two and the general form of the body is that of a fully developed animal. The smallest animal having these specifications, measuring 137.2 cm full length, was caught during this research project, which proves that the change from one phase to the other takes place during the growth period between 111.8 cm of full length to the above-mentioned size of 137.2 cm.

The works of Lütken (op. cit), who studied a series of larvae from 10 mm to 46 mm and some very young specimens; the two specimens of Cuvier and Valenciennes (op. cit) and some other isolated specimens; the detailed description of Arata on a series of larvae from 6.1 mm to

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192 mm of length; and the work of Taning (op. cit) on specimens caught by the Dana, are the only antecedents reported up to the present on swordfish larvae in the Atlantic, according to the consulted literature in this field.

Figure 2. Picture and sketch of a swordfish larvae (Xiphias gladius) of 7.60 mm full length caught north of Cabanas, Province of Pinar del Rio.

During this work, when performing the monthly oceanographic cruise, a plankton net was towed for 30 minutes on the surface or at varied depths each sortie, some of which took place during the day and others during the night. We were unable to catch any swordfish larvae. Later, in April '63, we coasted the same net for two hours and we found a 7.60 mm larva (Fig. 2), very similar in shape to the specimen Reg. No. 73 of Arata (op. cit). This larva was caught on the surface between 0900 to 1100 hours, between 5 to 10 miles north of Cabanas , Province of Pinar del Rio. Occasionally, in the /5

Northwestern waters of Cuba there have also been caught very young specimens the smallest of which was caught in November 1963, weighing 2.65 kgms. having an eviscerated length of 71.7 cm and a full length of 111.8 cm. Another young swordfish was caught in February 1961 which weighed 4.31 kgms., and had 82.5 cm of eviscerated length and 137.2 cm of full length. It is possible that specimens of this size may be more frequent in these waters, because, despite the large size hooks used by our commercial fisheries, reports of youngs or young adults caught are very frequent.

If we add to those records the previous compilations of larvae location (Goode, 1883; Gabrielson and La Monte, 1950) and the study done by Arata (op. cit) on larvae caught up to that moment, undoubtedly the distribution of the same comprises a wide zone of the tropical and subtropical Atlantic, indicating that the spawning area of this species is bigger than previously assumed, as it reaches from Florida in the west to Casablanca in the East, surrounding the south of Cuba and the Equatorial Atlantic. We must add that this distribution coincides with the general pattern of current circulation within the considered area, therefore we must presume that these masses of moving water greatly influence the larvae distribution, mainly in the first phase of their lives, when it forms a temporal part of the current plankton.

Although it has been pointed out (La Monte 1944) that the waters of the Northern coast of Cuba could be one of the most important spawning centres of swordfish, it is more reasonable to think that this location is not so restricted but that spawning can happen in any point of the vast area already indicated, when the animal runs against the water. To support this idea, besides the work of Arata (op. cit.) and the wide dissemination of larvae found, is the fact that the large adult females caught during our research, although they had well developed eggs, had ovules which did not reach the sizes reported in the Mediterranean for animals ready to spawn or spawning, while the great majority had them in a more underdeveloped stage. It does not preclude the possibility, as is obvious, that some spawning does take place near our archipelago, but the main spawning must take place after swordfishes have passed our waters, for in the opposite case the number of larvae caught during this research would have been much larger.

About the post-larval growth we know even less than about the larval. It is supposed, from information obtained from the Mediterranean, that young specimens weighing from 0.23 kgms to 3.63 kgms, caught in winter, correspond to the spring or early summer spawning and that those weighing from 10.89 kgms to 27.22 kgms are the young of the previous year. (Goode, op. cit).

As will be seen further on, the swordfish population in Cuban waters, of 160 cm full length and 59 kgm. average weight, is formed in large parts by over two year old specimens, according to previous findings.

FEEDING /6

Based on the analysis of stomach contents of the swordfishes caught during February and March 1961, the percentage of each one of the large marine groups contained was estimated and within each group we have tried to identify all species present. Results obtained are shown in Table 1 and Figure 3. From these it is possible to deduce that the swordfish has pelagic habits although sometimes it gets into the insular platform in search for food, as is evidenced by the presence (in the stomach) of a Cabrilla (Epinephelus guttatus) which is a bentonic species of the platform.

The main food of the swordfish is the fish Brama-brama which generally lives in deep water,

1. Brama-brama 37.20; 2. ~~Liquids~~ Squid 27.90;
3. Unidentified fishes 13.95; 4. Shrimp 13.95;
5. Unidentified crustacea 2.3; Octopus 2.3;
7. Cabrilla 2.3.

<u>Fig. 3.</u> Percentage of the different zoologic marine groups in swordfish (Xiphias gladius) food.

TABLE 1

Marine Animals Represented in the Swordfish (Xiphias gladius) food.

Systematic position	February	March	Total	Percentage
Arthropoda				
Crustacea				
Decapoda				
Macrura				
Unidentified shrimp	5	1	6	13.95
Unidentified crustacea	1	0	1	2.32
Mollusca				
Cephalopoda				
Decapoda				
Thysanotenthus rhombus and other unidentified	7	5	12	27.90
Octopoda				
Octopus sp.	0	1	1	2.32
Fishes				
Teleostomi				
Bramidae				
Brama-brama	13	3	16	37.20
Serranidae				
Epinephelus guttatus	0	1	1	2.32
Remains of unidentified fishes	4	2	6	13.95
TOTAL	30	13	43	99.96

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following in importance cephalopoda, such as squibs (Thysanoteuthis rombus) and an octopus (Octopus sp.). Shrimps, which could not be identified, were found in some stomachs.

Sometimes algae (Fucus) and mangrove leaves (Rizophora) are found in the stomachs, apparently swallowed when the swordfish tried to catch its prey.

PARASITA

Although during this research no special effort was made to collect swordfish parasites, when studying its feeding habits, the presence of parasites in almost all the stomachs examined, was verified. The amount of parasites in each animal is very large and they belong to several species. Figure 4 shows the percentage reached by each group in a test performed on 26 swordfishes. Later on, other species of parasites were found on the outer part of the body, deeply embedded in the tissues. The collected parasites belonged to different taxonomic groups and were identified, as much as it was possible, in the following groups.

Endoparasites

NEMATHELMINTHES. In almost all stomachs studied, many specimens of Ascaris incurva, a nematode of the Ascaridia genus, were found.

PLATYHELMINTHES: In smaller number than the above, an unidentified parasite of the Cestoda class appeared, strongly attached to the outer walls of the stomach and sometimes even in the inner walls.

ANNELIDA. Only two unidentified specimens of this parasite were found. They belonged to the Hirudinea class. It was forgotten to mention the specific stomach in which they were found.

Cestoda	23.97%
Hirudinea	7.69%
Nematoda	69.23%

Figure 4. Test with 26 swordfishes (Xiphias gladius), hosts for several types of parasites.

ECTOPARASITES

ARTHROPODA. Occasionally we have found a copepodus of the genus Pennela, family Pennellidae deeply inserted into the subcutaneous muscular tissue. The parasite presents a featherlike form which protrudes a little bit. When trying to pull it out, the cephalic region always remained inside and it was impossible to determine the species. Similar experience has been reported with the Pennella filosa in swordfishes of the Northeastern Atlantic. (Tibbo, Day and Doucet, 1961).

PSEUDOPARASITES

CHORDATA. The remora or sucking fish, Remoropsis brachiptera, a member of the Echeneidae family, was collected several times attached to the swordfish's skin by its cephalic disc.

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Besides the aforementioned parasites, the swordfish very often presents one or more very shallow oval wounds, which apparently do not affect the sub adjacent muscular layers and which we were unable to associate to any known animal (Fig. 5a). Undoubtedly, they were not produced by the remora or sucking fish because, as we have already mentioned, we have frequently caught this parasite still attached to the swordfish and when detaching it, no wounds could be noticed. It must be assumed that these wounds are caused by some genus of the Ciclostomata species, with which we have no experience in Cuba as they do not live in our waters, although, according to our description of marks left by these animals, those observed by us do not coincide with those reported for swordfishes (Tibbo et all, 1961) but with those found on whales. (Pike 1951).

Besides fresh wounds, many swordfishes present several oval scars (Fig. 5b) probably originated by wounds of the described type. If the assumption of their origin is correct, a new and valuable evidence of swordfish migration from the cold waters of the North Atlantic to these areas could be presented, as the several species of Ciclostomato do not live in our latitudes.

Figure 5. Characteristic injuries on the swordfish (Xiphis gladius) skin.

A. Fresh wound. B. Scar, probably originated by a wound similar to the one shown in A.

POPULATION. COMPOSITION BY SIZE.

The 242 swordfish caught during the year were classified by size differences of 10 cm, for this method is considered the most appropriate (Table 2) and on this base the histogram and the frequencies polygon shown in Figure 6 were designed and the normal curve was drawn by the Croxton and Cowden method (1954). The annual data

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were taking as basis to depict the central tendencies and measures of spread and also declining values and the kurtosis.

From the study of these facts we have reached the conclusion that the samples taken fit the corresponding pattern curve perfectly, mainly due to the catching method used which entirely complies with sample obtaining standards.

Analysing the central tendency parameters we observe that a large part of the population is constituted of specimens from 130 cm to 192 cm of pattern length, or the area comprised in the distribution by Ma + 5 and Ma - 5 which in this case is a little bigger than the 68 per cent corresponding to the pattern curve; which proves that a large amount of our population consists of younger adults, followed by larger size adults and young forms appear only to a much smaller degree.

Results obtained when estimating the median and mode corroborate the fit with the corresponding curve pattern, and also values obtained from decline estimates (0.03) and kurtosis (0.06) which results in a slightly leptokurtic frequency distribution.

Dispersion parameters show the samples in all their width. The average and typical deviation indicates the type of this distribution in respect to the samples' range, also reaffirming its adaptability to the corresponding pattern curve. The total range of 179 cm shows the variation between the lowest and highest observations recorded.

The swordfish is caught in our water throughout the year. During the two years of sampling, only in June we did not catch any. However, due to large difference in the size of catch, two well differenciated seasons can be considered: winter and summer. In the first one catches are scarce while the great part of the annual catch of this specimen takes place in the second season. Figure 7 shows histograms of the seasonal, monthly catch expressed in hundreds. From each one of these histograms its ratio to the corresponding standard curve has been computed by using the method of accumulating frequencies plotted on probability paper, as proposed by Dixon and Massey (1951), having found in all cases that each one of the samples studied match a normal distribution accurately enough, as can be observed in Figure 8, where plots form a single straight line with a great approximation; showing in this way its adjustment to the normal curve and at the same time discarding the possibility of belonging

TABLE 2

Total length (in centimeters), average length, Frequency and Average weight (in kilograms) of the Swordfish (Xiphis gladius) Population Classes in a sampling of 242 specimens.

Total length	Average length	Frequency	Average weight

(See original text - Page 9)

to two different populations as graphs do not present any doubt about the absence of bimodality.

In histograms corresponding to the different months appearing in Figure 9 and which are not expressed in hundreds, the volume of the monthly contribution to the total annual volume can be seen, indicating seasonal variation of the catch which increases in winter mainly from December to March when fishes are more abundant.

frequencies

kinds

Figure 6. Normal curve adjusted to frequency distribution Ma = 160.61 ± 1.98 etc.

A

Percentages

April-Sept.
N=70
Summer

B

October-March
N=173
Winter

C

Classes

February
N=57

D

Classes

May-September
N=40

D

March
N=41

G

October
N=48

E

April
N=48

H

November
N=27

Figure 7. Size frequency (percentage). A.B. Seasonal frequency C-H Monthly frequency.

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A - April-September summer B - October-May-Winter

C - February D - March

Figure 8. Adjustment of the size frequency to the normal curve

E - April | F - May-September
G - October | H - November
A-B. Seasonal frequency | C-H. Monthly frequency

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Frequency

February	July
N=57	N=18
March	August
N=41	N=11
April	September
N=28	N=8
May	October
N=3	N=48

November

N=27

Figure 9. Monthly contribution to annual volume of catch.

POPULATION BY SEX

The distribution by sex observed in our waters differs from that ovserved on the Newfoundland Grand Banks, where only adults females are caught (Tibbo et al 1961). In our fisheries both sexes appear, the male proportion being much larger than the female. It may be due to the fishing methods used, as Canadian fisheries only depend on catches of surface swimming animals caught by harpoon, while we use drifting gears (lines) with up to 200 meters of depth range. Logically this could mean a strict segregation by sex in the Grand Banks, as the total absence of males would be improbable.

Besides the unequal proportion between males and females (72% of 28%) it has also been found that females as a whole have an arithmetical mean corresponding to a larger length, reaching, in general - larger sizes than males, as shown in Figure 10.

Figure 10. Annual sample, separated by sex, showing the percentage contributed by each class.

Percentage

♀ - AM = 185.7
♂ - AM = 157.3

Classes

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Therefore, we have reached the conclusion that the swordfish population in our waters is composed of a large majority of young males and a few large size adults, while the female population in much greater numbers, is composed of a majority of adults, many of them of large size. Figure 11 shows that this distribution is kept constant, if the two seasons, winter and summer, in which the year has been divided, are considered separately.

Winter

Percentage ♀ AM = 196.8

♂ AM = 158.5

Classes

Summer

Percentage ♀ AM = 182.2

♂ AM = 153.9

Classes

Figure 11. Winter and summer samples, separated by sex, showing the percentage contributed by each class.

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The Swordfish is a solitary animal; it seldom has a partner. However, sometimes by successive hooks of the drifting gear, normally the deepest ones, a male and a female have been caught together, the latter being of larger size than the first. On other occasions, when a large specimen is lifted from the water, the opposite sex specimen swims around the boat making its catch very easy. These occurrences show that occasionally swordfishes cross our waters in couples, apparently on their way to spawning as it can be assumed by the large development of gonads of females caught under these circumstances, that they are travelling in this way to spawning areas.

LENGTH TO WEIGHT RATIO

Among the ratios used in Fishing Biology to determine conversion or comparison factors, one of the most frequently used is the length to weight ratio, due to its practical uses in research and even in commercial fisheries. In the case of the swordfish the linear regression weight to length method has been used due to its simplicity, according to formula $P=cL^n$, where P is weight in kilograms and L is length in centimeters, while constants c and n were obtained by the usual methods.

Table 3 offers real values in those obtained by calculations of $P=0.48643 \times 10^{-6} L^{3.64237}$ in each one of the total length classes, having used classes IV to XIII to estimate the formula constants. In Figure 12 the position of each class with respect to the straight line originated by the regression has been plotted, showing a quite satisfactory adjustment, if taking into consideration the relatively low number of samples used.

TABLE 3

The average weight and estimated weight (in kilograms) of different classes of pattern length (in centimeters), According to Formula: $P=0.48643 \times 10^{-6} L^{3.64237}$

Class	Pattern length middle point	Frequency	True Weight	Estimated Weight

(See original)

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TABLE 3 offers real values and those gotten by calculations of $P=0.48643 \times 10^{-6} L^{3.64237}$ in each one of the toal length classes, having used classes IV to XIII to estimate the formula constants. In Figure 12 the position of each class with respect to the stright line originated by the regression has been plotted, showing a quite satisfactory adjustment, if taken into consideration the relatively short number of samples used.

Table 3.

The average weight and estimated weight (in kilograms) of different classes of pattern length (in centimeters),

According to Formula: $P = 0.48643 \times 10^{-6} L^{3.64237}$

Class,	Pattern length middle point	Frequency	True weight	Estimated weight

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Weight

Length

Figure 12 - Weight to length lineal regression

Space - see original!

Weight

(See original)

Length

Figure 12. Weight to length lineal regression

CONDITION K FACTOR

The K factor or condition factor indicates the degree of robustness or health of specimens of a species. It also indicates the degree of use of surroundings by fishes or their sexual glands development, which imply changes in the shape of the body and which can be interpreted by analyzing this factor.

The method used to determine the value of factor K has been the use of the formula $K= \frac{100.000\ P}{L^3}$ (Rounsefell and Everhart 1960)(where P = weight and L= length) derived from the third power law: $W = KL^3$, modified for a better handling of values.

In the swordfish, the factor has been determined taking into consideration several aspects: total population; classes V to XV of pattern length and sex and the artificial division of summer and winter seasons in which we have divided the year due to our climatic conditions (Table 4).

The whole population has a K 1.315 factor which proves, given its relatively high value, that it has a large soma.

Differentiating by sex, we have a value of 1.450 for females and 1.270 for males, which can be explained by the scarcity of young females which have lower values, thus logically decreasing the general average; but if the values of similar length groups of both seasons are compared, results are identical, proving that in addition there is a noticeable difference between female and male bodies, the first being bigger than the second due to the space occupied by gonads, much larger than in males.

In general, a progressive increase of K value for both sexes is observed, showing a fattening process which took place from when they were young specimens, much slimmer, and which led to the characteristic adult shape, remarkable for its robustness, despite its hydrodynamic form.

TABLE 4

Class	Pattern length average	Winter Females	Winter Males	Winter Females	Winter Males	Annual F.	Annual M.
	(See original)		K condition factor				
TOTAL							

Comparing both seasons we can observe a great similarity in averages of females and males: 1.463 in winter and 1.431 in summer for females and 1269 against 1270 for males. It could be interpreted in the case of females as proof that spawning does not happen in a definite period of time as this fact would show a substantial decrease of the K factor in one season. The similarity of values in case of males is obvious as the shape of their bodies does not change noticeably with the full growth of their gonads.

Other indications of the constant value of this factor is the fact that the degree of the utilization of surroundings by these species do not undergo periodical changes in our waters as is the case with others living in higher latitudes where seasonal differences are noticeable.

The substantial decrease of the K factor observed in the females of the last class (XV) may suggest spawning; but the scarce number of samples obtained has made it impossible to verify this phenomenon. Besides, the fact that no spawned ovaries have been found in the specimens studied, contradict this.

Vertical Distribution

If we consider the whole swordfish population, it has a well defined vertical definition pattern as it prefers an area between the surface and 200 mtr. of depth. Fishermen's experience with this type of catch shows that it is fruitless to look for it below the aforementioned depth and attempts made during the course of research only showed a catch at 300 meter depth. Futhermore, data obtained during the 1961-62 and 1962-63 fishing seasons (Table 5) show that the maximum concentration remained in the first 100 meters depth where 69.7 per cent of the total catch of the first year was obtained.

In order to verify these data and taking into consideration the fact that professional fishermen are used to modify the length of their fishing gear according to moon phases, the next year a fishing vessel was hired to keep a part of its fishing gear at predetermined depths and changed the other in the customary way. Data supplied during this season corroborated those obtained last season, as the 0 to 100 metre zone contributed 77.2 per cent of the annual catch of the fishing vessel. (Table 5).

With data compiled during the two seasons we have tried to find out if this vertical distribution corresponded to some type of male and female stratification, or stratification by sizes. We obtained negative results, as the resulting possibility in each case proved negligible in the majority of cases by the association method (Simpson and Roe 1939) and in those cases in which it may have been positive, they did not coincide in both seasons.

DISTRIBUTION IN RELATION TO PHASES OF THE MOON.

In order to discover the possible relation between the vertical distribution of swordfish and moon

TABLE 5

Vertical distribution of the Swordfish (Xiphis gladius)

	1961-1962						1962-1963					
Depth	♀ (females)	%	♂	%	♀♂	%	♀	%	♂	%	♀♂	%
0-100m	35	62.5	115	72.3	150	69.7	17	70.8	34	80.9	51	77.2
101-200m	21	37.5	44	27.6	65	30.2	7	29.1	8	19.0	15	22.7

phases, the percentages of fish caught by gear at depths /21 not related whatsoever to moon phases and those caught

TABLE 6

Moon Phase	Depth (in metres)	Number of hooks	Number of specimens	Percentage
Waning Moon				
New Moon				
Crescent Moon		(See original)		
Full Moon				
Total				
Whole Moon cycle				
TOTAL				

by gear adjusted according to moon phases were determined. Results shown in Table 6 are in opposition to the generally held opinion among our fishermen of a possible vertical migration due to the amount of light in the waters, since the highest percentage per 100 hooks were always caught in the upper layer (0 to 100 meters), with no relation whatsoever to the moon phase. This indicates that the swordfish, contrary to public opinion, is not phototropically negative, at least to the moonlight and faint sunlight, as catches have been numerous at dawn. However, negative results, when submerging the drifting line during broad daylight, indicate that swordfish either reach lower depths when light intensifies or does not bite the bait placed at normal fishing levels. This is closer to results obtained on the North Atlantic by the use of fishing gear during the day or the night, because in this area swordfish is not caught during broad daylight.

DISTRIBUTION IN RELATION TO TEMPERATURE AND SALINITY

It has been suggested (personally) that the swordfish concentration at some levels is influenced by the water temperature of these areas; our results, however, contradict such assumption.

TABLE 7

Monthly Temperatures (in centigrades in the Fishing Area

Depth in meters	March 1962	April 1962	May 1962	June 1962	July 1962	August 1962
	Sept. 1962	Oct. 1962	Nov. 1962	Dec. 1962	Jan. 1963	March 1963

During the year in which this part of the /22
project continued, monthly sorties were made to determine hydrographic conditions concerning temperature and salinity of the fishing area, and we found an outstanding stability in these variable ratios during the whole year. Sorties results are shown in Table 7 and Figure 13 and the water temperature to catch ratio for the March to December period is shown in Figure 14.

March 1962	April 1962	May 1962	June 1962
July	August	September	October
November	December	January 1963	March 1963

Figure 13. Temperature to depth charts of the fishing area, during the March 1962 to March 1963 period.

Lines linking the isothermic points of 20,25 and 27 degrees centigrade at depths where they were found at each sortie were traced as well as the catching depth of swordfish caught by the fishing vessel hired for these months. As can be seen, there is no relation whatsoever between the vertical distribution of these animals and the water temperature, at least concerning temperatures over 20 degrees centigrade.

It can be said that the system used to find out the catching depth is not very accurate and frequent observations were made to verify the right level reached by hooks used in this type of gear. It has been tried, up to the maximum possible, to determine if the dropping line forms an angle with the vertical in days when the current is stronger, with negative results. It is true that the line must form a curve during fishing operations, specially at deeper levels but the fact of being a discontinuous and drifting gear in which each line is held by a small wooden buoy, must contribute to keep that curvature to a minimum and even if it exists the catching depth determination should be acceptable.

March April May June July August Sept. Oct. Nov. December

(See original text)

Figure 14. Isothermic lines of 20, 25 and 27 degrees C, during the period March to December, 1962, and catching depths of pilot vessel during same period.

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We have tried several times to get an echo by using a Fish Finder depth sounder model JRC, made in Japan, with negative results. Apparently the sound reflecting surface formed by the gear-bait-line complex is too small to create an echo, despite the fact that this type of equipment has a selector for different depths, adequate for our fishing levels.

After an analysis of methods used we arrived at the following conclusions. The swordfish presents in our water a well defined concentration area, the causes of which are unknown to us, although we have been able to eliminate some ambiguous facts which have been thought to cause this behaviour, such as temperature, moonlight, etc. which seem to have no noticeable influence on this distribution. Salinity, another factor which may have some influence on its behaviour, does not vary much in the fishing area, as it changed form a maximum of 35.25 per thousand at the surface to a minimum of 33.63 per thousand at a depth of 300 meters, during August; but the rest of the year the salinity did not go below 35.00 per thousand at that depth. In Figure 14 the isohaline were not determined because we were unable to find the slightest causality relation between this variable and the vertical distribution of the Emperador (swordfish) and its insertion would give a misleading effect in the graph.

MIGRATION

At the present time there are two theories about the swordfish population and its movements.

The most generally accepted one states that swordfish, at least Western Atlantic swordfish, form a group which migrate together at the end of each season and this theory is based on the apparent migration of swordfish from South to North in the Great Banks area at the end of the summer. The two large concentrations in this area and in waters near to Cuba during summer and winter can also help to support this theory.

The other theory maintains that the Atlantic swordfish do not form a single migratory group but form different population units (Gabrielson and LaMonte, 1950).

TABLE 8

Weight (kilograms) females and ovum of the swordfish (Xiphis gladius)

Date of Catch	Full weight of the animal	Weight of Ova
October - 1963	87.09	1.81
May - 1962	75.30	2.27
February - 1963	101.61	4.08
September - 1963	96.16	5.90
November - 1963	100.70	7.71
August - 1962	134.72	10.43
May - 1962	136.99	23.59

During the preparation of this work we have found several facts supporting the first theory, although it must be recognized that some facts are against the same. The following facts support the first theory:

a) The swordfish appear in the Great Banks waters at the beginning of summer and disappear in the fall, thus the fishing season starts in June and lasts till September.

b) Although the swordfish is caught in Cuban waters throughout the year, the maximum concentration occurs in winter, when the catch is larger than in the summer.

c) During the winter season, males and females are caught swimming in couples. The ova of the females

Catching areas of the Emperador (Xiphis gladius) in the Atlantic Ocean, the Gulf of Mexico and the Caribbean Sea.

Location of Emperor (Xiphias gladius) larvae in the Atlantic Ocean and Gulf of Mexico.

are very well developed, although in different stages (Table 8); ovules, averaging 0.60 mm. in diameter inside a 936 grams ovary, have never reached the spawning size which is attained in the Mediterranean.

d) Reports on swordfish catches, including the recent ones of the North American vessel "Delaware" in the Gulf Stream and the central North Atlantic, by long drifting line, and others shown in Plate II, could be a perfect expression of the migratory movement of this species considering the dates and locations of these catches. This species has a very extended population but of a very low density which makes its spawning trip against the general plan of the water circulation (Canaries stream, Gulf stream, Northern Equatorial and Bahamas stream).

e) Supplementing this theory, the location of swordfish larvae in the aforementioned areas (Plate III) indicates a spawning in the whole area which could be caused by the female migration passing through the Florida Strait, near our coast, with the females' ovaries in different stages of development.

f) This theory of the spawning migration from North to South would be stressed if the wounds and scars noticed on the tegument of adult specimens caught in Cuba would have been caused by some Cyclostomata species.

g) Fishermen with many years in the trade hold the opinion that swordfish, especially large specimens, always swim against the current, and their catch is influenced to a great extent by changes in current speed and direction. These changes can be caused by the displacement of the body of water of the Gulf Stream, approaching or receding

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from the Northern Coast of Cuba, possibly caused by winds or another nonidentified cause. When the Gulf Stream recedes from shore, it is replaced by a reverse current in the opposite direction which generally is very poor in swordfish and other large pelagic species.

To oppose this theory there is the fact that there is no evidence of any swordfish being caught having on it remains of harpoons or scars which could be assumed to be caused by this type of fishing gear, generally used in the Great Banks area. (Tibbo et al. 1961).

If these assumptions were certain, we would still have many unknown facts concerning this species, such as the origin of the specimens caught here, averaging 160 cm in length, which in view of their age have not reached the spawning stage and are aged at least over two years, judging by the growing rate data of those specimens from the Mediterranean. Another question still unanswered is precisely the growing rate of the species, and the answer would help to solve the great unknown fact about the swordfish (Emperador) whose life cycle is one of the most interesting problems at present raised in marine biology.

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FISHING ASPECTS

Swordfish fishing is done from small boats averaging 25 to 28 feet in length up to a maximum of 35 feet; powered by gasoline engines and more rarely by diesel engines; they are open boats without cabins which leave the harbour between 1800 and 2400 hours and return to it between 0900 and 1000 hours of the following day, depending on circumstances such as the strength of the current encountered, fishing gear used, etc. . Up to 1962 the fishing gear used was the creole drifting line, composed of independent sections having each one, three, four or five hooks and being held afloat by wooden buoys. The gear discontinuity prevented the use of a large number of hooks and the average number of hooks used by each boat was of about 48, or 12 sections of four hooks each. From that year on fishermen started using the long drift line, Japanese type, which, having from 4 to 6 miles of length, permits the use of over 200 hooks which undoubtedly increases catching chances.

Although the main catch of this gear during the winter months is the Emperador (swordfish), it is used in other months to catch other fish of commercial value, such as"marlin" (Makaira), White Spear Fish (Tetrapturas) and several types of sharks, of which the skin and fins are mainly used and also its flesh or meat in the case of the Dientuso (Isurus).

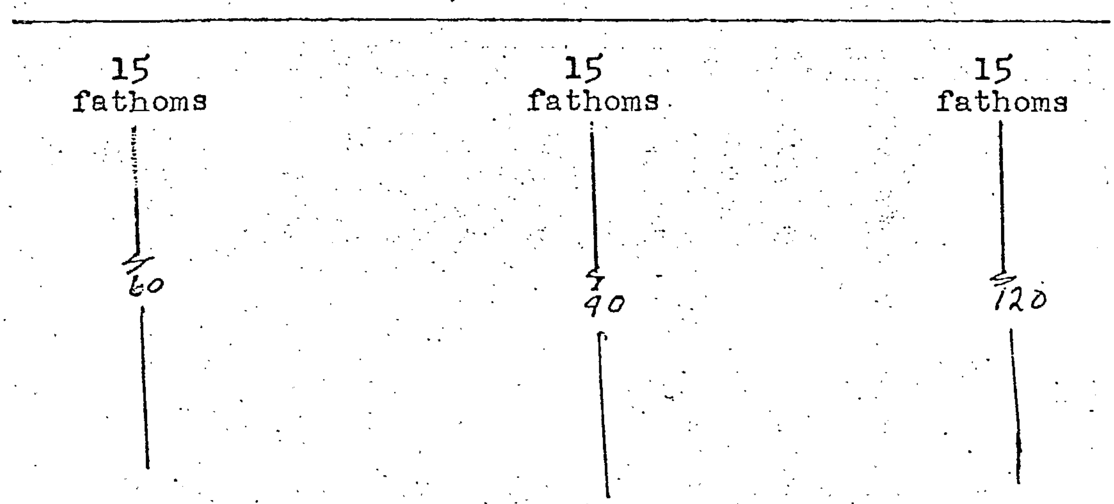

Figure 15. Creole drifting line, used on clear nights.

CREOLE DRIFTING LINE

This gear has traditionally been used by fishermen of pelagic fish in the waters of the Northern Coast of Havana Province.

It consists of a drifting gear formed by several independent sections (Fig. 15). Boats, depending on their sizes, can carry from 10 to 18 sections, each one composed of a main wooden buoy, a 50 cm. by 50 cm. board with caulked joints to make it watertight. Lately a similar board, made of wooden strips mounted on a light material, such as polyfoam or cork, has been used. (Fig. 16). This latter type has almost displaced the conventional board, because of its lightness and easy handling. It has a central perforation where a one-meter, more or less, mast with a pennant and bright light is placed. The main line, made from No. 300 cotton twine, is attached to the bottom surface of the buoy and every 15 yards it is connected to a simpler buoy, made of a light wood, such as cedar, oblong in shape which holds the gear. From each one of these small buoys, three or four for each main buoy, hangs a cord, normally No. 144 cotton twine, called "brazolada" (anchoring device (sic!) ending in a galvanized iron or stainless steel piece of wire, from which the hook hangs.

The bait, mainly Lisa (mugil) or Macabi (Albula), is carefully placed and tied to the shank of the hook in such a way that it is very difficult for it to get loose.

The Brazoladas (anchoring devices) hanging from each buoy are of a variable length, making it possible to fish at the desired depth.

As a rule, the coaming length is determined by the phases of the moon, in other words the catching depth depends on the lightness or darkness of the night; when there is more light the line is deeper than when there is less light and so the length is shortened when the moon is changing from full moon to waning moon and new moon. The deepest anchoring device normally in use is 120 fathoms in length, while the shortest one is 10 fathoms. As an example we should say that a typical section, composed of a board and three buoys, is equipped on a full moon night with 120 fathoms of coaming in the last buoy, 90 fathoms in the second and 60 fathoms in the closest one, while on a new moon night the last buoy has a 30-fathom coming, the second has a 20-fathom line and first has a 10-fathom line.

Figure 16. New board for drifting lines.

Fishing is done during the night, the boats /28
leaving the harbour at 1800 and 2100 hours. When they arrive in the chosen spot, from two to four miles off

the coast, they place their drifting lines perpendicular to the coastline. As sections are independent and are not affected to the same degree by currents and winds, they spread and must be taken in frequently. If a large specimen is caught by one of the sections it can immerse and momentarily sink the buoys in its flight and the bright light on top of the main buoy will be off. When the crew notices that the drifting line is missing, although it only remains underwater for a short period of time, the boat looks for the prey and works on it to put it on board. Sometimes the flight is not vertical but lateral or upwards and then a fast surface displacement of the drifting line is noticed, meaning that a specimen has been caught. The returning hour varies from 1100 to 1600 because when the day arrives fishermen wait outside the harbour for varied lengths of time, depending on the weather, roughness of the sea and number of fish caught. As the bait lasts in the ice-box of the boat for three or four days, it is usual to make sorties on several consecutive days, as many as the remaining bait and the weather permit and after a rest, more bait is prepared and then boats are ready for another fishing cycle.

When boats arrive at the Cooperative with their catch (Plate V-1), composed of Emperador (Xiphias gladius), White Spear-fish (Tetrapturus albidus), Black marlin (Makaira nigricans), Balck Spear-fish or Fan (Histiophorus Sp.) and several types of high sea sharks such as Alecrin (Galeocerdo cuvieri), Galano (Pterolamiops longimanus) Baboso (Eulamia floridana) Dientuso (Isurus oxyrinchus) and others, the catch is cleaned and weighed, except for the sharks (Plate V-2). The wastage of fish, after removing the head, tail, fins and internal organs, averaged at 30 per cent in a sample of 96 swordfishes, although as can be assumed this factor is not an accurate one because it depends to a large extent on the skill of the person doing the job. /29

LONG DRIFTING LINE (JAPANESE TYPE)

This gear, such as used in our waters to catch swordfish, spearfish, marlin and sharks has the same basic design as the conventional drifting line developed by the Japanese for tuna fishing although much shorter (Fig. 17). It is composed of a cotton cord No. 300 or similar synthetic fibre, called main line, held up by spherical glass buoys, traditional creole boards, 15 cm. plastic buoys tied up to the main line by cords, called "reinales" (twines). The main line is from 4 to 6 miles in length and from it hang 150 to 200 No. 12 hooks, joined by a 5 to 10 fathom comaing. The hook distribution, the length of the twines hanging from the buoy and the coaming length vary according to each fisherman's preferences. Almost all give a length of 5 to 10 fathoms to the twines hanging from the buoy so the main line can be submerged to this depth and be free from being cut by the propellers of vessels sailing over the drifting line. To facilitate the drifting line assembly, the main line is not continuous, but is divided into different sections which can be assembled when placing the gear.

Once the boat is on the chosen spot, more or less the same as when using the creole drifting line, the first buoy is placed in position and the boat is slowly driven

Placing the bait.

1. Boat arriving at the harbour with its catch.
2. Cleaning the fish at the cooperative.
3. Swordfish's head still hooked and cut by a shark.

Figure 17. Long drifting line, Japanese type.

in the desired direction. As the boat sails ahead slowly, the crew throws out the buoys, coaming, and main line until the whole gear is in position. This operation takes approximately two hours, depending of the drifting line length. Once the drifting line is in position, the buoy line is checked from time to time to verify if all buoys are afloat. If some of them are sunk, it means that a fish was caught and then this section is lifted, the fish caught and brought on board, and the section rearranged. This method is recommended as sharks frequently attack the hooked fish, seriously damaging it or even leaving only its head attached to the hood (Plate V-3). Generally speaking areas and hours are similar to those used for the creole drifting line.

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EXPERIMENTAL FISHING

COMPARATIVE ELEMENTS OF THE DRIFTING LINE

The Japanese type drifting line presents the following advantages over the Creole drifting line:

a) More hooks per area and, therefore, better chances of catching fish.

b) Better control of the fishing gear which does not spread itself over a large area.

c) More hooks in the most productive area.

It offers on the other hand the following disadvantages:

a) It requires more bait and therefore it is more expensive.

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b) It requires more work in placing and lifting the gear.

c) Its production cost is higher.

Analyzing these factors we arrive at the conclusion that the recommendation on its use must be governed by its yield. In order to make a rational comparison between both fishing gears, we decided to send out two boats, of the same size, equipped with the Creole drifting line and the other with the long drifting line, Japanese type, during the month of September, doing the same number of sorties and averaging similar fishing hours. Results of this test are shown in Table 9.

The boat equipped with the Creole drifting line caught 2,270 pounds of marlin and spearfish, 618 pounds of swordfish and 40 pounds of shark, with a total value on pier of 843.52 pesos, while the other boat caught 1,114 pounds of marlin and spearfish, 1,550 pounds of swordfish and 2,854 pounds of shark, with a total value on pier of 1,200.66 pesos.

The quantitative difference between the two gears is quite clear and it is mainly due to the larger number of hooks and larger area covered by the long drifting line. The qualitative difference is also clear, mainly in the different types of sharks and can be imputed to the different depth of the hooks, as previously seen, which are shallower in the case of the long drifting line. According to these facts, the long drifting line, Japanese type, yields more than the Creole type and, therefore, other considerations are incidental, and based on a higher cost and more work involved in its placing. Results prove its higher yield which compensates for its higher construction cost and also prevents the loss of one or more section, as frequently happens with the Creole type. Therefore, the wide use of this fishing gear is highly recommended.

TABLE 9

Comparison between catches by Creole and long drifting lines in 20 equivalent fishing sorties. (in pounds)

Sortie	Creole drifting line shark/Marlin-Spearfish/Swordfish	Long drifting line Shark/Marlin-spearfish/ Swordfish
Total		

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TABLE 10

Operating costs of the pilot boat from April to October, 1962
Total cost 908.03 pesos

Period of time	Gasoline	Oil	Bait	Ice
April 13-May 6	$ 24.90	$ 1.38	$ 28.77	$ 3.02
May 7-June 5	49.35	1.71	59.93	5.03
June 6-July 7	68.85	2.90	103.36	8.01
July 11-September 18	82.43	3.04	234.07	15.10
September 19-October 25	65.27	1.52	139.18	10.21
TOTAL	$ 290.80	$ 10.55	$565.31	$41.37

ECONOMIC ANALYSIS OF THE PILOT BOAT

As we were unable to get information on the operating cost of a cooperative fishing fleet we refer in this part of the paper to the cost incurred by the boat especially hired to do this research from April to September which, although it is not the best fishing season for swordfish, can be a good example for this type of fishing, if we consider that other species such as the marlin and the spearfish caught in summer have a similar economic value as the swordfish. Table 10 shows fishing expenses and Table 11 shows the result in the same period of time and actual fishing days.

From the study of this information we have reached the conclusion that the daily cost of a boat equipped with a drifting line is 9.26 pesos divided in the following percentages: gasoline 32.03%; bait 62.33%; oil 1.08% and ice 4.54%. The largest cost item is the bait because of the large number of hooks used.

During the same period 206 specimens were caught, divided in the following way: swordfish 47; marlin and speafish 100; shark 57, weighing a total of 19,299 pounds and having a value on pier of 5,033.53 pesos.

TABLE 11

Pilot boat catch from April to October 1962

Month	Fishing days	Swordfish Specimens	Swordfish weight (lbs)	Marlin-spearfish Specimens	Marlin-spearfish weight (lbs)	Shark Specimens	Shark weight (lbs)
April	8	5	874	2	410	4	181
May	14	14	2,187	17	1,140	15	642
June	18	-	-	28	2,032	16	1,099
July	8	-	-	17	1,244	4	242
August	12	9	1,010	4	564	5	370
September	20	6	618	19	2,379	2	140
October	18	13	1,147	13	1,475	11	1,663
TOTAL	98	47	5,836	100	9,226	57	4,237

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The net profit attained by the boat crew during this period of time was of 4,095.50 pesos, showing an average net profit per sortie of 41.79 pesos. These figures do not include maintenance expenses and depreciation of the boat, as well as boat outfit expenses.

NEW DESIGN DRIFTING LINE

As a result of the study of the vertical distribution, a long drifting line, covering adequately the most productive levels, was designed. It is adaptable to all types of vessels as it is made of equal sections of 100 fathoms each. The total length of the gear will vary depending on the number of sections used and will accommodate boats of any size.

In brief, each section is composed of the main line (100 fathom long) from which hang four twines placed 25 feet apart. The first, second and fourth are 5 fathom long and the third is 25 fathom long. In this way, when the main line forms an arch in the water the four hooks of each section reach an approximate depth of 10, 20, 45 and 20 fathoms respectively. Each section end is connected to a buoy or board, equipped with a mast and pennant, by a 5-fathom tip (rod). Each drifting line head is equipped with a bright light to determine the beginning and end of the fishing gear. The first and last hooks which hang from the buoys have a 120-fathom anchoring device to prevent the tendency of buoys to close together by the pulling down effect of the main line's weight.

EXPERIMENTAL FISHING

Results appearing in Table 12 were obtained during the experimental fishing sorties performed to study the possibilities of enlarging the present fishing area. From these results we have arrived at the conclusion that West of the present fishing the fishing yield is very high and also that it is advisable to change the present system of daily sorties and arrivals by another by which boats could remain in the area for a longer number of days in order to enlarge the fishing area and keep the fishing gear immersed for a longer period of time. This is obvious if we compare the economic results of the aforementioned fishing campaigns in which 843,52 pesos were attained in 20 days by using the Creole drifting line, and 1.200.66 pesos by using the long drifting line during the same time, while in six days of fishing in the new area the economic results amounted to 1.753.33 pesos. This means that presently used vessels, because of their specifications, cannot be used with this new method as vessels of a larger capacity having navigational, storage and comfort facilities for four or five day cruises are needed. According to the experience gathered during these fishing trips, the type of vessel to be used must have these minimum specifications: length, about 40 feet; sufficient free space on the stern deck to mount a capstan and to handle a six to eight mile long drifting line; a 10 cubic meter freezer; facilities for four or five crew members; fuel-oil engine; radio-telephone and 400 mile range.

TABLE 12

Three experimental fishing trips using long drifting lines during March and April, 1963, with a total catch of 9.575 lbs.

Fishing Area (Pinar del Rio-Havana)	Hours of actual fishing	Sharks		Swordfish, marlin and spearfish	
		Spec.	Weight	Sepc.	Weight
March 13 to 18 trip (3 days used in looking for bait)					
Punta Governadora-Santa Fe	16.54	7	2,021	6	649
Punta Governadora-Santa Fe	10.54	6	915	6	269
TOTAL	27.48	13	2,936	12	918
March 24-29 trip (3 days used in looking for bait)					
Puerto Esperanza-Santa Fe	18.45	8	2,219	4	445
Puerto Esperanza-Santa Fe	19.45	4	1,112	4	354
TOTAL	38.30	12	3,331	8	799
April 10 to 14 (2 days used in looking for bait)					
Cabanas-Santa Fe	18.40	4	718	1	70
Cabanas-Santa Fe	20.10	3	293	2	510
TOTAL	38.50	7	1011	3	580
GENERAL TOTAL	105.08	32	7,278	23	2,297

SUMMARY AND RECOMMENDATIONS

1. Among the different types of short range fisheries carried out in Cuba, one of the most productive is that of the swordfish, whose life cycle still constitutes an enigma.

2. In the swordfish growth three stages can be clearly distinguished: larvae, youth and adulthood. The size of a swordfish when it passes from larvae to the youth to the youth stage is from 30.5 cm. to 111.8 cm, and from/11.8 cm to 137.2 cm when it passes from youth to adult.

3. During this experimental fishing we caught a larva of 7.60 mm. on the surface, to the North of Cabana, Pinar del Rio Province.

4. Adding the information obtained during this study to that previously known about the location of swordfish larvae we can reach the conclusion that the actual swordfish spawning area is much larger than it was believed to be, as it spreads from Florida in the West, to Casablanca (Africa) in the East, surrounding the South of Cuba and the Equatorial Atlantic Ocean coinciding with the general circulation pattern of the currents of that area. This contradicts the theory that the waters of the Northern part of Cuba could be one of the main swordfish spawning areas.

5. The swordfish has pelagic habits although sometimes it enters the insular platform in search of food. Its main dietary source is the Brama brama fish, followed by cephalopoda and, on a smaller scale, crustaceans.

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6. The swordfish is a habitual host to a large number of parasites of different species. Its stomach is always full of parasites such as nematelminthelminthes, platyhelminthes and annelida. Occasionally a copepod of the Pennella genus can be found externally which deeply penetrates the subcutaneous muscular tissue of the fish. Besides being host to remoras, the swordfish frequently has oblong wounds, assumed to be caused by a Cyclostoma species. If this assumption were true, it would prove the possible migration of the swordfish from the cold waters of the Northern Atlantic to our waters, as these cyclostoma species do not live in our latitude.

7. From the study of the population by size, it can be inferred that the swordfish population in our waters average 160 cm. and it is mainly composed of young adults, although from time to time some specimens of 200 cm. in length have been caught.

8. There are two well differentiated swordfish fishing seasons: winter and summer. In summer the catch is limited, while in winter, specially from December to March, the largest part of the annual intake is caught, mainly because of the abundance of swordfish.

9. The swordfish population distribution by sex is different to that observed in other latitudes. In our fisheries both sexes were present, although the male population was much bigger than the female population and it was found out that the average size of the female is larger than that of the male. Therefore, the swordfish population in our waters is composed of a large majority of young

males and a few large adults and a more limited number of females, sometimes of a very large size. This distribution remains more or less invariable in both fishing seasons.

10. The swordfish population in our water offers, as a whole, a 1.315 K factor which evidence, given its high relative value, a voluminous soma. Differentiating by sexes, we get a value of 1.450 for females and 1.270 for males. In general, a progressive increase in value of K factor for both sexes is noticed. Taking into consideration both fishing seasons, a great similarity in male and female averages is noticed; 1.463 in winter and 1.431 in summer for females and 1.269 in winter and 1.270 in summer for males. Another indication of the constancy of the K factor value is the degree of utilization of its environment which does not show periodical oscillations in our waters as happens in higher latitudes, where differences between season are very noticeable.

11. Considering the population as a whole, the swordfish follows a well defined vertical distribution in our waters, as it prefers the zone between the surface and a depth of 200 meters the maximum concentration of specimens being in the first 100 meters of depth, with no distribution patterns by males, females or sizes.

12. Experiments performed show that the swordfish, against general belief, has no negative phototropism, at least to moonlight, since the highest catch percentages always happened in the upper layer (0 to 100), with no relation whatsoever to moon phases.

13. Results of this study contradict the assumption that the swordfish concentration in certain levels is influenced

by water salinity or temperature.

14. During the course of this study several facts appeared supporting the theory that the eastern Atlantic swordfish population forms a sole community which migrates according to seasons.

15. The Creole drifting line was the fishing gear traditionally used in Cuba. The long drifting line, Japanese type, has been recently introduced. Although the main catch of this fishing gear is the swordfish, during the winter campaign, other varieties such as marlin, spearfish and shark were caught during the year.

16. The analysis of experimental fishing results, using both drifting lines, shows the great superiority of the long drifting line over the creole type, so that the use of the first is highly recommended.

17. A drawback found in this type of fishing is the short life of cotton lines. This difficulty could be overcome by using synthetic fibre *, such as "Dederon" or by trying more effective ways of lines preservation. Another inconvenience is the high cost of the bait used. Therefore, it is recommended to study the possibility of using artificial bait, substituting totally or partially the natural bait.

18. As a result of the swordfish vertical distribution study, a long drifting line, adequately covering the most productive levels and suitable for any size of vessel, was developed.

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* The single thread "Nylon" is not recommended because of its entangling tendency.

19. Results of the experimental fishing campaign not only show that areas West of the presently used fishing area are highly productive, but that it is recommended to change the present fishing method with its daily sorties and arrivals, by another of longer days at sea in order to cover a larger area and keep the fishing gear in the water for a longer period of time.

20. Taking into consideration the possibility of extending the fishing area, we can say that the vessels presently used are not fit for the proposed fishing method as it requires bigger boats, with storage, navigational and comfort facilities to cruise during four or five days. We must point out that the Cardenas type boat, now built in our country, meets these requiresment. A boat having these specifications can fish at any point of the area between San Antonio Cape in the West to Varadero in the East, processing and keeping the catch until its delivery at any harbour of the area, for its final distribution or storage.

21. We must continue our research to obtain more information on swordfish growth. This will include the intensive tagging of larvae and young specimens, the study of their age, by the hard parts of the body and the macroscopic and microscopic analysis of sexual organs.
