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ALBACORE MIGRATIONS BETWEEN PORTUGAL AND THE SOUTHWEST OF IRELAND AS A FUNCTION OF ENVIRONMENTAL TEMPERATURE VARIATION

(Migrations du germon en fonction des variations thermiques du milieu entre le secteur portugais et le SO de l'Irlande.)

Translated from the French

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Encouraging results obtained during the 1967 summer tuna season in the Gulf of Gascony and on the Spanish<sup>1</sup> coast led us to enlarge our investigations this year to an area extending off Portugal to the south and to the southwestern part of Ireland to the north. The principal objective was to study the distribution and migrations of the albacore from spring until the beginning of autumn and also to make observations on bluefin and other species which might be encountered.

We were able to carry out this program during two cruises -- May 18 to July 5 with "la Pelagia", and August 19 to September 30 with "Thalassa" and "la Pelagia" operating together. The first cruise had two objectives: 1) To look for bluefin along the Spanish coast from Saint-Jean-de-Luz to Lisbon during the second half of May, 2) To study the distribution of albacore off the Portuguese coast as a function of oceanographic conditions, and to follow the albacore in its migration toward the north to the northwest of Galicia.

The objectives of the second cruise were: 1) To locate the northern limit of the albacore at the end of August, southwest of Ireland with the "Thalassa", while "la Pelagia" simultaneously studied the area of the French coast from Petite Sole to Saint-Jean-de-Luz, 2) To find concentrations of albacore off the Iberian Peninsula as a function of oceanographic conditions during the month of September.

It was agreed that the two ships would work simultaneously in the area where interesting results had been obtained in the previous year. The principal role of the "Thalassa" was to study the oceanographic regime, permitting identification of favorable areas where the "la Pelagia" could work. During these cruises 564 tunas, selected from about a thousand captured, were marked with dart tags. Measurement of all fish captured made it possible to study length-frequency and geographic distribution of different age classes. Biological observations included, among others, examination of stomach contents and of the sexual state of the fish.

Oceanographic observations included 261 bathythermograph casts to 300 meters and 88 reversing bottle stations (measurements of temperature and salinity at certain levels) -- these last in the Spanish area during the second cruise to a depth of 1,000 meters. One-hundred and sixty-nine plankton tows were made, some in the surface layers of the fishing areas, with a Hensen net towed horizontally, and some in the first 200 meters around the Iberian Peninsula with a Hensen net towed vertically. Some hauls made with a pelagic larval trawl completed the observations on the microfauna of the environment.

The following sounders were utilized for fish detection: On "la Pelagia" SCAM 610 and Atlas Ecograph Tiefseelot; on the "Thalassa" Simrad and SCAM 610 as well as the Atlas Explorator fishing asdic.

All data collected during these cruises are being studied and will be the subject of more detailed reports by the participants. An overall view is available already, however, which we present as we did last year to show the progress of the work, the ecological conditions observed, and the special observations made.

<sup>1</sup>Etude sur le comportement du germon en fonction des conditions hydrologiques-Sci. et Pêche, nov.-dec. 1967, Nos. 164-165.

Radio communication with the fishermen seems to have been satisfactory in most areas. Because of certain difficulties at the beginning, the wave length adopted for the broadcast of bulletins, 153 meters, was not practical because of constant static (LORAN chain broadcast). But good contact was made beginning the 20th of June on 140 meters (2139 kilocycles) and information was put out until the end of August everyday at the following hours: 7:00 and 11:30 A.M. and 6:30 P.M. by the "Thalassa"; 7:30 A.M., 12:00 and 7:00 P.M. by "la Pelagia". Special communiques were transmitted each time that large schools of fish were encountered. Communications became more difficult when the ships were widely separated from the fleets during the second cruise in prospecting the Spanish sector. It is for this reason that the principal information was at that time broadcast through "Radio Le Conquet" following the weather bulletin.

Many contacts were made with professional fishermen who were good enough to communicate information to us on their position and their fishing results and to exchange valuable information with us.

Eight general information bulletins summing up the progress of the research and the situation of the fisheries were also addressed by the I.S.T.P.M. to different quarters of "Affaires Maritimes" and local fishing committees.

I. - DEVELOPMENT OF THE CAMPAIGN

FIRST PART (FIGURE 1)

#### a. Searching for bluefin on the Iberian coast.

Work from May 22 to 29 on the Iberian coast showed that the waters remained cold in the coastal region and on the whole continental shelf --13.60° to 14.50°, the temperature being a little warmer in the Saint-Jeande-Luz sector -- 15.60° and offshore between Santander and Cape Peñas, where it reached 16.30°.

Figure 1.	Development of the oceanographic situation and movement of the
	fishing areas off the Spanish coast from May 22 to June 30. The
	limit of the "cold belt" is dotted; oblique lines are sectors of
Ŧ	concentration of albacore discovered by "la Pelagia" (the zones
	of greatest density are marked by a denser line). Horizontal and
	vertical lines show areas occupied by the principal tuna fleets.

On the western Iberian coast, investigated from May 30 to June 9, the conditions between Cape Finisterre and Vigo which seemed to be most favorable for tuna fishing, with temperatures above 16.00°, were rapidly disturbed by a strong northwest wind which blew constantly beginning May 20 and caused subsurface waters with a minimum temperature of 13.40° to rise up along the Portuguese coast (upwelling). This situation is doubtless one of the factors which slowed up the arrival of the bluefin in the Spanish region. No catches were made during this period and it was not until June 16, when there was practically no wind, that some warming was evident at the entrance of the Nazaré Canyon to the north of the Berlingues, and five bluefin were captured in this area. During our return we re-examined the conditions on the Spanish coast between the first and the fifth of July. The surface waters were clearly warmer and the temperatures varied from 17° in the coastal region to 18° offshore. It does not seem that the slightly cooler waters off Corunna were an obstacle to the passage of the bluefin, but in spite of more favorable conditions no fish were captured in this area.

#### b. Searching for albacore off the Portuguese coast and Galicia.

Between June 7 and June 30 "la Pelagia" searched the section between Lisbon and 40°30' N., out to 14°30' W., and also that included between Porto and northwest of Cape Finisterre to 16°00' W. At the beginning, movement of warm water was retarded by strong winds from the north to northwest which blew until June 15, and by the extension of cold waters from the deeper layers just off the coast. From the 7th to the 9th of June the 17.00° isotherm barely passed 39°00' N. out to 12°30' W., but farther offshore it reached 40°00' N. and 14°10' W. During the following days this isotherm moved along a northeast axis.

Albacore schools were found in waters whose surface temperature was  $16.80^{\circ}$  to  $17.50^{\circ}$ , and mostly on the edge of the inside of this favorable zone. Two fishing areas were found by us: 1) On the 9th and 10th of June around  $39^{\circ}15'$  N. and  $13^{\circ}12'$  W., extending about 30 miles southeast and northeast. 2) On the 14th and 15th of June, between  $40^{\circ}00'$  N. to  $40^{\circ}20'$  N. and  $10^{\circ}20'$  W. to  $10^{\circ}55'$  W. These two fishing areas were exploited by two fleets, each about 20 boats, which had satisfactory fishing based on our information. They remained productive until the 19th of June. Most of the tuna boats (Bretons who sailed May 13 and boats which left port around the 7th of June) worked in the area included between  $40^{\circ}40'$  to  $41^{\circ}40'$  N. and  $13^{\circ}20'$  to  $19^{\circ}00'$  W., where fishing was good, especially from the 9th to the 11th of June. It seems that temperature conditions in that area were mostly the same as in the one we found.

From June 19 to June 30 "la Pelagia" worked to the north of Porto to find the northeastern limit of the distribution of schools of albacore at that time. It appears that the limit was marked by the isotherm of 16.80° or 17.00°, because in the cooler waters farther to the north there were no tuna. This "boundary", which progressed mostly toward the north, proved to be poorer than the southern section and the principal fishing regions were more to the south, in waters of 18.00°, during the period from June 21 to June 26. On June 24 and June 25 several schools of albacore were found around 43°00' N. 13°40' W. and 43°10' N. 14°25' W. This fishery, which was exploited by the fleets, remained productive until June 29. At the farthest point explored, around 44°48' N. and 15°35' W., some "large" albacore could be caught in a movement of warm water to the northeast.

Beginning June 27 a rapid warming of the waters was noticed to the east of 12°00' W., south of 44°. A strong temperature gradient -- 17.00° to 20.00° -- marked this condition, and several concentrations of albacore were found in this gradient, notably around the following points: 43°53' N., 11°40' W.; 43°35' N., 10°45' W.; 43°16' N., 11°09' W.; 43°38' N., 10°54' W., 43°27' N. and 10°29' W. The schools which most often were in the form of large surface "sheets" were not stable, and changed with the rapid variations in temperature. Some fleets moved toward these points just as we ended this part of the work.

#### SECOND PART (FIGURE 2)

## a. <u>Searching for albacore to the southwest of Ireland, on the edge of the</u> <u>Celtic Shelf, and in the Gulf of Gascony</u>.

Figure 2. Surface temperature conditions and the presence of schools of albacore from August 20 to September 25. Dotted areas show the extension of upwelling water. Oblique hatching is schools of tuna found by the "Thalassa" and "la Pelagia". Presence of bluefin is shown by horizontal hatching.

The "Thalassa" left Brest August 19 to investigate the area bounded by the Petite Sole and the Grande Sole and found a large school of albacore at 48°20' N., 14°00' W. (A tuna fleet had good fishing at the same time farther to the south.) We then worked the block included between 48°00' N. and 52°00' N. and 12°00' W. and 20°00' W., an area where the synoptic charts show generally an incursion of warm water between Rockall Bank and Porcupine Bank.

Oceanographic conditions were favorable for albacore because the 17.00° isotherm had about reached 52° N. and waters over 18.00° had reached 51°30' around 17°00' W. The principal catches were made mostly in front of these warm advances, notably between  $51^{\circ}30'$  N. to  $51^{\circ}50'$  N. and  $18^{\circ}00'$  W. to  $16^{\circ}00'$  W. and around  $50^{\circ}20'$  N. to  $14^{\circ}45'$  W. One week before a fleet had worked farther to the south between  $49^{\circ}00'$  N. and  $49^{\circ}30'$  N. and  $17^{\circ}00'$  W. to  $20^{\circ}00'$  W., in a zone where the intrusion of warm water had just began to show.

Most of the fleets, which were dispersed at the beginning of this cruise between 48°30' N. and 52°00' N., had a tendency to regroup later between 48°30' N. and 49°30' N. This movement of the fisheries toward the south was related to a re-cooling of the water which we noticed in the north, following the northwest winds which began to blow August 30.

At the same time "la Pelagia" prospected along the shelf between Petite Sole and Saint-Jean-de-Luz. In a very general way the thermal structure showed some analogy with that of the previous year, in the sense that the warm lobe which again occupied the southwest part of the Gulf of Gascony with a maximum temperature of 20-21° was found again in opposition to the cold mass of northern water (minimum temperature observed 17.50°) which bordered the slope in the northern part. At no time, however, did the contact between the two water masses show a marked gradient by a strong difference of temperature in a short distance as it did in the previous year, and this could in part explain the absence of albacore in this region. On the other hand a stronger gradient was noted on the border of the northern band around the Petite Sole, and it is in this region around 46°50' N. and 7°40' W. that we found several schools of albacore under the same conditions as observed by the "Thalassa" off the Grande Sole.

# b. <u>Exploratory fishing for albacore</u>, bluefin and skipjack off the Spanish and Portuguese coast.

The two ships worked together on the north and western Iberian coast from September 6 until the end of the month. During that time the layer of warm water which occupied the southwest part of the Gulf extended (as it had in the previous year) along the Iberian Shelf, gradually cooling toward the west off Cape Peñas. Farther west the water was cold (minimum 15.40°), following the development of an important layer rising up from the water of the western Iberian area.

A fishing zone was marked in the area of contact between these two formations in 19.50° to 20.50° waters within the area 43°50' to 44°40' N., 4°10' to 5°00' W. This zone was subject to rapid fluctuations which could not be reproduced on the map shown here. "La Pelagia" was able to study these temperature variations, which agreed with the movement of the schools of albacore, between September 7 and September 11. One tuna boat entered the area while we were working, but it was not able to make satisfactory catches. On the other hand, a fleet made reasonable catches in the same region beginning the 25th of September. No fish were cought in the colder waters of the Galician section.

Exploration in the western Iberian sector was not very productive because of the upwelling of cold subsurface water from the beach to offshore. This cold band limited by the 19.00° isotherm (minimum temperature 15.50°) extended about 100 miles offshore from Corunna in the coastal section in the north and pulled back progressively to Cape Saint Vincent. Nonetheless, some intrusions of warmer water ware found offshore, notably toward the Bays of Setubal and Lisbon as well as toward the Nazare Canyon. Some indentations were observed in the Galician sector. It was in these advances, where the temperature gradient had a tendency to be scw-toothed, that we made some mixed catches of small albacore, bluefin and skipjack, especially at the following positions: 41°50' N. and 10°50' W. (albacore and skipjack); 39°00' N., 9°45' W. (bluefin); 38°40' N., 9°30' W. (albacore and bluefin).

During the return trip about 15 albacore were captured off Corunna around 44°30' N., 9°45' W. when they were doubtless beginning their southward migration at the time when the waters were cooling. We noticed cooling by about two degrees in this area, and on September 29 off the La Chapelle Bank the temperature was less than 15.50°, a difference of more than three degrees compared with the month of August.

# II. - DISTRIBUTION AND MIGRATIONS OF ALBACORE AS A FUNCTION OF TEMPERATURE CONDITIONS

### a. <u>Movements of the schools as a function of surface variations of the</u> thermal front.

We noted a major upwelling of cool water during the summer of 1967 to the north of the west coast of Iberia, caused by the action of the dominant northerly winds and which demonstrated the effect which such a development could have on the migration of albacore toward the Gulf of Gascony. During the summer of 1968, this upwelling was more extensive than in the previous year and involved more or less all of the west coast of Iberia. The band of cold water thus created (15 to 19°) was at its maximum development to the northwest of Galicia and all the way to the center of the Gulf of Gascony. This distribution could in itself explain the lack of albacore in the waters of the Gulf of Gascony. The situation was aggravated by a phenomenon which began early on the Portuguese coast. We were able to follow the different phases of its formation when the strong north-northwest winds began to blow May 31. Weak offshore between Vigo and Leixões, it developed rapidly to occupy all of the Continental Shelf.

Considering the effects which this situation had on the movement of the albacore toward the Gulf, it seems that it also could have been one of the causes of the lack of bluefin in the northern Spanish sector which remained cold until the beginning of the month of June (13.50° onshore to 16.00° offshore). Another consequence of the strong northerly winds which blew at the beginning of spring was certainly a slow-down in the warming of surface water from south to north.

Figure 1 shows how the isotherm of 17.00° moved between June 7 and June 27 from the latitude of Lisbon to Cape Finisterre as progressive deformations in the movements of warmer southern waters. It was in these lobes where the temperature gradient was of a saw-toothed nature that we found the principal concentrations of albacore.

In the northern-most part of the western Iberian area, the areas of strong thermal gradients were no longer around the 17.00° isotherm, but between the 17.50° and 19.00° isotherms. The fisheries were at that time carried on in the warmer waters of the thermal front, where the forage was doubtless more abundant. It is worth noting that marked local variations showed up at times during the day which were not due to insolation; but without doubt to variations in currents of which we have no knowledge.

We could not follow the situation through the month of July, during which "la Pelagia" was engaged in other work, but we suppose that there was a rapid movement of the isotherms toward the north, corresponding to changes in the wind regime, because the situation had become normal during the second half of August in the northern area. It is probable that this rapid evolution created upsets in the fishery, and the albacore appeared to be dispersed during that period. Toward the end of August the fish were found again on the edges of the Celtic Plateau off the Grande Sole and Petite Sole in conditions quite analogous to those which were found off Cape Finisterre, that is to say around the 18.00° isotherm.

We must note that it is at the time when the warming has reached a maximum that the albacore finds the northern limit of the thermal front, which at that time has reached the corridor situated between the extensions of Rockall and Porcupine Banks. It is then that the albacore is found in waters of 17.00° around 51.45° N.

The conditions found on the edges of the shelf of the Gulf of Gascony were probably largely the same as those of the summer of 1968, discounting the fact that the thermal front of the lobe of warm water which occupied the southwest sector did not have as well marked a gradient as in the previous year. This is not sufficient, however, to explain the absence of "bonitos" [small albacore -- Trans.] in the French region, and this situation should be more probably attributed to the early appearance and the persistence of the Spanish upwelling which created a barrier of cold water off Galicia. It is probable that the only important concentration of albacore encountered on the northern Spanish coast will appear only when there is a southwesterly wind. However, we should remark that few "bonitos" were caught on the border of the western cold belt in September. On the other hand, some small fish (from 40 to 48 cm) were captured to the south of the 42°. This leads us to believe that the 50-60 cm age class was very poor during this fishing season (which poses a problem because there were no substantial landings nor was there overfishing of these fish in the preceding year).

#### b. Correlation with the thermocline.

We investigated the deeper water by bathythermograph casts. On the border between Portugal and Galicia the vertical disposition of the isotherms (shown by a vertical trace on the slides) is a characteristic of upwelling which brings toward the surface the cooler waters from the depths. Further work in these regions is necessary for discovery of tuna. Farther offshore the thermocline is marked by 14.5° to 16.5°, and is found most often around 40 to 50 meters. In certain regions it rises to 20 meters, and as we said last year, it is on the slopes of these domes that the major fisheries take place.

Although considerably diffuse in the southern sector, the thermocline was a little more marked toward the north. In the most northern region there is the same correlation between fishing zones and thermal dome slopes, but the domes are weak, which appears to correspond with dispersion of the fish. The thermocline is between 25 to 30 meters, its deepest part corresponding to a temperature of 14.00° and its shallowest to a temperature of 17.00°, which leaves a quite large vertical field of water in which the fish may swim without showing at the surface.

#### c. Optimal temperature conditions in fishing areas.

We may say once again that the formation of a thermal front in a range of favorable temperatures associated with a slope of the thermocline plays an essential role in the presence of the schools of albacore.

A more detailed analysis will allow us to calculate the optimum temperature for maximum yield in a given area. Let us take for example all of the catches from June 9 to June 15 to the west of the Iberian Peninsula. During that period 300 fish were caught in water of  $16.40^{\circ}$  to  $17.80^{\circ}$  at the surface (a difference of  $1.40^{\circ}$ ); 94% of these catches were made in waters of  $16.70^{\circ}$ to  $17.60^{\circ}$ , a difference of less than  $1^{\circ}$ . On June 15 alone 85% of 111 fish captured in waters of  $16.80^{\circ}$  to  $17.70^{\circ}$  were taken between  $17.20^{\circ}$  to  $17.70^{\circ}$ , that is with a variation of a half of a degree.

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As another example let us choose the fishery for "bonitos" off Cape Peñas between the 7th and the 11th of September: 86% of 151 fish caught in waters whose temperature varied from 19.40° to 21.40° were caught in 19.70° to 20.20°, a variation of only a half a degree.

This narrow limit of optimal temperature, which itself varies in different regions, makes frequent temperature measurements necessary and requires a great mobility of the boat to stay in the area of maximum yield, especially if it works alone. The problem is different for a fleet which works together in a certain sector.

#### d. Effects of temperature on the distribution of other species.

As far as bluefin is concerned, we think that the rare incursion which it may make toward the end of summer in the warm waters in the southwest part of the Gulf could not take place except when there is a rupture of the cold Spanish band. However, it is not very probable that the presence of these cold waters is the only cause of the absence of the bluefin, because such an obstacle does not exist in the western Portuguese section and conditions were favorable at the entrance of the Nazaré Canyon and off Cape Mondego, and in the Lisbon-Setubal area with surface temperatures of 17-20°. These conditions are analogous to those present in the fishing areas of the central Moroccan region between Safi and Agadir, where the boundary between the cold coastal band and the warmer water offshore is definitely marked.

Catches on the Spanish coast amounted to only 46 bluefin, which indicates an extremely weak run. We know that the Portuguese catches were small, as were those on the American coast. Only a study of age classes can inform us further on this subject.

Small skipjack were captured on the edge of the Iberian cold band at the same time as small albacore in surface temperatures varying from 18.30° to 20.00°. Doubtless we are dealing with the later displacement toward the north and to the thermal limit of their habitat of a very young fish whose tropical affinities are clearly more accentuated than those of the albacore.

June 7-30

Northwest Spain - Portugal - Western Spain

Figure 3. Length-frequencies of the albacore caught by "la Pelagia" showing the geographic distribution of age-classes. G = large, M = medium, B = "bonitos".

#### **III. - BIOLOGICAL OBSERVATIONS**

#### a. <u>Geographic distribution of different age classes</u>.

Measurements of 940 fish permit us to determine the different classes of age of the population which inhabits all of the region between Portugal and southwest Ireland. The histograms of Figures 3 and 4 give an idea of the variations which exist in the composition of the stock from one fishing area to another. The first albacore which appear off the Portuguese coast in temperatures of 17° to 18° are "large", from 70 to 85 cm (mode 76 cm), and "medium" from 60 to 70 cm (mode 63 cm).

These schools (we do not know much about their distribution toward the west beyond 20°) move progressively toward the north and stay offshore, following the displacement of their threshold temperature -- 17 to 18°. Fish of the same class are found at the end of August southwest of Ireland and on the border of the Celtic Shelf.

August 20 to September 25

Portugal - Western Spain - Northern Spain - Southwest Ireland

Figure 4. Length-frequencies of the albacore caught on the second "Thalassa" cruise, showing the geographic distribution of age-classes. G = large, M = medium, B = "bonitos", P = small.

Fish of 50 to 60 cm (mode 55 cm) called "bonitos" arrive behind the "large" and the "medium" with the warmer waters of 19° to 20° surface temperature. It does not seem that the tunas of this class move along the edges of the shelf, and that is why their migrations toward the Gulf appear blocked, as we have seen, by the development of the cold Iberian band.

Finally, the last arrivals to come during September west of the Iberian Peninsula are the "small" fish of 40 to 48 cm (mode 44 cm). These schools stay on the edge of the cold water band (18.50-20.00°) and do not seem to pass  $42^{\circ}$  N.

During the 1968 fishing season the captures of "la Pelagia" and "Thalassa" were divided into four age classes distributed in the following way (Figure 5):

Small	(40-48 cm)	9%
"Bonitos"	(50-60 cm)	28%
Medium	(60-70 cm)	37%
Large	( > 70 cm)	2.0%

Aging of albacore is not certain yet; some material was collected with the objective of studying the problem.

#### b. Other observations.

A few hundred stomachs were taken and the examination of the contents is now going on for food studies.

Figure 5. Percent of each size caught. The letters mean the same as in Figures 3 and 4.

We do not have sufficient information to make biological studies of other species. The bluefin which were caught measured from 59 to 65 cm. The skipjack were generally small -- 38 to 45 cm -- but a few were a little larger, 55 to 58 cm in the Lisbon area.

#### IV. - TAGGING

Tagging operations began last year and continued this year. The objectives of such work are:

1. To follow the migrations of the albacore during the fishing season and from one season to another, so that we may know in the latter case the growth of a tagged specimen after a year at large and the areas to which the population returns.

2. To know the yield from the stock. We are dealing with a minimum estimate because we do not know the natural or tagging mortality, which may change from season to season, the size, or the susceptibility of the species.

During this season 564 fish were tagged -- 516 albacore, 14 bluefin, 34 skipjack. The fish were tagged at the level of the second dorsal fin with two types of dart tags -- FT 1 with a dart and a yellow plastic ribbon bearing the inscription of I.S.T.P.M. (this is the same type that was used the year before), and WH with metallic dart and a yellow plastic ribbon. Most of the latter were furnished to us by Woods Hole Oceanographic Institution as an experiment; almost all bear the mark of that Institution.

Following is a list of tagging operations which was put out the 21st of October to the different quarters of the "Affaires Maritimes" and to local fishing committees.

#### 1. Albacore (Thunnus alalunga)

a. Western Iberian Region from 7 to 30 June ("la Pelagia") -- 273 albacore tagged within the following block: 39°00' to 43°50' N. -10°10' to 15°40' W. mostly within 39°50' to 40°20' N. and 10°35' to 10°50' W.; tagged with FT 1 series 402-625 and WH series 500-557.

- b. Southwest of Ireland and west of the Celtic Plateau from the 20th of August to the 4th of September ("Thalassa") -- 66 albacore tagged within the following blocks: 48°20' to 48°50' N. and 11°14' to 15°32' W.; 50°20' to 51°45' N. and 14°30' to 17°30' W., tags FT 1, series 2701-2769.
- c. Gulf of Gascony from the 20th of August to the 5th of September ("la Pelagia") -- 26 albacore tagged within the following block: 46°45' to 47°43' N. and 6°50' to 8°23' W., tags FT 1, series 626-654.
- d. Northern Spanish area from the 5th to the 12th of September ("Thalassa" and "1a Pelagia") -- 106 albacore tagged around a line between 43°50' N. -- 50°40' W. and 44°15' to 4°30' W., tags FT 1, series 655-758.
- 2. Bluefin (Thunnus thynnus) in the Portuguese region
  - a. 14 and 16 June ("1a Pelagia") -- 3 bluefin tagged at 40°20' N., 10°54' W.; 40°04' N., 10°42' W. and 39°34' N., 10°15' W., tags (marked Woods Hole) numbers WH 520, 524, and 548.
  - b. The 18th to the 25th of September ("Thalassa" and "1a Pelagia") --11 bluefin at the following positions: 38°37' N., 9°35' W.; 39°00' N., 9°43' W., tags WH 0001 and 0002 (marked I.S.T.P. M.); 41°19' N, 9°42' W., tags WH 563 (Woods Hole); 40°13' N., 9°31' W., tags FT 1, 2032 -- WH 560-561-565 to 569 (Woods Hole).
- 3. Skipjack (Katsuwonus pelamis)
  - a. Portuguese area from the 10th to 20th of September ("1a Pelagia") --34 skipjack marked around the following points: 41°30' N., 9°50' to 10°40' W.; 40°00' N., 9°40' W., tags FT 1, series 771 to 799 and 2000 to 2027.

Until now only 7 recaptures have been reported to us -- only one by a French fishermen from Ile d'Yeu, the 6 others by Spanish fishermen. Three "medium" albacore tagged around the 15th of June near  $4^{\circ}10'$  N. and  $10^{\circ}40'$  W. were recaptured -- one on the edge of the French shelf around  $45^{\circ}00'$  N. after one month and a half at large, two others on a line connecting Cape Finisterre and Petite Sole at  $46^{\circ}10'$  N. and  $47^{\circ}20'$  N. after two months at large. This divergence of the migration shows that there is a division beginning northwest of Galicia in two directions -- that on the edge of the Aquitanian shelf and that on the edge of the Celtic shelf.

Another "medium" albacore tagged farther offshore at 39°16' and 13°14' was captured at 43°25' N. and 17°15' W., 200 miles northwest of the point of departure after 35 days at large. It seems that the group to which this fish belongs followed the progression of the 17.00° isotherm offshore.

There could also be a divergence which operates from the 15° meridian because a "medium" fish tagged at 43°12' N., 43°30' W. was recaptured a month afterwards to the east-northeast at 43°30', 12°15'.

Another albacore ("bonito") tagged the 10th of September on the northern Spanish coast at 44°05' N., 5°02' W. was recaptured the 4th of October 60 miles to the north of Cape Machicaco, which indicates that it had gone around the warm water band in the deeper part of the Gulf to move toward the northeast, its retreat having been no doubt cut off by the band of cold water to the west.

The last recapture is a bluefin which was tagged the 23rd of September at the latitude of Cape Mondego and recaptured the 13th of October on the edge of the Nazaré Canyon. It thus remained in a narrow area doubtless corresponding to the same temperature conditions.

If we look at the overall albacore tagging, the percentage of recapture is 1.2 but if we take into consideration only the "medium" class (60-70 cm), of which 5 from 246 were recaptured, the percentage rises to 2.

The chances for recapture were the greatest among fishes of the first cruise, on the one hand because they were tagged at the beginning of the season, and on the other because they represent the class which was most exploited in this year by the tuna fleets. The "bonitos" of which only one was recaptured, were tagged rather late in the season; but the Spanish fishermen followed the fishery to the end of October around the northern Spanish coast and it is possible that other tags have not yet been returned.

The "small" albacore (40-47 cm) tagged at the end of the season cannot give us any recaptures until the following season when they have reached 50-60 cm. Finally, the large fish averaging 75 cm, tagged principally in the most northerly area, have doubtless moved farther offshore where only longliners could capture them.

#### CONCLUSIONS

The results of these research cruises during the fishing season of 1968 complete those obtained during the summer of 1967 on the edge of the continental shelf of the Gulf of Gascony and the northern Spanish coast in furnishing new data on the situation off the western Iberian coast and the southwestern part of Ireland. They show that as in the previous year the role taken by the study of the environment in exploratory fishing for albacore, and confirm again the hypothesis as to the incidence of upwelling of cold water along the Iberian coast, at least so far as concerns the age classes which inhabit the Gulf. It appears that this year the northerly winds which blew from the beginning of the season retarded the warming of the surface water and upset the general situation of the fishery.

We have also seen that different age classes in the population distribute themselves in well-defined areas.

Although numerous tagging experiments were carried out during this year, there have been only a few recaptures, which show that the fishery is operating on two percent of the stock of "medium" albacore. However, recaptures next year may give valuable information on the migrations from one year to another. A good deal of information was collected during these cruises which points up the necessity of knowing quickly as possible the surface temperature conditions.

We may already know that this method of exploration permits a single research vessel to sketch out a fishing region as rapidly as can be done by an organized tuna fleet which spreads out in the usual way in a certain area without the capacity for taking temperature measurements. However, the field of investigation is very limited by the characteristics of the ship, and that is why it is essential to try to find the most practical way for measuring surface temperatures simultaneously on a large scale. Such information could be furnished by certain central services, notably by the National Weather Service, which proposes to establish synoptic charts from measurements made in a large sector of the North Atlantic by selected ships. These charts, broadcast several times a day, together with synoptic charts indicating the barometric situation and the effect of the winds on temperature changes, would obviously allow the tuna fleets to deploy around the research vessel which receives and interprets this information. Other methods which lead to rapidity and simultaneity of observation are also being studied.

It is such a basis -- exploratory fishing offshore -- that makes it necessary to elaborate a future program operating in areas outside of the areas normally fished by the French fleets.