DISTRIBUTION, FISHERIES AND LIFE HISTORY DATA RELEVANT TO IDENTIFICATION OF ATLANTIC BLUEFIN TUNA STOCKS *

by

F. J. Mather[1], J. M. Mason[1] & A. C. Jones[2]

[1] Woods Hole Oceanographic Institution
[2] National Marine Fisheries Service

* Most of the tables and figures have been omitted here but appear in Data Record, Vol. 3. Chapters 1-6 have been omitted in accordance with the authors' instructions.

La plupart des tableaux et des figures ont été omis, mais ils sont inclus dans le Vol. 3 du Recueil des Données Statistiques. Les Chapitres 1-6 ont été omis suivant les instructions des auteurs.

La mayoría de los cuadros y figuras se han omitido, pero se incluyen en el Vol. 3 de la Colección de Datos Estadísticos. Los Capítulos 1-6 no figuran, por deseo de los autores.

VII SUMMARY

The available historical size composition data for various fisheries are tabulated by years in terms of length frequencies (5 cm groups) and plotted in terms of three size groups (small, 2.5-32 kg; medium 70-270 kg; and large or giant, more than 270 kg).

A table of size for age data is presented.

The bluefin tuna ranges over most of the Atlantic from lat. 40° to lat. 55° (W. Atlantic) - 75° (E. Atlantic) N., and adjacent temperate and tropical seas. Its distribution varies seasonally, and with size of fish.

Fisheries for bluefin tuna did not change drastically until after 1945. Until then, the most productive fisheries were traps and hook and line and centered in the Mediterranean and the eastern North Atlantic. The area and intensity of fishing have subsequently been greatly increased through the introduction of the live bait, purse seine, and longline methods, and improvements in vessels and gear used in some of the older types of fisheries. The use of new and improved methods caused temporary increases in catches, usually followed by considerable declines.

Canadian sport fisheries for bluefin tuna exist in Nova Scotia, Prince Edward Island, and Newfoundland. The season extends from July into October. Medium-sized bluefin were important in the catches in some years prior to 1964. Catches in subsequent years have consisted of giants, with increasing modal sizes. The production of the Nova Scotia fishery has been poor for several years. The Newfoundland fishery peaked in 1968 and 1969 and has since declined considerably. The new fishery at Prince Edward Island has maintained good catches of extremely large fish, partly through increased effort.

Bluefin tuna are taken by mixed gears (handline, harpoon, seine, trap, and rod and reel) off the U.S. coast from Cape Cod to Maine. The season here also extends from July into October. In the period 1947-1964, smaller or medium-sized bluefin dominated the catches in several years. Starting in 1965, however, the catches have consisted mainly of giants and their modal size has generally been increasing. It is very difficult to assess this fishery. Sport fishing success for giant bluefin was very high in 1971 and 1972, but declined considerably in 1973. On the other hand, small bluefin have virtually disappeared from the landings, and catches of medium-sized fish have been sporadic.

The smaller bluefin (small and some medium-sized) are fished extensively from Cape Hatteras to Cape Cod during the warm season by purse seine and sport fishing gear. It is very difficult to assess the sport fishery, but it has declined greatly since the advent of the seine fishery in 1962. Seine catches increased to a maximum of 5,600 tons of bluefin and 5,000 tons of skipjack, Katsuwonus pelamis, in 1964. Subsequent bluefin catches have varied from one eighth to one half of this figure except in 1970 and 1971, when 4,200 and 3,600 tons were taken. Catch per unit of effort has not varied proportionately, perhaps because of the increased efficiency of the New England based boats and the absence of boats from other areas except in years of abundance.

Giant tuna are taken in a seasonal sport fishery off the northwestern Bahamas (Straits of Florida) in May and June. No fish in the smaller size groups have been taken. Meager data indicate that the average size of the fish taken has increased notably in recent years, while the numbers of fish taken in the tournaments have declined. Longline fisheries of several nations collectively fish nearly all of the tropical and temperate oceanic waters of the Atlantic. The only adequate catch and effort data available,

however, are for the Japanese fishery. The largest bluefin tuna catches (22,000 - 67,000 fish per year) were taken in the years 1962-66, with the highest catch rates occurring off the easternmost part of Brazil and in the western North Atlantic. In each important fishery area, the catch rates increased rapidly for three or four years to peaks of 3 or 4 fish per thousand hooks then fell within one or two years to less than one fish per thousand hooks. Sparse data indicate that most of the fish taken were large, and the remainder were of medium-size. More extensive data on United States longline catches in the western North Atlantic show that all fish taken south of lat. 35° N were giants, whereas those taken north of that latitude were of mixed sizes. Medium sized fish predominated in most of the years from 1956 through 1964, but giants were most important in the last years for which there are data, 1965-1967.

Following the introduction of the purse seine method in Norwegian waters in the late 1940's, the yearly catch of bluefin tuna increased from a few hundred tons to about 10,000 tons in 1951-55. The catches have recently declined greatly; only 300 fish were taken in 1972, and only 100 in 1973. In the 1950's, the fishery utilized an early run of very large fish which migrated northward along the coast from near lat. 62°N, and one or two later runs of smaller fish, including many of medium size, which migrated southward along the coast from the same area. Since 1962, the runs of smaller fish virtually ceased, and the larger individuals switched from their northward migratory pattern to the southerly one previously followed by the smaller fish. No size data are available for the peak years of the fishery - 1951-55. Medium-sized bluefin were very important in the catches of 1956-58, but gradually disappeared in the period 1959-61 due to lack of recruitment. Catches in subsequent years have consisted entirely of giant fish, with the modal length increasing to 250 cm in 1971.

German and Danish handline fisheries in the North Sea and in Scandinavian waters took from 1,000 to 2,000 tons of bluefin in some years, but since 1962 the former has been defunct and the latter insignificant. Both of these fisheries were for giant bluefin. The German fishery took very large fish in its final years (1960-62), and the sizes of fish taken in the Danish fisheries have increased considerably over the past few years.

Following its conversion from the trolling to the live-bait method in 1949, the catches of the French-Spanish fishery for small bluefin in the Bay of Biscay increased rapidly to over 5,500 tons in 1955. Subsequently, the catches decreased to 1,000 tons in 1960, and have only once, in 1966, substantially exceeded 2,000 tons. Little data on the size composition of the catches beyond a division into tons of fish over or under 30 kg, are available. About 90 percent of the fish caught each year usually weigh less than 30 kg. The few available size samples indicate that fish of age II are often most important, followed by ages III and I and some older ages.

Small bluefin are also taken off the west coast of Portugal and Morocco. The Portugese catches are small, and evidently consist of one- and two-year old fish. The Moroccan catches are more numerous, and evidently include considerable numbers of age 0 fish, as well as older ones. The yearly catches averaged about 2,000 tons in 1963-67, but were less than 1,000 tons in 1969-72.

Spanish, Portuguese and Moroccan trap fisheries have harvested bluefin of various sizes in spring and early summer in the Ibero-Morroccan Bay, west of Gibraltar. These traps were very productive, with total annual catches as high as 100,000 fish weighing over 13,000 tons in the 1950's. The fisheries have declined rapidly since 1962. Total catches of the few surviving traps

were less than 1,000 fish in 1972 and only about 2,000 in 1973. The traps nearest to Gibraltar take the fewest small bluefin and produce the highest average weights, with the Portuguese traps taking more medium-sized and small bluefin than the others. The size composition of the Portuguese traps has been variable, with large bluefin predominant in most years, but sometimes exceeded in numbers by small or medium-sized ones. The Spanish fisheries have been dominated by the large fish since 1962, with few medium sized fish and hardly any small ones. No detailed size data for the Moroccan catches are available, but their average weights have usually exceeded those of the Spanish catches.

Moderate catches of bluefin tuna are taken with various gears along the Mediterranean coasts of Spain, France and Morocco. Age 0 bluefin are especially abundant along the coasts of Morocco and southeastern Spain. Large bluefin are taken in traps near Gibraltar and by hook and line off the mouth of the Rhone. Elsewhere along the French coast the catches consist mainly of fish of ages I-IV. An ancient trap fishery on the coast of Provence has disappeared.

Trap fisheries in the central Mediterranean - off mainland Italy, Sicily, Sardinia, Tunisia, and Libya - were formerly productive, but have evidently suffered a sudden decline. Very few of the once numerous traps are still in operation, and these are producing only fractions of their previous catches. Total yearly catches of the Italian traps which varied between 1,700 and 7,500 tons in 1896-1914, were only about 600 tons in 1972 and even less in 1973. Sidi Daoud in Tunisia, formerly the most productive trap in the Mediterranean, with an average catch of about 8,000 fish per year for 1863-1923 reportedly took only 100 fish in 1972. The recent trend in the Italian catches has been toward exceptionally large fish, with one haul of 111 fish having an average weight of 470 kg.

Small tuna are taken by purse seine in many parts of the central and western Mediterranean, including the Adriatic and Tyrhennian Seas. Large quantities of age 0 bluefin are reportedly taken in some areas. There is little information on the tonnage and size composition of the seine catches.

Bluefin tuna of various sizes are taken by traps, handlines, and harpoons in the vicinity of Istanbul, Turkey. Most of the bluefin recorded have been giants, some of which were extremely large. Scattered records indicate that sales of bluefin tuna in the Istanbul market have varied from 15 to 764 tons per year.

Small bluefin tuna range over most of the eastern Mediterranean, except its southeastern corner, but no important fisheries for them exist.

Trap fisheries along the coast of Libya have produced up to 2,000 tons of bluefin per year, but there is little detailed information on recent catches. Total bluefin tuna catches for Libya for 1964-71 varied from 300 to 800 tons.

Bluefin tuna spawn fractionally, and fully ripe individuals are rarely caught. The eggs cannot be positively identified except by hatching them and raising the larvae to a recognizable size. Bluefin larvae and small juveniles have been collected in many parts of the Mediterranean and Black Seas, especially around Sicily. They have also been collected off the Bahamas, in the Gulf of Mexico, and off the United States coast from Florida to New York. Studies of gonad condition indicate that bluefin spawn in these areas, and also in the Ibero-Moroccan Bay and, possibly, in the Bay of Biscay. Spawning in the latter two areas has not, however, been confirmed by collections of larvae and small juveniles. Possibly the products of spawning in the Ibero-Moroccan Bay are carried into the Mediterranean by the surface currents, or the adult bluefin

which pass in and out of the Bay at the spawning season actually enter the Mediterranean to spawn and then return to the Atlantic. Spawning in the Mediterranean begins in mid-June and extends to the end of July or later. Spawning in the western Atlantic probably occurs earlier, with the larger individuals probably spawning near the Bahamas in May and early June, and the medium-sized ones spawning further north somewhat later.

Studies of the migrations of bluefin tuna have been based on analyses of observed distribution patterns, morphological and genetic studies, and tag returns.

The principal wintering areas for giant bluefin tuna in the western North Atlantic are off eastern most Brazil and around the Greater Antilles and in the Gulf of Mexico. Many of these fish migrate northward through the Straits of Florida and east of the Bahamas in May and June. Their usual destination probably is the summer feeding area off northeastern North America, but in some years considerable contingents cross the Atlantic to Norwegian waters.

Medium-sized bluefin tuna in the western North Atlantic evidently winter between the edges of the continental shelf and the Gulf Stream north of lat 35°N, and spend the warm season on feeding grounds on the continental shelf from Cape Hatteras to Nova Scotia. They tend to move northeastward within this area as the season advances.

The wintering grounds of small bluefin in the western Atlantic are not known. These fish concentrate on the continental shelf from Cape Hatteras to Cape Cod, and on some of the offshore banks, in the warm season. They also tend to move in a northeasterly direction within this area during the season. In some years, contingents of these fish have migrated across the Atlantic to the Bay of Biscay.

No wintering areas of the larger bluefin in the eastern Atlantic are known. Many small, and some medium-sized, ones winter off the coast of Morocco. Some of these migrate in spring to the Bay of Biscay or the Ibero-Moroccan Bay. Others evidently remain off the Moroccan coast. In May and June, numerous maturing bluefin of all sizes, but chiefly large ones, enter the Ibero-Moroccan Bay traveling eastward. An undetermined portion of these enter the Mediterranean. In July and August, most of these fish depart from the Ibero-Moroccan Bay in a spent condition, traveling westward. Evidently many of the larger individuals go to Scandinavian waters, and many of the smaller ones, along with others from Morocco, go to the Bay of Biscay. The fish remain in these areas through the balance of the summer and the early fall. Some small bluefin have migrated from Iberian waters to the northwestern Atlantic during the cold season.

The situation in the Mediterranean is complex, and is probably complicated by the seasonal immigration and emigration of large spawners from the Atlantic. As in the Ibero-Moroccan Bay, there are eastward migrations of ripening fish in the central Mediterranean (Sardinia, Sicily, southwestern Italy, Tunisia and Libya) in May and June, and westward migrations of spent fish in July and August. Bluefin of many sizes occur in these spawning migrations, but the majority are usually large. There are winter fisheries for bluefin, mostly of small or medium size, in several areas, in addition to warm season fisheries for bluefin of all sizes. There is little positive knowledge of migrations within the Mediterranean.

Considerable evidence supports a theory that bluefin weighing over 100 kg tend to enter the Mediterranean for spawning but spend the rest of the year in the Atlantic, whereas smaller individuals spend the entire year in one habitat or the other.

There are strong indications that the migratory patterns of bluefin tuna are subject to changes which cannot be predicted.

VIII. DISCUSSION AND CONCLUSIONS

Introduction

Although much information is available, many important questions about various aspects of the biology of the bluefin tuna remain unanswered.

Distribution

The year-around distribution of the species is not completely known. Although there are extensive coastal fisheries for bluefin tuna in the eastern North Atlantic and the Mediterranean during the warm season, little is known of its distribution in those waters during the cold season. There are coastal winter fisheries for bluefin off southern France, Sicily, Tunisia, and Algeria, and in the Bosphorus. Most of these depend mainly on small to medium-sized fish, although large individuals are also taken, especially in Turkish waters. The only considerable coastal winter fishery for bluefin in the eastern Atlantic is off Morocco. Extensive longline fishing in eastern North Atlantic and Mediterranean waters during the cold season should greatly increase our knowledge of the year around distribution of the species in those areas.

It also seems remarkable that, although longline records indicate that the bluefin is widely distributed in the Atlantic down to latitude 20°S, and it has been recorded as far south as latitude 40°S, there are no important coastal fisheries for it south of latitude 20°N.

Spawning

There is much to be learned about the spawning of the bluefin tuna. One very important and hotly-debated question is whether the bluefin which support the trap fisheries in the Ibero-Moroccan Bay actually spawn in that area, or enter the Mediterranean, spawn there, and return to the Atlantic almost immediately. As noted previously, studies of the gonad condition of fish caught in the Ibero -Morrocan Bay and in the Mediterranean indicate that spawning takes place between the "arrival" run in May and June, and the "return" run in July and August. No larvae or small juveniles (less than 10 cm long) have been collected in the Ibero-Moroccan Bay or nearby Atlantic waters, but they are very abundant in parts of the western and central Mediterranean. Possibly these bluefin actually spawn in the Ibero-Moroccan Bay but the products are transported into the Mediterranean by the surface current before they become fully mobile. On the other hand, evidence of migrations of adult bluefin from the Ibero-Moroccan Bay into the Mediterranean in this period has been presented. Sarà (1963) proposed the hypothesis that large (over 100 kg) bluefin migrate from the eastern Atlantic into the Mediterranean to spawn, and then return to the eastern Atlantic, while the smaller mature bluefin spawn in whichever of these bodies of water they inhabit. This theory fits well with many of the available facts. In any case, there can be no doubt that large numbers of bluefin tuna from the eastern Atlantic

concentrate in the Ibero-Moroccan Bay in May-June, spawn either there or in the Mediterranean near the end of June, and return to eastern Atlantic waters in July-August.

The central Mediterranean is well established as a prime spawning area for bluefin tuna, but the proportions of "native" Mediterranean fish and "transient" Atlantic fish among those spawning there remain in doubt. Much less is known about actual or suggested spawning areas in the Black Sea, the western Mediterranean, the Bay of Biscay, and equatorial waters south of Sierra Leone.

In the western Atlantic, the prime spawning area, as determined by collections of larvae and small juveniles, is in the Straits of Florida. Additional larvae and small juveniles have been collected in the Gulf of Mexico, and off the United States coast from Florida to New Jersey. Ripe or nearly ripe bluefin have been found in most of these areas, and also in the northern Caribbean and east of the Bahamas. Since bluefin between 50 and 185 cm long have rarely been found in North Atlantic waters south of latitude 35°N and west of longitude 60°W, most of the spawning in the areas mentioned is almost certainly by large or "giant" bluefin. The extent of this spawning area has not been positively defined, since collecting effort has not been uniformly distributed over the Atlantic.

There are less numerous indications of a secondary spawning area in the western North Atlantic at the northern edge of the Gulf Stream east of the Middle Atlantic States. This area is frequented mainly by medium (120-185 cm) sized bluefin, and most of the ripe or nearly ripe fish captured there have been in this size range. More information on the spawning of these medium-sized bluefin is urgently needed.

The age at which bluefin tuna first spawn, and their variations in fecundity with size and age, are two other important elements which are not known with certainty.

Some writers have reported that eastern Atlantic and Mediterranean tunas first spawn in their fourth, or, sometimes in their third, year of life. Sarà (1963), however, reported that the youngest mature bluefin that he had examined was in its fifth year. No information on this subject has been published for western Atlantic bluefin. The senior author has observed virtually no signs of maturity in 3-year-old fish in the western Atlantic, and only slight signs in 4 and 5-year-old fish.

Frade (1950) calculated that a ripe female weighing 160 kg had 9,360,000 eggs in her ovaries, which weighed 7.8 kg. Rodríguez-Roda (1964a) showed that the ratio of gonad weight to body weight for ripening bluefin was generally greater for large bluefin than for small ones. More exact knowledge in these areas is most important for proper management of the species.

We have found no indications of spawning of bluefin tuna in the South Atlantic.

Migrations

Although thousands of bluefin tuna have been marked in several areas and about 2,500 of these tags have been returned, much remains to be learned about the distributional and migratory patterns of the species. Returns have generally been concentrated in relatively small areas of intensive fishing, and migratory patterns appear to vary from year to year. The latter effect has also been deduced from studies of the size composition of yearly landings in various areas (Hamre et al., 1966; 1968; 1971).

Among the migration problems to be solved are the following:

1. Determination of the processes of recruitment of new-born bluefin into the small fish fisheries, and of recruitment from the small fish fisheries to those for large bluefin.

2. Determination of rates of interchange of fish between the eastern and western Atlantic, between the Atlantic and the Mediterranean, and between various fishing areas within all these water masses.

3. Determination of migratory patterns of the groups of tunas supporting the different fisheries, and their variations with age of fish and from year to year.

4. Identification of the existing stock (or stocks) of bluefin tuna, and delineation of its (or their) habitat.

Perhaps the most important missing link in the known distributional cycle of the bluefin is the process by which age 0 fish are recruited to the small fish fisheries, which, in waters north of latitude 35°N at least, harvest fish one year old and older. Evidently recruitment of bluefin to the Bay of Biscay and northwestern Atlantic small fish fisheries usually occurs at age I or age II. Off Sicily, Morocco, and eastern Spain, however, age 0 fish are apparently vulnerable to capture in quantity.

Age 0 bluefin are abundant in late summer and fall off the east coast of Spain, and the Mediterranean and Atlantic coasts of Morocco. Tagging of numbers of these fish, which should not be difficult to accomplish, might solve important problems. One of these is the question of which fisheries, Mediterranean or Atlantic, these age 0 fish in various areas eventually recruit to.

Age 0 bluefin are much less available in the western North Atlantic, but it is most important to mark them there also. Age 0 bluefin are sometimes observed in numbers in the Straits of Florida, and, less frequently, in the Gulf of Mexico and along the U.S. coast from Florida to Cape Hatteras. These are presumably the fish which were spawned in the previous spring by the giant bluefin in the southern spawning areas described above. It is also presumed that they are recruited to the small fish fishery between Cape Hatteras and Cape Cod when they attain ages of I or II years.

Although this assumption is reasonable, it is most important to confirm it by tag returns.

Age 0 bluefin also occur occasionally off the U.S. coast from Cape Hatteras to Cape Cod in late summer and early fall. It is uncertain whether these are recruited from the southern area where the giant bluefin spawn, from the more northern area where the medium-sized fish apparently spawn, or from both areas. Marking them, however, would lead to further knowledge of the life history of the species, and espeically of the recruitment to the small fish fisheries.

Tagging of age 0 fish might also contribute importantly to our knowledge of transatlantic mixing. The most numerous transatlantic migrants, as indicated by tag returns, were I or II years old when tagged. Age 0 bluefin tuna have crossed the Pacific (Clemens and Flittner, 1969).

A few age 0 bluefin have been tagged in the Atlantic and in the Mediterranean. No returns have been obtained in the former area, and only a few in the latter. Large scale tagging of bluefin of this age would be a most promising undertaking.

Sustained tagging of small (2.5-32 kg) bluefin in the northwestern Atlantic, and sporadic tagging in the Bay of Biscay and off the western Iberian coast, have produced interesting but limited results. Sustained tagging in both areas is needed to monitor transatlantic mixing, which apparently varies from year to year, the effects of fisheries on the stocks, and the recruitment from the small fish into the large fish fisheries. Sustained tagging of small bluefin must also be extended to the small fish fisheries off the Atlantic coast of Morocco and in the Mediterranean to gain a full understanding of the stock structure of the bluefin in the Atlantic and adjacent seas.

The tagging of large bluefin is more difficult, but is essential to attaining full knowledge of the migrations and stock structure of the species. Large bluefin marked in the Straits of Florida have been recaptured in the western North Atlantic, western South Atlantic, and Norwegian waters. Large individuals tagged off Norway have been recaptured off southern Spain, and others tagged in the latter area have been recaptured in the Mediterranean, and off Morocco and Portugal in the Atlantic.

These results, and collateral data, suggest that important numbers of large bluefin tuna are recruited from the western to the eastern North Atlantic in some years, but not in others, and that the fisheries off Norway and off southern Spain depend, at least partially, on the same stock in some, but not all, years. They have also shown movements of a bluefin tuna from the Atlantic into the Mediterranean, with indications that some of the fish were returning to the Atlantic when recaptured.

Problems such as rates of mixing between the Atlantic and the Mediterranean, and between the eastern and western Atlantic remain largely unsolved. There is also little information on the migrations between the western parts of the North and South Atlantic. Even the generally assumed migration of giant bluefin from the Straits of Florida to New England and Canadian coastal waters has not been definitely established.

Unfortunately, the collapse of the eastern Atlantic fisheries has precluded the tagging of any giant tuna there since 1967, and the extremely high prices offered for large bluefin in the northwestern Atlantic have made tagging there extremely difficult.

The migratory patterns of bluefin tuna appear to be subject to unpredictable changes. One such change occurred in the Norwegian and North Sea fisheries in the early 1960's. Throughout the 1950's the Norwegian fishery consisted basically of two runs of fish, both of which arrived off the coast at about latitude 62°N. The first run, of very large fish, migrated northward along the Norwegian coast, and then apparently went south into the North Sea, where it supported the German fishery. The second run, of smaller fish, travelled southward along the Norwegian coast, sometimes entering the Skagerrack. After these smaller fish disappeared from the Norwegian fisheries in 1962, the larger individuals changed over to the migration route previously followed by the smaller ones. Consequently, the fisheries off northern Norway and in the North Sea collapsed completely.

Changes in the migratory patterns of the bluefin taken off Norway and off southern Spain were indicated by changes in the size composition of the catches. In 1955-60, the size compositions of the Norwegian and Spanish catches were quite similar, but in 1961-64, they were quite different. In 1965, they were similar again. Hamre et al. (1968) attributed these changes to a sub-division of the northeast Atlantic tuna population into two contingents with different migratory habits in 1961-64.

Stocks

Obviously, an infinite number of combinations of stocks, and degrees of mixing between them, might theoretically exist in the Atlantic and connected seas, but we will consider the following basic combinations only:

1. A single stock inhabiting the Atlantic and connected seas.
2. One stock[12] inhabiting the Mediterranean system (including the Black Sea) and another inhabiting the Atlantic and other connected seas.
3. One stock[12] inhabiting the Mediterranean system and two or more inhabiting the Atlantic and other connected seas.

As noted above, varying degrees of mixing, or none, may occur between the components of dual- or multi-stock combinations.

[12]Some authors have maintained that there are two or more stocks of bluefin within the Mediterranean, whereas others have maintained that there is only one. The evidence appears to be inconclusive in this regard. For the purposes of this discussion, we assume that any group stocks which may exist mainly in the Mediterranean system comprises a single stock.

We will concentrate most of our discussion on two questions which appear to be of paramount importance:

1. The stock structure of bluefin tuna in the Mediterranean and the eastern Atlantic.

2. The stock structure of bluefin tuna in the Atlantic Ocean.

From the pre-Christian era well into the last century, nearly all studies of Atlantic bluefin tuna were concentrated on the Mediterranean system (including the Black Sea) and its Atlantic approaches. Indeed, the very existence of true bluefin tuna in other parts of the Atlantic was seriously doubted by some investigators up to the end of the last century. The early belief was that bluefin tuna from the Atlantic entered the Mediterranean in May-June to spawn (in the Black Sea, according to Aristotle and his followers) then returned to the Atlantic in July-August, and spent the balance of the year there. Knowledge that bluefin spawned in the central Mediterranean, and could be caught throughout the winter in many parts of that sea, cast doubt on this theory. In the late 1800's and up to 1930, most investigators believed that the Mediterranean and Atlantic bluefin tuna were autochthonous stocks, separated by a thermal or thermo-haline barrier at the Straits of Gibraltar. Findings of lures and hooks in tuna caught by other means, and, more recently, tag returns, have indicated that some bluefin tuna do migrate from the Atlantic into the Mediterranean. Schools of bluefin tuna have been tracked with echo sounders as they moved through the Straits of Gibraltar into the Mediterranean in May-June, and out into the Atlantic in July-August. The "migratory" theory again became widely accepted.

There are several indications that the larger bluefin tuna are the most apt to migrate from the Atlantic into the Mediterranean. The average size of the bluefin tuna taken in the traps on either side of the Ibero-Moroccan Bay increases with the proximity of the trap to the Straits of Gibraltar. The largest bluefin are taken at Tarifa and Cape Spartel, at the very entrance of the Straits. Although bluefin tuna of all sizes are taken in parts of the Mediterranean throughout the year, large individuals are rare during the feeding (as opposed to spawning) season, except in certain localities which are rich in suitable food for these fish. As noted in the part of this section on spawning, a hypothesis proposed by Sara (1963) fits many of the facts. According to his theory large bluefin (over 100 kg) move from the Atlantic into the Mediterranean to spawn, and then return to the Atlantic whereas the smaller mature fish spawn in the body of water which they inhabit. It would seem, however, that, if the small fish fisheries in the eastern Atlantic, and the balance in numbers of fish in the respective areas are maintained, some of the fish spawned in the Mediterranean must move into the Atlantic early in their life. In addition, the possibility that eggs and larvae spawned in the Ibero-Moroccan Bay might be carried into the Mediterranean by the surface currents before attaining full mobility would also call for movements of very young bluefin from the Mediterranean into the Atlantic to maintain a balanace between the groups. Such a migration is, in fact, suggested by the progression of the dates of catches, and the sizes of fish caught, in the western Mediterranean and off the western coast of Morocco.

Hamre et al. (1966; 1968; 1971) showed that there were considerable differences, in both the trends of the catches (Fig. 4) and their size composition, between the fisheries for large bluefin in the eastern Atlantic and those in the Mediterranean. They concluded tentatively that the respective fisheries were supported by different stocks. More recently, however, the catches of many Mediterranean trap fisheries have declined drastically, and the sizes of the fish taken have increased markedly. Thus, after a considerable lag, they appear to have followed the trends of the north-eastern Atlantic large fish fisheries.

Biometric studies have indicated differences in external morphology between bluefin tuna caught in the Atlantic and others caught in the Mediterranean. Immunological studies also show that some small bluefin among samples collected off the Mediterranean coast belonged to a different race or population from specimens collected off the Atlantic coast of France.

Apparently there are considerable movements of bluefin tuna between the Atlantic and the Mediterranean. For mature fish, these appear to be related to spawning. For newborn fish, they may reflect passive drift, or preferences for plankton rich waters in the western Mediterranean in their earliest stages, and for the sardine rich Atlantic waters off Morocco when they develop into more active predators.

We can only conclude that some bluefin are resident in the Mediterranean, at least for parts of their life span, and that others, possibly including some of these same individuals, in other parts of their life span move seasonally between the Atlantic and the Mediterranean. In view of the present depressed state of the fisheries in these areas, it seems extremely unlikely that this complex problem of stock identification will be solved in the foreseeable future.

The situation with regard to bluefin tuna in the Atlantic and connected seas other than the Mediterranean (North Sea, the Baltic and its approaches, the Caribbean, and the Gulf of Mexico) is also extremely complex. There are some arguments for a single stock occupying the entire ocean, and others for two stocks, with spawning areas on the east and west sides of the Atlantic.

The arguments for a single stock are as follows:

Fluctuations in catches, and trends in their size composition, appear to be rather similar throughout the ocean. A correlation analysis, based on the assumption that the sizes of the fish caught in the two fisheries were the same, showed a positive correlation in the catch per unit of effort between the small fish fisheries in the northwestern Atlantic and in the Bay of Biscay.

Tag returns have traced several transatlantic migrations of small and large bluefin tuna, as well as several other migrations between widely separated localities in the Atlantic.

Studies of heart muscle protein from bluefin tuna collected on opposite sides of the Atlantic showed no differences in the characteristics which were studied, between the samples from the two areas.

The arguments for separate eastern and western Atlantic stocks are as follows:

Bluefin of all sizes are found on both sides of the ocean, with the exception that very few larvae or small (less than 10 cm) juveniles have been found in the eastern Atlantic.

Bluefin spawn on both sides of the Atlantic (whether the bluefin which arrive in the Ibero-Moroccan Gulf with ripening gonads and depart with spent gonads actually spawn in that area or in the Mediterranean seems irrelevant in this context). There is no evidence of extensive spawning in mid-Atlantic. Spawning in the eastern Atlantic (and/or the Mediterranean) is later than spawning in the western Atlantic.

There is no correlation between trap catches in the eastern Atlantic and Japanese longline catches in the western Atlantic.

The patterns of spring and summer-early fall distribution of bluefin tuna on the two sides of the Atlantic are quite similar:

Size of fish	Eastern Atlantic	Western Atlantic
	Spring	
Small	Morocco; Bay of Biscay	?
Medium	Ibero-Moroccan Bay, Medit.?	Gulf Stream-Edge of Cont. Shelf
Large	Ibero-Moroccan Bay, Medit.?	Bahamas-Gulf of Mexico
	Early summer	
Small	Bay of Biscay; Morocco	Middle Atlantic Bight
Medium	Ibero-Moroccan Bay, Medit.?	Middle Atlantic Bight; Gulf of Maine
Large	Ibero-Moroccan Bay, Medit.? Norway	Cape Cod-Newfoundland
	Mid-summer-early fall	
Small	Bay of Biscay; Morocco	Middle Atlantic Bight
Medium	Scandinavia, Bay of Biscay	Middle Atlantic Bight; Gulf of Maine
Large	Scandinavia , North Sea	Cape Cod-Newfoundland

The principal exceptions may be attributed to different spawning habits. Spawning occurs later in the eastern Atlantic (Ibero-Moroccan Bay and/or Mediterranean) (about the end of June) than in the corresponding western Atlantic spawning area (Bahamas, Gulf of Mexico) (May, early June). The "return" (spent fish) run in the Straits of Florida occurs in May-June, whereas the "return" run off southern Spain and Portugal occurs in July-August. This accounts for the later arrival in northern summering areas of the medium and large bluefin in the eastern Atlantic, as against the western Atlantic.

Also, the spawners in the Ibero-Moroccan Bay and/or the Mediterranean, although predominantly large, include medium-sized and reportedly, even small fish, whereas all of those which spawn in the Bahamas-Gulf of Mexico area are giant fish (over 122 kg).

Tag return data indicates that west to east transatlantic migrations of small bluefin tuna are the exception rather than the rule. As of the end of 1972, about 9,700 small bluefin had been tagged in the Middle Atlantic Bight. Disregarding 1,112 local recaptures within less than 6 months of release, 1,201 returns were from the release area as against 40 from the eastern Atlantic.

Recoveries from large bluefin tuna tagged off the Bahamas have been more numerous in the eastern Atlantic (7) than in the western Atlantic (5), but, with the collapse of the eastern Atlantic fisheries and increased effort in the western North Atlantic, the trend in recoveries has reversed itself. As with the transatlantic migrations of small bluefin, those of large bluefin appear to be important in some years and negligible in others. There have been no transatlantic returns from numerous taggings of large bluefin off New England, Canada, Norway, and Spain.

Preliminary comparisons of extensive data on the external morphology of bluefin tuna from the eastern and western Atlantic indicate that there are slight differences between fish from the respective areas. The fish from western Atlantic tend to have longer heads and pectoral fins, and deeper bodies, than those of similar sizes from the eastern Atlantic.

There is little evidence for a separate stock of bluefin tuna in the South Atlantic. The oceanic distribution of the species appears to be continuous from off eastern Brazil to off New England and eastern Canada. Also, the more significant Japanese longline catches of bluefin tuna appear to progress seasonally from off eastern Brazil in March and April to off Cape Hatteras by the end of June. Furthermore, two bluefin tuna tagged in the Straits of Florida have been recaptured in the western South Atlantic, one of easternmost Brazil, and the other off Argentina. No evidence that bluefin spawn in the South Atlantic has come to our attention.

The evidence is insufficient to permit clear cut conclusions. In our opinion, the most probable combinations are:

1. A single Atlantic or Atlantic-Mediterranean stock and one or more essentially Mediterranean stocks.

2. Two Atlantic spawning stocks, one spawning in the western Atlantic and the other spawning in the eastern Atlantic and/or the Mediterranean, with one or more essentially Mediterranean stocks.

The greatest weight of evidence appears to favor the second arrangement. For management purposes, however, it must be recognized that important interchanges between the two proposed Atlantic stocks occur on an apparently erratic and unpredictable basis.

The problem of the stock structure of Atlantic bluefin is one of enormous complexity. With the present depressed state of most of the fisheries, and the consequent diminution or termination of research on the species in several nations, there is no prospect that it can be solved definitively in the foreseeable future. Management of the species should be undertaken on the basis of the best information now available if its commercial extinction is to be avoided.

IX ACKNOWLEDGEMENTS

The preparation of this paper was supported by the Office of Sea Grant, National Oceanic and Atmospheric Administration, U.S. Department of Commerce Grant Nos. GH-82 and 04-3-158-12 and the National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U. S. Department of Commerce Contract Nos. 03-3-043-29 and 03-4-042-11.

Additional financial support and assistance, for which we are most grateful, came from the Sport Fishing Institute and numerous dedicated sport fishing organizations and individual sportfishermen.

We wish, also, to thank the many participants in the various Atlantic and Mediterrnaean tuna research programs for their cooperation in contributing to the collection of this vitally needed information. Dr. William Bayliff, Gordon Broadhead, Johannes Hamre, Drs. James Joseph, William Lenarz, Brian Rothschild and Klaus Tiews gave valuable assistance through reviews of the manuscript which enabled it to become a much more significant piece of work. Finally, we should like to express our deep appreciation for the most valued assistance of Howard A. Schuck in reviewing, revising and reorganizing our very rough manuscript.

X LITERATURE CITED

ANONYMOUS

1928a La pesca del tonno nel 1927 in Tripolitania. Boll. Pesca Piscic. Idrobiol., 4(1): 23-27.

1928b La pesca del tonno nel 1972 in Cirenaica. Boll. Pesca Piscic. Idrobiol., 4(1): 28-29.

1929a La pesca del tonno in Tripolitania nella campagna del 1928. Boll. Pesca Piscic. Idrobiol., 5(2): 290-294.

1929b Relazione sulla pesca del tonno in Cirenaica durante l'anno 1928. Boll. Pesca Piscic. Idrobiol., 5(3): 538-539.

1932 La pesca de tonno in Tripolitania nel 1931. Boll. Pesca Piscic. Idrobiol., 8(1): 87-91.

1933 Compte-rendu de la conférence d'experts pour l'examen des méthodes scientifiques et techniques à appliquer à l'étude des poissons de la famille des Thonidés (Madrid-Cadiz 16-22 Mai 1932). Rapp. Cons. Perm. Int. Expl. Mer, 84(3): 91-103.

1934a La pesca del tonno in Tripolitania nella campagna del 1933. Boll. Pesca Piscic. Idrobiol., 10(2): 272-276.

1934b Relazione sulla pesca del tonno nelle acque della Tripolitania. Boll. Pesca Piscic. Idrobiol., 10(6): 797-802.

1935a La campagna del tonno in Tripolitania in 1934. Boll. Pesca Piscic. Idrobiol., 11(1): 139

1935b La pesca del tonno in Tripolitania. Boll. Pesca Piscic. Idrobiol., 11(3): 558.

1936 La pesca del tonno in Libya. Boll. Pesca Piscic. Idrobiol., 12: 428.

1954 Rapport d'ensemble sur les Travaux l'Office Scientifique et Technique des Pêches Maritimes de 1945 à 1953. Recherches sur les poissons. Thon rouge Thunnus thynnus (Linné). Rev. Trav. Inst. Pêches Marit., 18(2-4): 65-67.

1960 Libya. Tuna landings up for 1959 season. Commer. Fish Rev., 22(1): 75-76.

1962 Tuna migrations in the North Atlantic studied by R/V "Crawford." Commer. Fish Rev., 24(2): 41-42.

1971 Port Vendres-La pêche en Avril. Sète-La pêche en Avril. Pêche Marit., (1118): 378.

AKYÜZ, E. F. and I. ARTÜZ

1957 Some observations on the biology of tuna (Thunnus thynnus) caught in Turkish waters. Proc. Gen. Fish. Coun. Medit., 4: 93-99.

ALONCLE, H.

1964 Note sur le thon rouge de la Baie Ibéro-Marocaine. Bull. Inst. Pêches Marit. Maroc, 12: 43-59.

1966 Note sur le thon rouge de la Baie Ibéro-Marocaine (II). Resultats d'une campagne de prospection thonière en Baie Ibéro-Marocaine. Bull. Inst. Pêches Marit. Maroc, 14: 29-41.

ALONCLE, H., J. HAMRE, J. RODRÍGUEZ-RODA, and K. TIEWS

1971 Report from the bluefin tuna working group. Observations on the size composition of bluefin tuna catches from 1970. Cons. Perm. Int. Expl. Mer, C.M. 1971/J: 2, 17 p., 2 figs.

1972 Report from the bluefin tuna working group. Observations on the size composition of bluefin tuna catches from 1971. Cons. Perm. Int. Expl. Mer, C.M. 1972/J: 2, 24 p., 2 figs.

1973 Report of the bluefin tuna working group. Observations on the size composition of the bluefin tuna catches from 1972. Cons. Perm. Int. Expl. Mer, C.M. 1973/J:3, 20 p., 2 figs.

ARENA, P.

1963 Observations dans la partie sud de la mer Tyrrhenienne sur les habitudes et le comportement du thon rouge (Thunnus thynnus L.) pendant sa periode genetique. Proc. Gen. Fish. Coun. Medit., 7: 395-411.

1971 Orientamenti ed attivita del Centro Sperimentale per l'Industria della Pesca e dei Prodotti del Mare di Messina. Mem. Biol. Mar. Oceanogr. N.S. 1(2): 21-52.

ARENA, P. and R. SARÀ

1967 Campagna di marcatura dei tonni 1965. Quaderni di Ricerca e Sperimentazione, Suppl. Boll. Inform. Sicilcamere, Palermo, 4: 15-25.

ARICO, F. and S. GENOVESE

1953 Sui caratteri biometrici de tonno (Thunnus thynnus L.) Tirrenico. Boll. Pesca Piscic. Idrobiol., 8(1): 1-44.

ARISTOTLE

1897 History of animals. Ten books. Translated by Richard Cresswell. London, bk. 5, ch. 25, p. 3; bk. 6, ch. 16, p. 5; bk. 8, ch. 16, p. 5; bk. 8, ch. 17, pp. 2-3; bk. 8, ch. 20, pp. 8-9; bk. 9, ch. 3, p. 1.

ATHANASSOPOULOS, G.

1923 Sur les thonnidés en Grèce. C. R. Acad. Sci., Paris, 177: 501-502

1924 Note complémentaire sur les "Thonidés" en Grèce (Méditerranée orientale) Bull. Inst. Océanogr. Monaco, 440: 1-3.

1926 Notes sur la faune marine de la Grèce. Bull. Inst. Océanogr. Monaco, 480: 1-3.

BAYLIFF, W.H. and L. M. MOBRAND

1972 Estimates of the rates of shedding dart tags from yellowfin tuna. Inter-Amer. Trop. Tuna Comm., Bull. 15: 441-462.

BECKETT, J.S.

1970 Swordfish, shark and tuna tagging 1961-1969. Tech. Rep. Fish. Res. Bd. Can., (193): 13 p.

BELLOC, G.

1961 Inventory of Mediterranean tuna traps. Proc. Gen. Fish. Coun. Medit., 6(52): 345-371.

BOUNHIOL, J. P.

1911 Une théorie hydrodynamique des psuedo-migrations du thon commun (Thynnus vulgaris Cuv. et Val.) dans la Méditerranée. C. R. Acad. Sci. Paris, 152: 733-736.

BULLIS, H. R. Jr. and F. J. MATHER, III

1956 Tunas of the genus Thunnus of the northern Caribbean. Amer. Mus. Novit., 1765: 12 p.

BUSER-LAHAYE, J. and F. DOUMENGE

1954 Observations biometriques sur les thons du Golfe d'Aigues - Mortes. Vie et Milieu , Bull. Lab. Arago, 5(1): 35-65.

CARP, B.

1951 Fishery resources of Turkey. U. S. Fish Wildl. Serv., Fish. Leaflet, 390: 23 p.

CESAREO, A.

1972 La pesca - Tonni giganti in Provenze e Costa Brava. Mondo Sommerso, 14(12): 13.

1973 La pesca. Le tonnare volanti. Mondo Sommerso, 15(3): 13.

CETTI, F.

1777 Storia naturale di Sardegna 3. Anfibi e pesci. Sassari, Stamperia di J. Piattoli; 208 p.

CLEMENS, H.B. and G. A. FLITTNER

1969 Bluefin tuna migrate across the Pacific Ocean. Calif. Fish. Game, 55(2): 132-135.

COLLIGNON, J.

1964 Les pêches maritimes Marocaines en 1963 - Résultats statistiques. Bull. Inst. Pêches Marit. Maroc, (12): 61-

1965 Les pêches maritimes Marocaines en 1964 - Résultats statistiques. Bull. Inst. Pêches Marit. Maroc., (13): 81-102.

1966 Les pêches maritimes au Maroc en 1965 - Résultats statistiques. Bull. Inst. Pêches Marit. Maroc., (14): 76-89.

1967 Les pêches maritimes au Maroc en 1966 - Résultat statistiques. Bull. Inst. Pêches Marit. Maroc., (15): 59-70.

1968 Les pêches maritimes au Maroc en 1967 - Résultats commentés. Bull. Inst. Pêches Marit. Maroc., (16): 77-94.

1969 Les pêches maritimes au Maroc en 1968 - Résultats statistiques. Bull. Inst. Pêches Marit. Maroc., (17): 49-60.

1972 Les pêches maritimes au Maroc en 1969 et 1970 - Résultats statistiques. Bull. Inst. Pêches. Marit. (Maroc), (20): 131-147.

de BUEN, F.

1924 Rapport préliminaire sur la croisière de l'ALMIRANTE LOBO et le PRINCIPE ALBERTO DE MONACO. Bull. Comm. Int. Mer Médit., 10: 28-32.

1925 Biologia del atun Orcynus thynnus (L.). Result. Camp. Acuerd. Int. Madr., (1): 118 p.

1927 Notes et bibliographie sur la biologie du thon. Rapp. Cons. Explor. Mer, 44: 98-107.

1931 El supuesto paso por el estrecho de Gibraltar. Rapp. Comm. Int. Mer Médit., 6: 405-409.

1937 Aires de pont du thon (Thunnus thynnus L.). Proc. Int. Congr. Zool., 12: 2123-2136.

de BUEN, O.

1924 Les migrations du thon (Orcynus thynnus) sur les côtes Atlantiques du sud de l'espagne. C.R. Acad. Sci., Paris, 178: 1104-1106.

de BUEN, R.

1927 An account of the work which Spain has carried out in the Atlantic Ocean and the Straits of Gibraltar. J. Cons., 2(3): 269-308.

de CRISTOFARO, S.

1970 Le tonnare italiane-La evoluzione tecnologica ed ubicazionale - Le prospettive. Ministero della Marina Mercantile, Memoria 26: 76 p.

de GAETANI, D.

1948 La pesca col "cianciolo". Nota I, Relazione tecnica. Boll. Pesca Piscic. Idrobiol., 3(n.s.) (1): 125-135.

DEVEDJIAN, K.

1926 Pêche et pêcheries in Turquie. Constantinople: pp. 10-15, 299-301, 318.

DIEUZEIDE, R.

1951 Campagne en Méditerranée du navire océanographique de l'Office Scientifique et Technique des Peches Maritimes "Président Théodore Tissier" Bull. St. Aquic. Pêche Castiglione, N.S. (3): 85-138.

DOUMENGE, F.

1953 La pêche au thon dans le Golfe d'Aigues - Mortes. Vie et Milieu, Bull. Lab. Arago, 4(3): 381-410.

DOUMENGE, F. and J. LAHAYE

1958 Quelques nouvelles observations biometriques sur les thons (Thunnus thynnus L.) du Golfe d'Aigues - Mortes. Rapp. Comm. Int. Mer Medit. 14: 329-350.

EDMUNDS, P. H. and J. I. SAMMONS

1971 Genic polymorphism of tetrazolium oxidase in bluefin tuna, Thunnus thynnus, from the western North Atlantic. J. Fish. Res. Bd. Can., 28: 1053-1055.

1973 Genic polymorphism of tetrazolium oxidase in bluefin tuna, Thunnus thynnus, from the Atlantic coast of France. J. Fish. Res. Bd. Can., 30 (7): 1031-1032.

EHRENBAUM, E.

1924 Scombriformes. Rept. Danish Oceanog. Exped. 1908-1910 to the Medit. and adjacent seas, 2 (8) (Biology) A11: 42 p.

FAO PANEL OF EXPERTS FOR THE FACILITATION OF TUNA RESEARCH, LA JOLLA, CALIFORNIA, U.S.A. 8-12 NOVEMBER, 1971. (Referred to as: "FAO Panel of Experts---").

1972 Final report of the working party on tuna and billfish tagging in the Atlantic and adjacent seas. FAO Fish. Rep., (118) Suppl. 1: 37 p.

FARRINGTON, S. K., Jr.

1939 Atlantic game fishing. Garden City Publishing Co., Inc., N.Y.: 298 p.

1949 Fishing the Atlantic offshore and on. Coward-McCann, Inc., N.Y.: 312 p.

FERREIRA, E.

1932 La pesca dell'albacora nelle Azzorre. Not. Dtsch.-Ital. Inst. Meeres-biol. Rovigno d'Istria, (8-9) N-1: 3-10.

FISHERIES AGENCY OF JAPAN

1965 Annual report of effort and catch statistics by area on Japanese tuna longline fishery, 1962. Fish. Agency Jap., Res. Div., 183 p.

1966 Annual report of effort and catch statistics by area on Japanese tuna longline fishery, 1963. Fish. Agency Jap., Res. Div., 322 p.

1967a Annual report of effort and catch statistics by area on Japanese tuna longline fishery, 1964. Fish. Agency Jap., Res. Div., 379 p.

1967b Annual report of effort and catch statistics by area on Japanese tuna longline fishery, 1965. Fish. Agency Jap., Res. Div., 375 p.

1968 Annual report of effort and catch statistics by area on Japanese tuna longline fishery, 1966. Fish. Agency Jap., Res. Div., 299 p.

1969 Annual report of effort and catch statistics by area on Japanese tuna longline fishery, 1967. Fish. Agency Jap., Res. Div., 293 p.

1970 Annual report of effort and catch statistics by area on Japanese tuna longline fishery, 1968. Fish. Agency Jap., Res. Div., 283 p.

1971 Annual report of effort and catch statistics by area on Japanese tuna longline fishery, 1969. Fish. Agency Jap., Res. Div., 299 p.

1972 Annual report of effort and catch statistics by area on Japanese tuna longline fishery, 1970. Fish. Agency Jap. Res. Div., 326 p.

1973 Annual report of effort and catch statistics by area on Japanese tuna longline fishery, 1971. Fish. Agency Jap. Res. Div., 319 p.

FRADE, F.

1931 Données biométriques pour l'étude du thon rouge de l'Algarve (Côte méridionale du Portugal) Bull. Soc. Portu. Sci. Nat. II (7): 89-130.

1937 Recherches biométriques sur la maturité sexuelle du thon rouge, C. R. 12 th. Int. Zool. Congr., Lisbon. Sept. 1935, 3: 2137-2142.

1950 Estudos de pescarias do ultramar portugués. Os atuns. Coloq. Jta. Invest. Colon.

FRADE, F. and S. MANACAS

1933 Sur l'état de maturité des gonades chez le thon rouge génétique (Note préliminaire). Trav. Sta. Biol. Marit. Lisbonne 33: 1-15.

FRADE, F. and H. VILELA

1962 Le thon rouge et le germon. Thunnus thynnus (L.) et Germo alalunga, (Bonn.). Morphologie, biologie, et pêche. Estudos, Ensaios, e Documentos Jta. Invest. do Ultramar, Lisbon, No. 98: 13-92.

GENOVESE, S.

1956 Il tonno, la sua storia e la sua vita. Atti Soc. Peloritana Sci. Fis. Matemat. Nat. 2(1): 3-11.

1957 Ulteriori osservazioni sui caratteri biometrici del tonno (Thunnus thynnus L.) Tirrenico. Il tonno intergenetico dell Stretto di Messina. Boll. Pesca Piscic. Idrobiol., 32, 11(1):

1958 Dati biometrici sul tonno (Thunnus thynnus L.) Tirrenico. Rap. Comm. Int. Mer Medit., 14: 327-328.

1965 Dati sulla pesca all'amo del tonno nello stretto di Messina. Boll. Pesca Piscic. Idrobiol., 20(1): 41-52.

GIANNELLI, E.

1969 Mecca di tonni (La prima "zona calda" per i pescatori sportivi nel Mediterraneo). Mondo Sommerso, 11(10): 964-966.

GINSBURG, I.

1953 The taxonomic status and nomenclature of some Atlantic and Pacific populations of yellowfin and bluefin tunas. Copeia 1953, (1): 1-10.

GORBUNOVA, N.N. and D. SALABARRIA

1967 Reproduction of scombroid fishes (Pisces, Scombroidei) in western regions of the Atlantic. Invest. Pesq. Soviet.-Cuban.: 120-131. (In Russian and Spanish, English translation by W.L. Klawe, Int.-Am. Trop. Tuna Commn. 1968: 24 p.)

GOURRET, P.

1894 Les madragues de Marseille. Ann. Mus. Hist. Nat. Marseille (Zool.), 4: 59-75.

GRUVEL, A.

1926 L'industrie des pêches sur les côtes tunisiennes. Boll. Sta. Oceanogr. Salammbô, 4: 26-29, 79-92.

HAMRE, J.

1960 Tuna investigation in Norwegian coastal waters 1954-1958. Ann. Biol. (Copenhagen) 15: 197-211.

1962 The Norwegian tuna investigations, 1960. Ann. Biol. (Copenhagen) 17: 231-235.

1965 The Norwegian tuna investigations, 1962-1963. Ann. Biol. (Copenhagen) 20: 232-236.

HAMRE, J. and K. TIEWS

1964 Report from the bluefin tuna working group. Cons. Perm. Int. Expl. Mer, Sta. News Letters, and 20: 43 p.

HAMRE, J., F. LOZANO, J. RODRIGUEZ-RODA and K. TIEWS

1966 Report from the bluefin tuna working group: Cons. Perm. Int. Expl. Mer, Stat. News Letters, 26: 34 p.

1968 Report from the bluefin tuna working group. Cons. Perm. Int. Expl. Mer, Stat. News Letters, 38: 27 p.

HAMRE, J., C. MAURIN, J. RODRIGUEZ-RODA and K. TIEWS

1971 Fourth Report of the bluefin tuna working group. Cons. Perm. Int. Expl. Mer, Coop. Res. Rep. Ser. A. 23: 49 p.

HAYASHI, T., T. KOTO, G. SHINGU, S. KUME, and Y. MORITA

1970 Status of the tuna fisheries resources in the Atlantic Ocean, 1956-1967. Far Seas Fish. Res. Lab., Shimizu, Japan. S. Ser., 3: 1-72 p.

HELDT, H.

1927 Contribution a l'etude des races de thon (Thunnus thynnus L.). Caractères biométriques du thon tunisien et considérations sur sa croissance. Ann. Sta. Oceanogr. Salammbô, 4: 54 p.

1929 Le thon rouge et sa pêche. Rapp. Comm. Int. Mer Medit., 4: 97-112.

1932 Le thon rouge et sa pêche (7e Rapport). 8: 185-255.

1934 Le thon rouge et sa pêche (8e Rapport). Rapp. Comm. Int. Mer Medit., 8: 185-255.

1937 Le thon rouge et sa pêche, rapport pour les années 1933, 1934 et 1935 (9e. Rapport). Rapp. Comm. Int. Mer Medit., 10: 235-315.

1938 Le thon rouge et sa pêche (10me Rapport). Rapp. Comm. Int. Mer Medit., 11: 311-358.

IYIGÜNGOR, D.

1957 Methods and gear at present in use for tuna fishing in Turkey. Proc. Gen. Fish. Coun. Medit. 4(33): 251-255.

KEYVANFAR, A.

1962 Serologie et immunologie de deux especes de thonidés (Germo alalunga Gmelin et Thunnus thynnus Linné) de l'Atlantique et de la Méditerranée. Rev. Trav. Inst. Pêches Marit., 26(4): 407-456.

LAMBOEUF, M.

1972 Tuna Fisheries in Morocco - Status at the beginning of 1971. In Report for biennial period, 1970-71, Part III. (English version). Int. Comm. Conserv. Atl. Tunas, Madrid,: 176-180.

LA TOURRASSE, G. de

1951 La pêche aux thons sur la côte basque Francaise et son évolution recente. Rev. Trav. Off. Sci. Techn. Pêches Marit., 17(66 fasc. 1): 1-42.

LEBEDEFF, W.

1936 Paradise for big game fishing. Tunny, 700 K.; swordfish: 180 K.; shark 1800 K. Winter season 1935-36 in Turkey. Fishing Gazette, 113: 3102.

LE DANOIS, E.

1938 L'influence des transgressions sur la biologie et la pêche. In L'Atlantique (Histoire et vie d'un océan), Paris, Albin Michel: 246-286.

LEE, J.Y.

1965 Observations sur la sérologie et l'immunologie des thons rouge (Thunnus thynnus Linné) de Méditerranée. Rapp. Comm. Int. Mer Medit., 18(2): 225-228.

1967 Note complementaire sur l'immunologie des thons rouges (Thunnus thynnus Linee) de l'Atlantique et de la Méditerranée. Rapp. Comm. Int. Mer Medit., 19(2): 279.

LE GALL, J.

1927 Contribution à l'étude de la biologie du thon rouge (Thunnus thynnus L.). Sur la présence de thons rouges en Mer du Nord et dans l'Atlantique nord-est. J. du Cons., 2(3): 309-331.

1929 Le thon rouge (Thunnus thynnus L.) en Mer du Nord et dans l'Atlantique nord-est. Journal du Conseil, 4(2): 200-206.

1959 Thunides. Thon rouge (Thunnus thynnus L.) Dans les parages de St. Jean de Luz, en 1949, 6: 71.

1952 Thonides. Le thon rouge (Thunnus thynnus L.) dans le Golfe de Gascogne en 1951. Ann. Biol., 8: 82-83.

LOUYS,

LOZANO CABO, F.

1958 Los escómbridos de las aguas españolas y marroquies y su pesca. Primera Parte. Trab. Inst. Esp. Oceanogr., (25): 254 p.

1959a Critical study of echo-sounders used for tuna detection. Proc. Gen. Fish. Coun. Medit., 5(8): 91-99.

1959b The use of echo-sounders in the study of the migrations of tuna. Proc. Gen. Fish. Coun. Medit., 5(9): 101-104.

MARR, J. C. and M. B. SCHAEFER

1949 Definitions of body dimensions used in describing tunas. U. S. Fish Wildl. Serv., Fish. Bull., 51(47): 241-244.

MATHER, F. J. III

1962 Transatlantic migration of two large bluefin tuna. J. Cons., 27: 325-327.

1969 Long distance migrations of tunas and marlins. Underwater Naturalist, 6(2): 6-14, 46.

MATHER, F. J. III, M. R. BARTLETT and J. S. BECKETT

1967 Transatlantic migrations of young bluefin tuna. J. Fish. Res. Bd. Can., 29(9): 1991-1997.

MATHER, F. J. III, B. J. ROTHSCHILD, G. J. PAULIK AND W. H. LENARZ

In press Preliminary analysis of migrations and mortality of bluefin tuna tagged in the northwestern Atlantic Ocean.

MATHER, F. J. III, and H. A. SCHUCK

1960 Growth of bluefin tuna of the western North Atlantic. U. S. Fish Wildl. Serv., Fish. Bull., 61(179): 39-52.

MEYER-WAARDEN, P. F.

1959 Relation between the tuna populations of the Atlantic, Mediterranean and North Seas. Proc. Gen. Fish. Coun. Medit., 5(22): 197-202.

MIYAKE, M. P. and C. G. TIBBO

1972 Int. Comm. Conserv. Atl. Tunas, Madrid., Stat. Bull., 2 (no pagination).

1973 Int. Comm. Conserv. Atl. Tunas, Madrid. Stat. Bull., 3 (no pagination).

MOROVIC, D.

1961 Observations sur les variations du nombre de pinnules chez le thon rouge (Thunnus thynnus L.) pêché en Adriatique à la senne tournante. Rapp. Comm. Int. Mer Medit., 16(2): 341-344.

1968 Sur quelques caractéristiques biométriques du thon rouge Adriatique (Thunnus thynnus L.). Rapport taille/poids et longeur du corps/longeur de la tête. Rapp. Comm. Int. Mer Medit., 19(2): 291-293.

MOSS, F.T.

1967 The case of the subway tuna. Sportfishing, 3(6): 10, 47-49.

NAVAZ, J. M.

1950a Contribucion al estudio de las escombridos la costa vasca (atun, bonitos y melva). Bol. del Inst. Esp. de Oceanogr., no. (31): 1-21.

1950b Thunidés. Le thon de la côte basque. Ann. Biol., 6: 71-72.

NÉDÉLEC, C.

1954 Données biométriques sur le thon rouge de la Mer du Nord. J. Cons., 19(3): 350-355.

NINNI, E.

1921a Le comparse del tonno nel mare e nelle lagune di Venezia e revisione del gruppo "tonni" per l'Adriatico. Boll. R. Comit. Talassogr. Ital., 10 (Fasc 1-2-3) (69-71): 43-48.

1921b Per la pesca in Libia, Eritrea e Somalia. Mem. R. Comit. Talassogr. Ital., 86: 5-77.

1922 La migrazione del tonno nei mari di Levante. Boll. R. Com. Talassogr. Ital., 74: 109-116.

OREN, O. H., A. BEN-TUVIA and E. GOTTLIEB

1959 Experimental tuna fishing cruise in the eastern Mediterranean. Proc. Gen. Fish. Coun. Medit., 5(36): 269-279.

OSSADA, F. d'AMICO DUCCA d'

1816 Observations pratiques sur la pêche, la course et les routes des thons. Messina.

OVEN, L. S.

1959 Pelagic fish eggs in the Black Sea off Karadag. Trudy Karadagskoi Biol. Stants. Akad. Nauk Ukrainskoi SSR, 15: 13-30.

PADOA, E.

1937 Scombriformes pp. 471-547. In Lo Bianco, S., Editor, Fauna e flora del Golfo di Napoli, Part 3.

PARONA, C.

1919 Il tonno e la sua pesca. Mem. R. Comitat. Talassogr. Ital., 68: 3-263.

PAVESI, P.

1889 L'industria del tonno (Orcynus thynnus). Relazione alla Commissione Reale per le Tonnare, Atti Min. Agric. Ind. Commer.

PICCINETTI, C. and G. P. MANFRIN

1970 Osservazione sulla biologia dei primi stadi giovanile del tonno (Thunnus thynnus L.). Boll. Pesca Piscic. Idrobiol., 25: 223-247.

POSTEL, E.

1956 Données biométriques sur quelques Scombrides tunisiens. Bull. Sta. Oceanogr. Salammbô, 53: 50-63.

1962 Les thonidés d'Afrique du Nord. Bull. Inst. Pêches Marit. Maroc, 8: 17-27.

POTTHOFF, T. and W. J. RICHARDS

1970 Juvenile bluefin tuna, Thunnus thynnus (L.), and other scombrids taken by terms in the Dry Tortugas, Florida. Bull. Mar. Sci., 20(2): 389-413.

RICHARDS, W. J.

1969 Tropical Atlantic tuna larvae collected during equalant surveys. Commer. Fish. Rev., 31(11): 33-37.

RICHARDS, W. J. and D. C. SIMMONS

1971 Distribution of tuna larvae (Pisces, Scombridae) in the northwestern Gulf of Guinea and off Sierra Leone. Fish. Bull. 69(3): 555-568.

RIVAS, L. R.

1954 A preliminary report on the spawning of the western North Atlantic bluefin tuna (Thunnus thynnus) in the Straits of Florida. Bull. Mar. Sci. Gulf Carib. 4(4): 302-322.

1955 A comparison between giant bluefin tuna (Thunnus thynnus) from the Straits of Florida and the Gulf of Maine, with reference to migration and population identity. Proc. Gulf Carib. Fish. Inst., Seventh Ann. Sess., Havanna Nov. 1954: 1-17.

RODEWALD, M.

1967 Transatlantic migrations of the bluefin tuna and anomolies of the atmospheric circulation. Cons. Com. Perm. Int. Explor. Mer, C.M. 1967/2:7: 7 p.

RODRÍGUEZ-RODA, J.

1957 Crecimiento relativo del atún, Thunnus thynnus (L.), de Barbate (Costa sudatlántica española). 9: 33-64.

1959 Aparición en la costa sudatlántica española de atunes marcados en Noruega. Inv. Pesq., 14: 115-119.

1960a Consideraciones sobre la biologia del atun, Thunnus thynnus (L.), de Barbate (costa sudatlántica de España). Bol. Real Soc. Espan., 58(2): 347-362.

1960b Marcacion de atunes, Thunnus thynnus (L.) en el Golfo de Cadiz, IV Reunion sobre Productividad y Pesquerias. Inst. Invest. Pesq. 89-90.

1963 Investigaciones sobre tunidos. Publ. Tecn. Jta. Estud. Pesca., 2: 39-77.

1964a Biologia del atun Thunnus thynnus (L.) de la costa sudatlántica de España. Inv. Pesq., 25: 33-146.

1964b Talla, peso y edad de los atunes, Thunnus thynnus (L.)., capturados por la almadraba de Barbate (costa sudatlántica de España), en 1963 y comparación con el período 1956a-1962. Inv. Pesq., 26: 3-47.

1965 Sobre las fluctuaciones en la produccion de atunes de las almadrabas sudatlanticas. Publ. Tecn. Jta. Estud. Pesca, 4: 205-209.

1966a El atún, Thunnus thynnus (L.), de la costa sudatlántica de España en la campaña almadrabera del año 1964 y consideraciones sobre las fluctuaciones periódicas. Inv. Pesq., 30: 9-35.

1966b Estudio de las atunes, Thunnus thynnus (L.), capturados en 1965, por la almadraba de Barbate (costa sudatlántica de España) Inv. Pesq. 30: 483-496.

1969a Resultados de nuestras marcaciones de atunes en el Golfo de Cadiz durante los años 1960a-1967. Publ. Tecn. Jta. Estud. Pesca., 8: 153-158.

1969b El atun, Thunnus thynnus (L.) del sur de España en la campaña almadrabera del año 1967 y estudio de la evolución de la pesquería de Barbate. Inv. Pesq. 33(1): 87-96.

1970 El atún, Thunnus thynnus (L.), del sur de España en la campaña almadraba del año 1969 y su relación con la temperatura y transparencia del agua del mar. Inv. Pesqu., 34(2): 503-514.

1971 Investigations of tuna (Thunnus thynnus) in Spain. In: Internat. Com. Conserv. Atl. Tunas, Rept. Bien. Per. 1970-1971, Part II, English version: 110-113.

1973 Les captures de thon rouge à madragues par les pêcheries du sud de l'Espagne en 1972. Pêche Marit., 20 June 1973: 431-432.

ROULE, L.

1913 Observations sur la migration reproductrice du thon commun (Orcynus thynnus L.) Bull. Mus. Hist. Nat., Paris, (7): 422-423.

1914 La biologie et la pêche du thon dans la Mediteranee occidentale. Rev. Gen. Sci. Pures Appl., Paris, 25: 808-814.

1917 Étude sur les aires de ponte et les déplacements périodiques du thon commun (Orcynus thynnus L.) dans la Méditerranée occidentale. Ann. Inst. Océanogr. Monaco, 7: 1-26.

1923 Considérations sur l'oecologie abyssale des alevins de thon. Commun. au Congrès de Paris: Comm. Int. Explor. Mer, 1923.

1924 Étude sur les déplacements et le pêche du thon (Orcynus thynnus L.) en Tunisie et dans la Méditerranée occidentale. Bull. Sta. Océanogr. Salammbô, 2: 1-39.

RUSSELL, F. S.

1934 Tunny investigations made in the North Sea on Col. E.T. Peel's yacht, "St. George", summer, 1933. Part I. Biometric data. J. Mar. Biol. Ass. U. K., 19(2): 503-522.

SANZO, L.

1910a Studi sulla biologia del tonno (Orcynus thynnus L.). Riv. Men. Pesca Idrobiol., 12 (5): 1-15.

1910b Uova e larve di scomberoidei. Boll. Minist. Agric., ann. 9, 1, ser. C, (12): 18-20.

1929 Uova e larve di Tonno, ("Orcynus thynnus Ltkn"). R. C. R. Accad. Lincei, Ser. 6, 9: 104-106.

1932 Uova e primi stadi larvali di tonno (Orcynus thynnus Ltkn.). Mem. R. Comit. Talass. It., Mem. 189: 16 p.

SARÀ, R.

1963 Data, observations and comments on the occurrence, behavior, characteristics and migrations of tunas in the Mediterranean. Proc. Gen. Fish. Coun. Medit., 7:(37): 371-388.

1965a Occurrence of bluefin tuna (Thunnus thynnus) along the Italian coast. Proc. Gen. Fish. Coun. Medit., 8(3): 73-77.

1965b Distribution of bluefin tuna (Thunnus thynnus) along the western Sicilian coast. Proc. Gen. Fish. Coun. Medit., 8(4): 79-81.

1968 La evoluzione della pesca del tonno nel basso Tirreno, negli ultimi anni. Boll. Pesca Piscic. Idrobiol., 23(1): 33-46.

1969 La pesca del tonno in Tirreno nel 1969. Boll. Pesca Piscic. Idrobiol., 24(2): 159-164.

SCACCINI, A.

1959 Bio-écologie des jeunes thons dans les mers italiennes. Proc. Gen. Fish. Coun. Medit., 5(43): 495-499.

1961 Remarks on the deplacements and distribution of young tunas in the Adriatic Sea. Proc. Gen. Fish. Coun. Medit., 6(45): 293-294.

1968 Étude des caractères différentiels des premiers stades dans différentes espèces de Thonidés. Rapp. Comm. Int. Mer Medit., 19(2): 311-312.

SCACCINI, A. and T. BIANCALANA

1959 Tuna fishing methods in Italy and fishing with ring nets. Proc. Gen. Fish. Coun. Medit., 5(65): 465-471.

SCORDIA, C.

1931 La pesca del tonno all'amo nello Stretto di Messina. Boll. Ist. Zool. Univ. Messina, 5.

1932 Per la biologia del tonno (Thunnus thynnus L.) III. Osservazioni sui tonni dello Stretto di Messina. Mem. Biol. Mar. Oceanogr., Messina, 2(1): 91 p.

1934 Per la biologia del tonno (Thunnus thynnus L.) VI. Ulteriori osservazioni sui tonni dello Stretto di Messina. Mem. Biol. Mar. Oceanogr. Messina, 3(2): 35 p.

1935 Per la biologia del tonno (Thunnus thynnus (L)) VIII. Osservazioni sui tonni dello Stretto di Messina eseguite nell'annata 1934-35. Mem. Biol. Mar. Oceanogr., 4(2): 38 p.

1938 Per la biologia del tonno (Thunnus thynnus (L.)) XV. Le migrazioni dei tonni entro il Mediterraneo. Mem. Biol. Mar. Oceanogr., Messina, 5(8): 50 p.

1939 Notizie sulle migrazioni dei tonni del basso Adriatico. Mem. Biol. Mar. Oceanogr., Messina, 6(1): 7 p.

SELLA, M.

1911 Contributo alla conoscenza della riproduzione e dello sviluppo del (Xiphias gladius L.) Mem. R. Comit. Tallas. Ital. 2: 16 p.

1912 Alcuni appunti sulla pesca del pesce nella Libia. Mem. R. Com. Talass. It., 18: 30 p.

1924 Caratteri differenziali dei giovani stadi di Orcynus thynnus Ltkn., O. alalonga Risso, Auxis Bisus Bp. R. C. R. Accad. Lincei, Roma, (Ser. 5) 33, Sem. 1(7): 300-305.

1927 Les migrations des thons étudiées par le moyen des hameçons. Bull. Sta. Aquic. Pêche Castiglione, fasc. 2: 101-136.

1929 Migrazioni e habitat del tonno Thunnus thynnus (L.) studiati col metodo degli ami, con osservazioni sull'accrescimento, sul regime delle tonnare ecc. Mem. R. Comit. Talass. It., 156: 24 p.

1930 Distribution and migrations of the tuna (Thunnus thynnus L.) studied by the method of hooks, and other observations. Int. Rev. Ges. Hydrobiol., 24: 446-466.

1932 Sulle migrazioni del tonno (Thunnus thynnus L.). Conv. Biol. 1°Conv. Biol. Mar.-Napoli, dicembre 1931: 103-136.

SHIOHAMA, T., M. MYOJIN and H. SAKAMOTO

1965 The catch statistic data for the Japanese tuna long-line fishery in the Atlantic Ocean and some simple consideration on it. Rep. Nankai Reg. Fish. Res. Lab., 21: 131 p.

SPARTA, A.

1933 Osservazioni compuite nello Stretto di Messina sul comportamento dei pesci e cefalopodi all'azione di sorgenti luminose. Mem. R. Comit. Talass. It., 206: 22 p.

SPRINGER, V. G. AND H. D. HOESE

1958 Notes and records of marine fishes from the Texas Coast. Texas J. Sci., 10: 343-348.

TIEWS, K.

1960 Bestimmung des altersaufbaues des roten thunes (Thunnus thynnus (Linnaeus)) in der Nordsee mit hilfe des allometrischen wachstums der augenhohle. Arch. Fischereiwiss., 11(1): 12-17.

1963 Synopsis of biological data on bluefin tuna Thunnus thynnus (Linnaeus) 1758 (Atlantic and Mediterranean). FAO Fish. Rep., 6(2): 422-281.

1964 Der thunbestand (Thunnus thynnus (Linnaeus)) in der Norsdee, seine wanderungen, seine transatlantischen beziehungen und seine nutzung durch die deutsche fischerei. Arch. Fischereiwiss. 14(3): 105-148.

VILELA, H.

1960 Estudos sobre a biologia dos atuns em Portugal 1958-1960. Bol. Pesca 69: 3-26.

VILELA, H. and E. CADIMA

1961 Études sur les thons, Thunnus thynnus (L.), de la côte portugaise. Ann. Biol. Copenhagen, 16: 241-245.

VILELA, H., et al

1960 Sur les thons qu'on pêche au Portugal, Ann. Biol., Copenhagen, 15: 212-215.

VODYANITSKII, V. A.

1936 Observations on pelagic eggs of fishes of the Black Sea. Akad. Nauk SSSR, Trudy Sevastopol. Biol. Stants., 5: 3-43. (In Russian; pp. 23-26 translated by W. L. Klawe).

VODYANITSKII, V. A. and I. I. KAZANOVA

1954 Diagnostic descriptions of the eggs and larvae of Black Sea fishes. Trudy VNIRO, 28: 240-323. (In Russian; sections pertaining to bonito and bluefin tuna translated by W. L. Klawe).

WATHNE, F.

1959 Summary report of exploratory long-line fishing for tuna in Gulf of Mexico and Caribbean Sea, 1954-1957. Commer. Fish. Rev., 21(4): 1-26.

WESTMAN, J. R. and W. C. NEVILLE

1942 The Tuna Fishery of Long Island, N.Y. Board of Supervisors, Nassau County, Long Island, N.Y.: 31 p.

WILSON, P. C.

1965 Review of the development of the Atlantic coast tuna fishery. Commer. Fish. Rev., 27(3): 1-10.

WILSON, P. C. and M. R. BARTLETT

1967 Inventory of U. S. exploratory longline fishing effort and catch rates for tunas and swordfish in the northwestern Atlantic, 1957-1965. U. S. Fish Wildl. Serv., Spec. Sci. Rep. - Fish., 543, 52 p.

WISE, J. P. and C. W. DAVIS

1973 Seasonal distribution of tunas and billfishes in the Atlantic. NOAA Tecn. Rep. NMFS Spec. Sci. Rep. - Fish. 24 p.

WISE, J. P. and J. C. LE GUEN

1969 The Japanese Atlantic longline fishery, 1956-1963. Proc. Symp. Oceanogr. Fish. Resourc. Trop. Atlantic - Rev. Pap. Contrib. UNESCO, Paris, 26: 317-347.