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Habitat and Distribution of Horse Mackerel in the Area off North-West Africa Depending on the Oceanological Environment

by

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Information on the habitat and features of distribution of fish species, as influenced by environmental factors is rather important for the study of inter-annual variations in abundance as well as inter-annual fluctuations in productivity of the fisheries.

In this connection the authors carried out the investigations on intraspecific groupings of horse mackerel found in the area off North Africa, as well as on their possible habitat and seasonal distribution. For this purpose the data on size-age structure, morphology, maturation, fecundity, reproduction, feeding and parasitofauna were analysed in relation to the hydrographical features of separate locations of the area under investigation.

Two horse mackerel species *Trachurus trachurus* and *Caranx rhonchus*, which are the main fishing objects among the commercial fish of the African north-west coast were analysed.

Until now all investigations on horse mackerel biology and distribution were limited to the study of their habitat in shelf waters. Therefore, biological observations in shelf waters were included in the treatment and analysis.

It is known that the habitat of *Trachurus trachurus* covers a greater part of the shelf waters as compared with other species. It occurs along the whole African coast. Its main commercial concentrations are found between 14°N and 26°N at the depths of 50-250 m with near-bottom temperatures of 13-16° off North-west Africa. Massive spawning takes place from October to April.

The main habitat of *Caranx rhonchus* is limited by 8° and 22°30'N. Small concentrations of this species are found on the shelf and in southern areas. It is more a warm water species. Optimum near-bottom temperatures for *C. rhonchus* seem to concentrate around 15-22°. Spawning is observed in shelf locations between 9°N and 18°N in summer.

In the papers (3 and 4) the hypothesis has been suggested that the habitat of some pelagic fish of this area were not restricted to the shelf waters, but covered a considerable space of the open sea.

This paper presents a detailed study of this problem with the North-west African horse mackerel as an example.

914 curves of size-frequencies were analysed to identify local groups of horse mackerel, based on the material collected by AtlantNIRO vessels in 1967-1970. Among these 774 curves concerned *Trachurus trachurus* and 140 curves referred to *Caranx rhonchus*. Moreover, morphological investigations included the analysis of 90 specimens of *Trachurus trachurus* from the coastal areas of Morocco, Mauritania, Senegal (29°55'N, 20°45'N and 15°40'N), and of 51 specimens of *Caranx rhonchus* from the areas of 19°07'N and 11°02'N.

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The analysis of these data enabled the identification of several horse mackerel size-age groups of different sizes and ages, the only size and age being predominative. Figures 1-4 show the positions of these groups. They illustrate seasonal and area variations in the size-age structure. This phenomenon has previously been related to seasonal migrations in a latitudinal direction. The assumption was not confirmed by the authors' analysis of a number of morphological characters and some biological aspects of horse mackerel.

The estimation of the significance of the difference between mean values of two selected conjunctions of a number of morphological characters was made by Student's criterion (1):

$$t = \frac{(\bar{x}2 - \bar{x}1)}{\sigma \bar{x}_2 - \bar{x}_1} = t_{\gamma}(R) \qquad (1)$$

where the difference between mean values of two selected conjunctions is in the numerator, and the mean error of this difference is in the denominator.

Critical deviation, $t_{\gamma}(R)$, with a given confidence γ and degrees of freedom number R was defined by t-tables of Student's criterion (1).

The results of these investigations are shown in Tables 1 and 2. As is seen from Table 1, the northern forms of Trachurus trachurus (Agadir Point) differ essentially from the forms from an intermediate area (Cape Blanc) by two morphological characters (AD and AA). The critical deviation, $t_{\gamma}(R)$, = 2.66; $t > t_{\gamma}(R)$. As for other characters these differences are not significant: $t < t_{\gamma}(R)$.

More pronounced differences are observed in a number of morphological characters (maximum body depth H, AD, AA and AV) between Trachurus trachurus forms from the intermediate area (Cape Blanc) and a southern area. Critical deviation $t_{\gamma}(R)$ = 2.70; $t > t_{\gamma}(R)$.

The data in Table 2 give evidence of the fact that northern forms of Caranx rhonchus (Cape Blanc) also differ essentially from those of the southern area (Cape Vert) in a number of morphological characters (maximum body depth H, AD, AA, AV). Critical deviation, $t_{\gamma}(R)$ = 2.66; $t > t_{\gamma}(R)$.

The above differences between the morphological characters of Trachurus trachurus forms from three areas and those of Caranx rhonchus from two areas suggest the existence of separate local groups of fish in these areas which appear to have their own stable reproductive and feeding groups. The differences in a number of biological features of fish confirm this fact as well.

Thus, 3 local groups of Trachurus trachurus determined by us differ between each other in non-equal fecundity (Table 3).

Absolute fecundity determination is somewhat troublesome, since horse mackerel from North-west Africa appears to spawn by portions.

The methods of fecundity determination were as follows. Fecundity was defined by counting-weight in individuals in IV stage of ovaries maturity. Counts were made in 100 mg subsamples. Only ovocytes with yolk were taken into consideration when counting.

We cannot exclude the possibility that the figures found by ovocyte counts are somewhat smaller than the actual number of eggs spawned during a season.

Trachurus trachurus inhabiting the area off the northern point of Africa (31°N-33°N) is characterised by higher fecundity as compared with that of the Cape Blanc area where it is at a minimum (Table 3). In the southern area (Saint Louis) the fecundity increases again as compared with the intermediate area.

Trachurus trachurus spawning grounds were also localized. The most intensive spawning was observed in the range of shelf waters off Cape Vert, Saint Louis and especially off Cape Blanc (Figure 5). The analysis of the maturation of 13 000 Trachurus trachurus showed that the spawning peaks in different local groups appeared to be in different months. Thus, fish inhabiting the area off Cape Blanc spawn intensively in November, and specimens from the Saint Louis area in March (5 and 6).

Larvae and fry of horse mackerel inhabit the same areas where the intensive spawning takes place, preferring localities with small thermal variability. Therefore they are often found in great numbers in waters adjacent to the shelf where these variations are less pronounced than on the shelf, as will be shown later.

The analysis of the feeding of Trachurus trachurus from different areas of North-west Africa shows that the southern forms feed upon larger organisms than the northern ones. Table 4 confirms this fact.

The analysis of infestation by parasites in the musculature give different pictures for separate areas as well. In particular, the intensity of infestation by a helminth, Scolex pleuronectes, is 10 times higher in the area of Saint Louis than in the area of Cape Blanc (36 individuals of fish were examined).

Thus, the above-mentioned material shows that in the area from 11°N to 33°N separate local stocks of Trachurus trachurus and Caranx rhonchus represented by various size-age groups are found. Let us now examine the causes of the changes in size-age structure by seasons.

As can be seen from Figures 1 and 2 all size frequency curves of Trachurus trachurus from the areas of Agadir (34°N-30°N) and Cape Blanc (20°N-23°N) have dominatings lengths of 12-33 cm corresponding to an age of 1-6 years throughout the year. In the area of Saint Louis (14°N-19°N) all size frequency curves of Trachurus trachurus have the dominating lengths of 12-33 cm which corresponds to the age of 1-6 years throughout the year. In the area of Saint Louis (14°N-19°N) size frequency curves of Trachurus trachurus show one type of size-age groups during the warm period of the year, 10-12 cm lengths being dominant corresponding to the age of 1 and 5 years. In the cold period of the year other size-age groups occupy this area.

Analogous seasonal variations in the structure of size-age groups are also found in the forms of Caranx rhonchus (Figures 3 and 4).

Relative isolation of local groups of horse mackerel in the above areas of North-west Africa, and the existence of considerable seasonal variations in the size-age structure of these stocks are in good agreement with the existence of seasonal migrations not in the latitudinal, but in the longitudinal direction, and in their wider habitat covering the waters of the open sea.

In our opinion, this phenomenon is caused by the peculiarities of the dynamic structure of the water masses in the areas under investigation, and by a different seasonal variability in them. Water dynamics and distribution of thermohaline and hydrochemical indices form the conditions for living organisms, and thereby regulate the distribution of commercial concentrations as well as the strength of fish brood in the ocean.

We use the topographic charts of the 16° isothermic surface for the warm and cold periods to characterise the dynamic structure of the waters of the area under investigation (Figures 5 and 6). Convergence and divergence zones are well traced in these charts. In the convergence zones, the 16° isothermic surface sinks abruptly, in the divergence zones (to the left when observed upstream) this being situated above. The convergence zones usually coincide with the maximum of geostrophic current velocities in such charts (2).

Figures 5 and 6 show that the convergence zones are situated close to the shelf in the areas of Cape Blanc and to the north of this throughout the year. These areas are characterised by an intensive inflow of deep waters into the shelf. In the southern area, a well defined convergence zone is situated far from the shelf, in the open sea. In the cold period, a secondary convergence zone is formed adjacent to the shelf, east of which deep waters appear to flow into the shelf. Thus, in contrast to the northern areas, there is a considerable seasonal variability in the intensity of deep water inflow into the shelf.

Considerable differences in seasonal variations of water dynamics in some locations of the area are attributed to the corresponding changes in the distribution of the physical fields of these areas. This is shown in Figure 7, from which we see that the shelf waters of the Cape Blanc area, in contrast with the southern areas, are characterised not only by the stability of the water dynamic structure, but by the relative constancy of thermal conditions during the year as well.

The distribution of feeding grounds is the consequence of well defined seasonal changes in the dynamic structure of the Saint Louis area, as distinct from the northern areas. Thus, the shelf waters off Cape Blanc differ from those of the southern area by a higher plankton biomass (Figure 8). In the southern area, the locations of high plankton biomass are found in the open sea, on the boundaries of upwelling and sinking (Figures 5, 6 and 8).

The above-mentioned features of the seasonal changes in the dynamic structure and physical properties, and, consequently in the distribution of feeding grounds in some localities off North-west Africa accordingly influence the peculiarities of the seasonal distribution of the horse mackerel size groups, their habitat and biology.

Thus, the stability in the fish size-age composition during the year in the Agadir and Cape Blanc areas is the consequence of a stable upwelling on the shelf in all seasons. A significant amount of the horse mackerel stock seem to inhabit this area continuously in the shelf zone (Figures 1, 2, 5 and 6).

The opposite is true in the Saint Louis area. In the summer period when the intensity of upwelling is weakened over the shelf area, horse mackerel concentrations of size-age groups representing ages of 1 and 5 years, are formed here (Figures 2 and 5). In the winter period with the intensification of the upwelling over the shelf area, other size-age groups which were previously absent, occupy the area (Figures 1 and 6). Commercial concentrations of horse mackerel are formed in the southern area by this time.

The existence of localities with a significant plankton biomass in the open sea area adjacent to Saint Louis (Figure 8), a somewhat lesser seasonal variability in dynamic and physical properties of the waters as compared to the shelf waters, and the presence of intensive zones of upwelling and water sinking, all create the conditions for horse mackerel concentrations beyond the shelf. The data collected by expeditions of AtlantNIRO vessels confirm the presence of horse mackerel concentrations in the open sea. The results of the analysis of the feeding of tuna, sailfish and dorados, taken from the open sea in the area of 14°N-23°N, also confirm this.

This conclusion is also confirmed by a number of morphological and biological features of fish from different areas.

Thus, in the Saint Louis area an increase is observed in the predorsal, preanal and interventral distances of <u>Trachurus trachurus</u> forms as compared with the Cape Blanc area (Table 1). An increase in the number of gill rakers of <u>Trachurus trachurus</u> from the north to the south (Table 1) indicates that the southern forms of <u>Trachurus trachurus</u> have to feed upon smaller organisms.

The analysis of the feeding of fish inhabiting the shelf waters do not confirm this suggestion. The material shows (Table 3) that in more southern areas <u>Trachurus trachurus</u> feed upon larger organisms in the shelf, and fish prevail in their diet. This suggests that the southern forms of horse mackerel inhabit the open sea in great number, apparently coming to the shelf waters only in the spawning period.

Thus, in the area off North-west Africa a number of local groups of horse mackerel do exist. Some of them spend the greatest part of their life in the shelf waters (north of Cape Blanc), while others have a wider habitat extending considerably into the open sea. A part of their life cycle is spent in the shelf waters, the rest is spent in the open sea where all the required conditions for their living exist.

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Table 1. Intraspecific geographical variability of horse mackerel, *Trachurus trachurus*.

Area	Fish body length after Smith (cm)	Subsample volume (Ni)	Morphological characters														
			Maximum body depth H (mm)			Predorsal distance AD (mm)			Preanal distance AA (mm)			Preventral distance AV (mm)			No. of gill rakers in the 1 opercularch (pcs.)		
			Mean value xi	Mean error xi	Normalized deviation t	Mean value xi	Mean error xi	Normalized deviation t	Mean value xi	Mean error xi	Normalized deviation t	Mean value xi	Mean error xi	Normalized deviation t	Mean value xi	Mean error xi	Normalized deviation t
Agadir (29°55'N)	28-31	35	62.25	0.26	1.54	94.88	0.44	2.68	157.02	0.70	3.86	83.00	0.47	1.20	60.10	0.26	2.44
Cape Blanc (20°45'N)	28-31	35	63.22	0.14	6.27	92.74	0.20	6.34	152.54	0.66	9.57	81.90	0.35	6.99	61.74	0.19	0.58
Saint Louis (15°40'N)	28-31	20	67.55	0.34		98.20	0.54		165.75	1.25		89.80	0.93		62.20	0.30	

Table 2. Intraspecific geographical variability of *Caranx rhonchus*.

Area	Fish body length after Smith (cm)	Subsample volume (Ni)	Morphological characters											
			Maximum body depth H (mm)			Predorsal distance AD (mm)			Preanal distance AA (mm)			Preventral distance AV (mm)		
			Mean value xi	Mean error xi	Normalized deviation t	Mean value xi	Mean error xi	Normalized deviation t	Mean value xi	Mean error xi	Normalized deviation t	Mean value xi	Mean error xi	Normalized deviation t
Cape Blanc (19°07'N)	28-30	30	70.71	0.30	3.90	89.63	0.31	2.97	151.54	0.69	3.75	78.27	0.13	4.55
Conakry (11°02'N)	28-30	21	66.66	0.78	(2.68)	92.66	0.75	(2.68)	157.66	1.47	(2.68)	82.19	0.62	(2.68)

Table 3. Fecundity of horse mackerel, Trachurus trachurus, from different areas of the shelf.

No.	Area	No. of specimens	Mean fecundity (thousands of eggs)
1	31°-33°N	13	250
2	21°-23°N	7	133
3	14°-15°N	7	166

Table 4. Food items of Trachurus trachurus in some areas of the North-West African shelf.

		% of dietary clot
29°57'N		100
18°34'N-23°05'N	Euphausiids	87.2
	Shrimps	0.9
	Ctenophora	0.4
	Squids	0.4
	Phytoplankton	0.9
	Copepoda	1.0
	Fish	9.2
	Among them:	
	Anchovy (En. hepsetus)	5.7
	Horse mackerel (Tr. sp.)	0.4
	Unidentified	3.1
15°12'-17°09'N	Euphausiida	80.7
	Fish	14.8
	Mysids	3.4
	Copepoda	1.1
13°39'-15°12'N	Fish	50
	Copepoda	33
	Euphausiids	17

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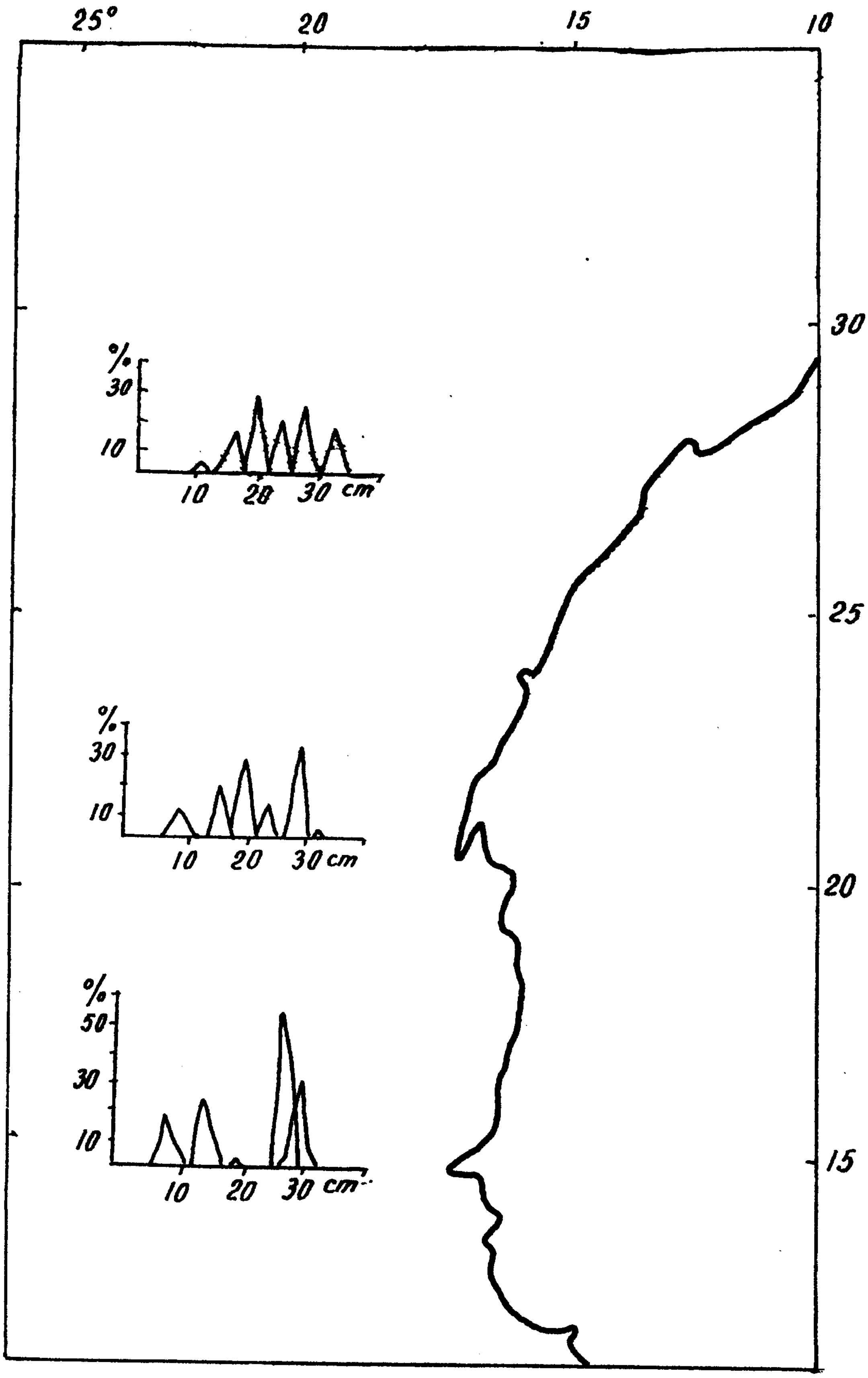

Figure 1. Distribution of the size groups of *Trachurus trachurus* in the cold period (November - April).

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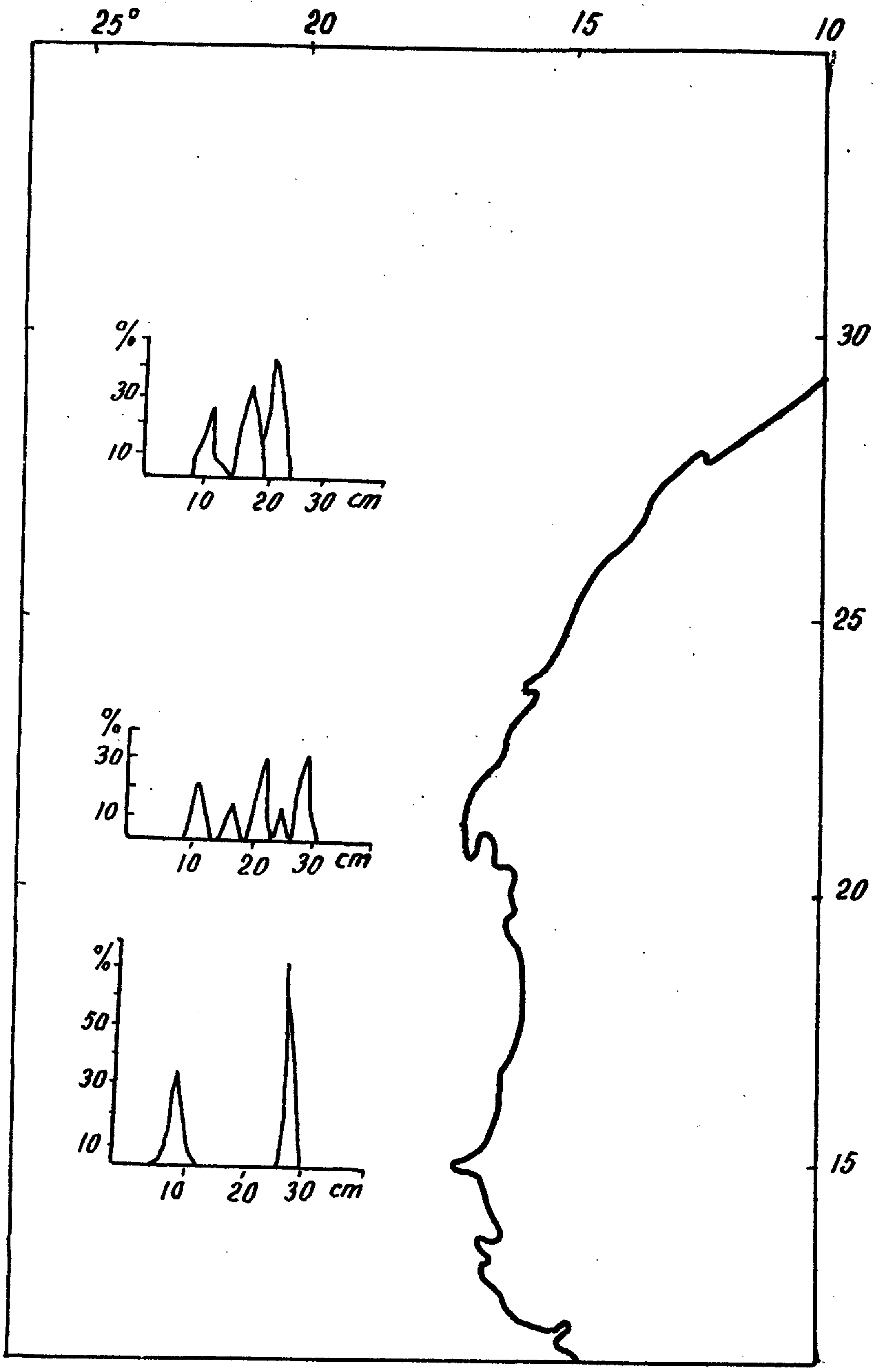
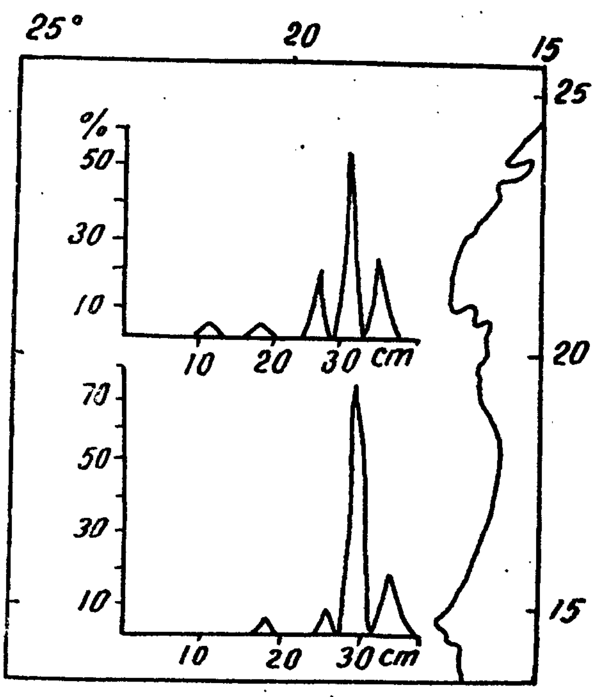


<u>Figure 2.</u> Distribution of the size groups of <u>Trachurus trachurus</u> in the warm period (May-October).



<u>Figure 3.</u> Distribution of the size groups of <u>Caranx rhonchus</u> in the cold period (November - April).

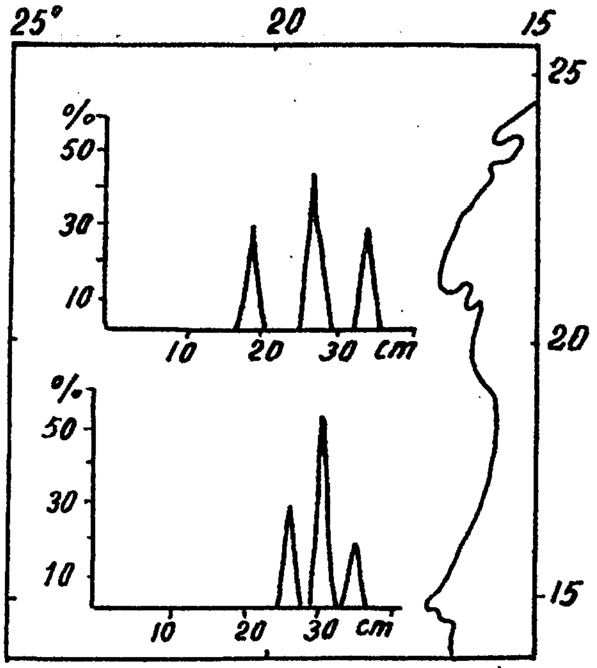


Figure 4. Distribution of the size groups of Caranx rhonchus in the warm period (May - October).

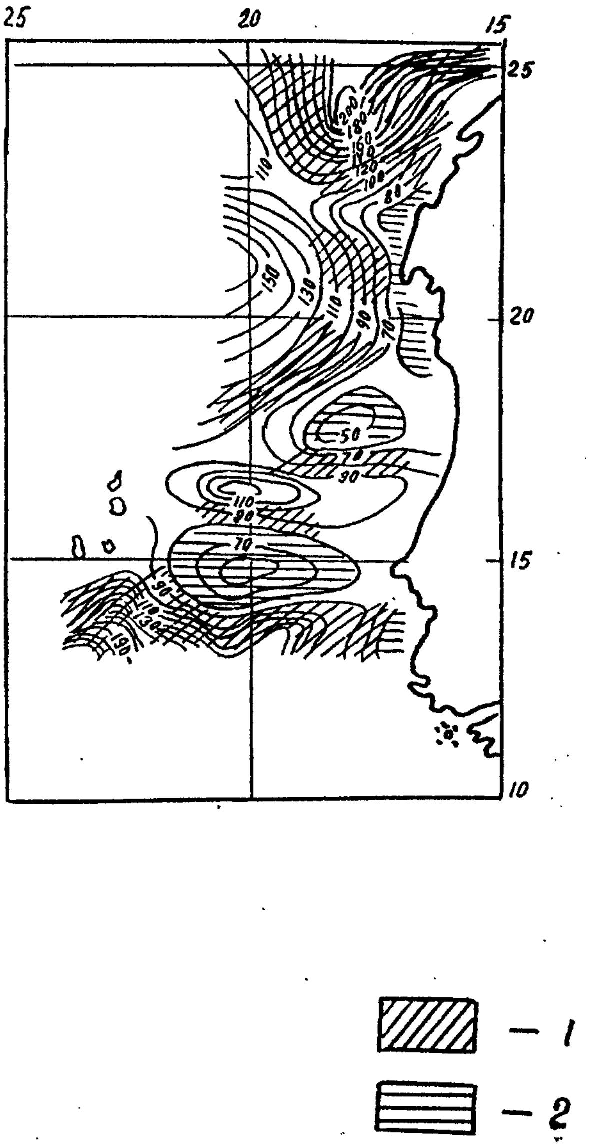


Figure 5. Chart of 16° isotherm depth (16°C isothermal surface) in the cold period (December - May):

1 - zones of water sinking

2 - zones of upwelling

This legend 1 and 2 goes for Figure 6, 7, and 8 also.

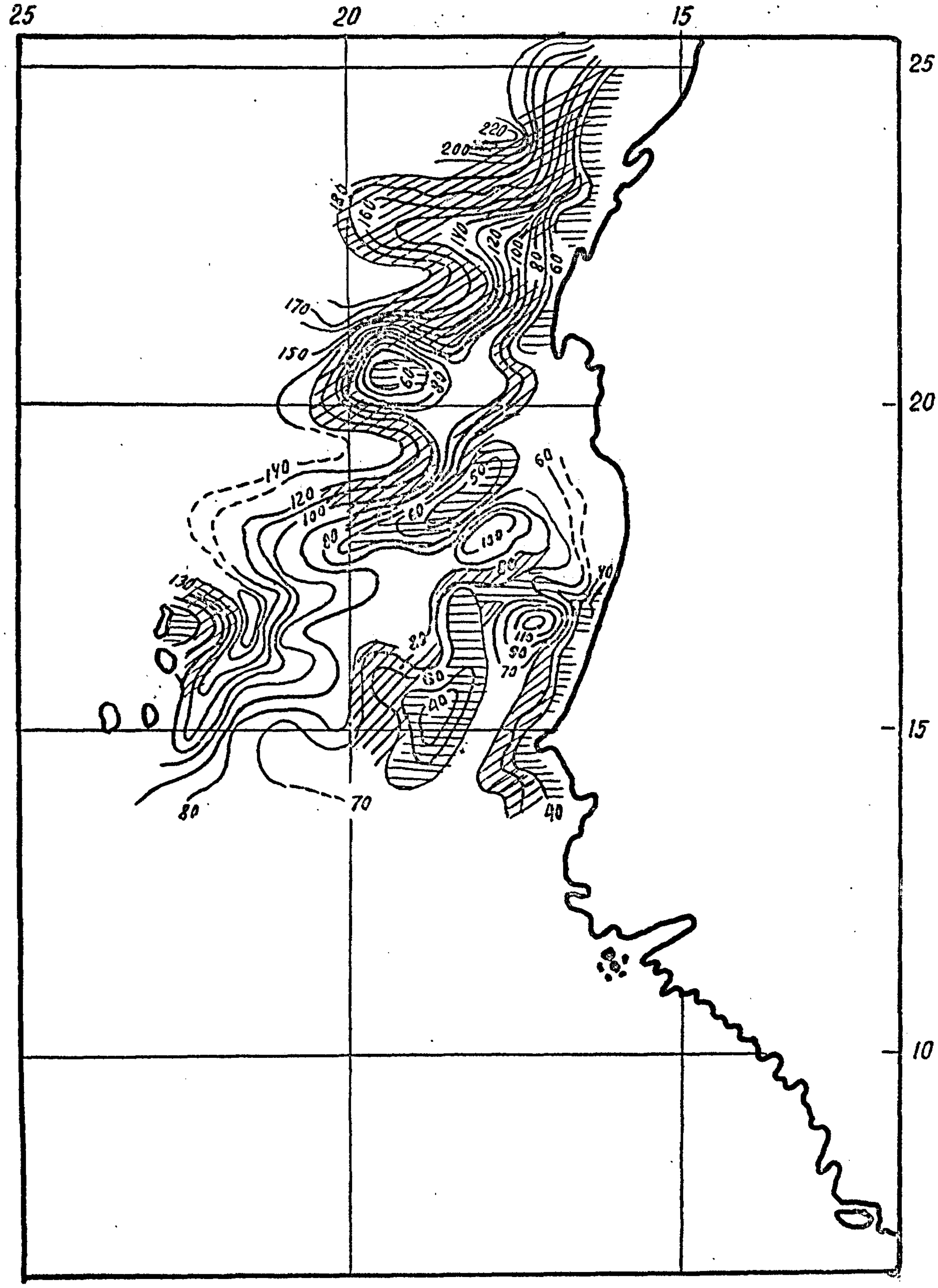


Figure 6. Chart 16° isotherm deoth in February 1966.
For legend: see Figure 5.

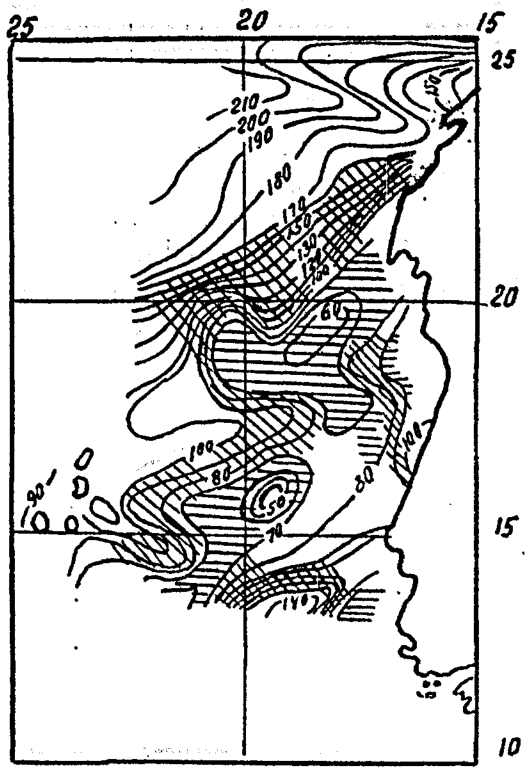


Figure 7. Chart of 16° isotherm depth in the warm period (June-November):

Legend: see Figure 5.

1 - zones of water sinking

2 - zones of intensive upwelling.

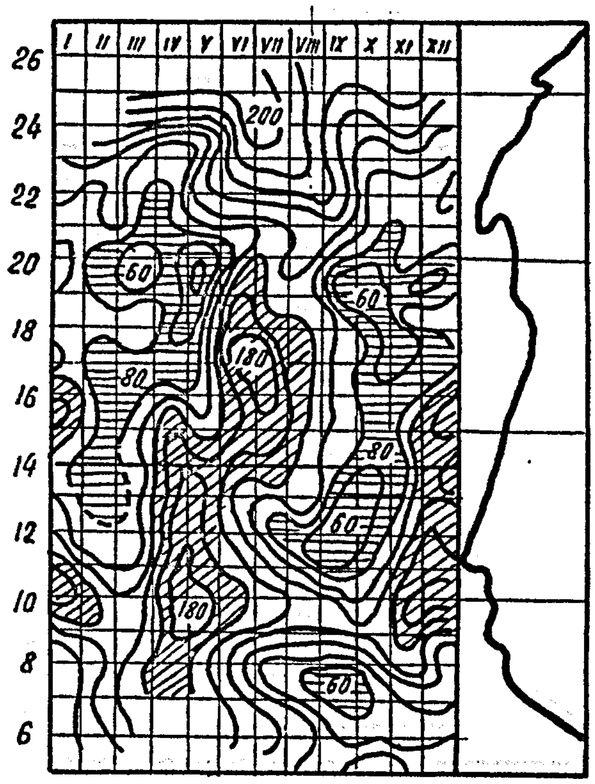


Figure 8. Chart of seasonal variations in 15° isotherm depth (15°C isothermal surface) in the shelf water zone of north-west Africa (after Sigaev). For legend, see Figure 5.

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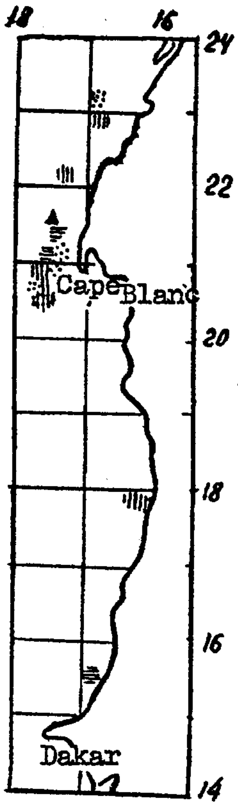

Figure 9. Spawning grounds.

<100 eggs — 1

100–120 —"— — 2

501–1000 —"— — 3

>2500 —"— ▲ — 4

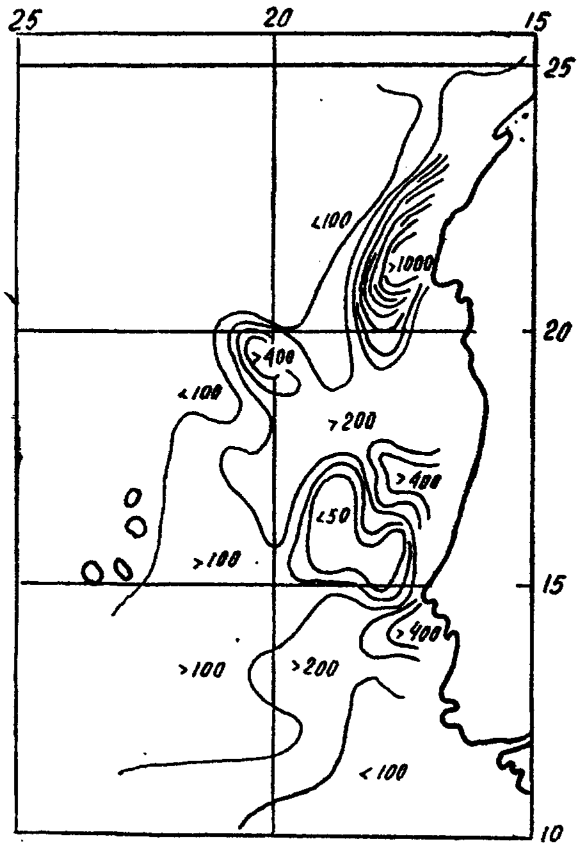

Figure 10. Distribution of the plankton biomass in the 0-100 m layer (according to data of the oceanological survey in March 1966).