FISHERIES OF THE SOUTH-EASTERN MEDITERRANEAN SEA ALONG THE EGYPTIAN COAST

SOVIET-EGYPTIAN EXPEDITION
1970-1971

Edited By

A. A. Al-Kholy and S. K. El-Wakeel
Institute of Oceanography and Fisheries
Academy of Scientific Research and Technology
A. R. Egypt

Editorial Secretary
H. M. Botros

INTRODUCTION

The Mediterranean Sea fisheries play a very imoprtant role in the national economy of the Arab Republic of Egypt. A substantial catch increase took place in the fifties and at the beginning of the sixties and was attributed to the increase of the fishing fleet and its mechanization. In 1962 the fish and prawn catch near the Egyptian shores accounted for 378 thousand centners ; the biggest amount for the whole history of fisheries.

In 1963 the marine prdoucts output tended to decrease, a trend which has continued up till now. A special sharp decrease was in the sardine catch (from 182 thousand centners in 1962 down to 12 thousand centners in 1966) and the prawn catch (from 71 thousand centners down to 27 thousand centners in the respective years). In 1966 the total ARE catch in the Mediterranean Sea accounted for 150 thousnad centners.

Such decline in the marine fisheries called for enhancing the fish investigations. Hence, in 1965-1966 the first Soviet-Egyptian Expenidition took place on R/V "Ichthiolog".

The results of the expendition allowed to assess the condition of the marine resources within the period of study and find out certain causes for the drop. In the opinion of Egyptian specialists the main reason of the sharp decrease in the number of commercial units was the intensification of fisheries and utilization of more up-to-date fishing gear. (c.f. El-Zarka and Koura, 1965).

In 1965-1966, the High Aswan Dam was erected. This led to a sharp drop of the river discharge which used to play a major role in the formation of the bilogical productivity in the southeastern part of the Mediterranean Sea.

The drop in the Nile discharge and the change of the oceanographic coniditions in the area under study affected badly the conditions of existence and multiplication of marine organisms.

The joint fishing efforts and the decrease of the Nile river discharge resulted in a further catch drop which in 1969 accounted only for 85 thousand centners of fish and prawns.

The 6th Session of the Soviet-Egyptian Commission on fisheries, held in Cairo, during February 1970, took a decision to set an expedition with a view to evaluate the state of marine fisheries resources in connection with the considerable change of the hydrological regime.

All the work stipulated by the programme was implemented in full. The scope and characteristics of the materials collected are given in Table 1.

In accordance with the bilateral agreement, the Azcherniro (Kerch) was presented with data on the temperature, salinity and oxygen of sea water ; material on biology and dimension-composition of prawns and fishes and total samples of zoolpankton in the spring and summer seasons of 1971. The Alexandria Institute of Oceanography and Fisheries was presented with copies of all the above materials, as well as data on biogenous substances, samples of phytoplankton, zooplankton and ichthyoplankton on all standard levels as well as zoobenthos samples.

For the purpose of summing up the material collected by the expedition and with a view to writing a report, the contract stipulated a two months' stay in ARE of Soviet specialists in the field of oceanography and biology. In acordance with the said agreement, two Soviet specialists stayed in Alexandria from February 7 through April 22, 1972, viz V.A. Bybik, senior research worker, laboratory Head of commercial oceanography of Azcherniro, and S.S. Drobysheva, Cand. Biol. Sc., Hydrobiological Laboratory.

Apart from the Soviet specialists the report was also elabortaed by workers of the Alexandria Institute of Oceanography and Fisheries (Table 2). As a result of their joint work, this report was prepared. It comprises seven chapters, an introduction and a conclusion. Certain sections of the report are written by the following Soviet and Egyptian specialists :

Chapters I and II are written by the authors of this report.

Chapter III, section "Distribution of physicochemical characteristics of sea water", is written by V.A. Bybik, senior research worker, Dr. S. Gorgi, Dr. M. Lotfi El Hehiawy and N.A. Ryabchikova, Hassan Mustafa and Hosni Omara, research workers. The remaining part of this chapter, viz. "Meteorological Conditions", "Water Bodies", "Currents" and "Continent Drainage", as well as Chapter IV are written by V.A. Bybik, senior research worker, and Dr. M. Lotfi El Hehiawy.

Chapter V is prepared bv V.R. Yashkin, and Chapter VI is fully written by S.S. Drobyscheva, Y.P. Aseev, jun. research worker, and by Dr. M. El Hawary with participation of Prof. A. Al-Kholy and F. Abdel-Razek, research worker. The section "Contemporary state of prawn population" is written by S.S. Drobysheva.

Table 1.—Scope of Work Carried Out by the Expedition

Ser. No.	Description of work performed	by quarters of year				Total
		1	2	3	4	
1	2	3	4	5	6	7
1.	Distance covered by ship (in miles)	3050	2965	3359	3356	12730
2.	Distance covered with trawl	138.4	138.1	148.4	150.4	575 3
3.	Distance covered with fathometer	1678	.91058	2749	.91939	7031.9
4.	Fathometer performance, hrs.	161	164	350	251.8	936.8
5.	Trawling operations	47	50	53	53	203
6.	Light stations performed	9	5	6	7	27
7.	Anchor stations performed	35	35	42	42	154
8.	Phytoplankton samples collected	208	200	211	215	834
9.	Zooplankton samples collected	153	169	223	243	788
10.	Ichthyoplankton samples collected	—	77	112	112	301
11.	Zoobenthos samples collected	6	11	10	14	41
12.	Water temperature measurements taken	353	348	492	433	1626
13.	Water salinity measurements taken	353	348	492	433	1626
14.	O_2 determination performed	353	348	480	433	1614
15.	Water oxidation determination performed	—	104	116	196	416
16.	Phosphate content determination performed	290	224	302	266	1082
17.	Silicate content determination performed	207	224	310	260	1007
18.	Nitrate content determination performed	207	224	295	266	992
19.	Nitrite conetnt determination performed	207	224	286	266	983
20.	Fish biological analyses	9	7	18	22	56
21.	Number of fish analyzed (pieces)	718	472	560	1089	2839
22.	Number of fish measured (pieces)	2767	2025	1148	4449	10381
23.	Number of fish weighed (pieces)	1028	818	765	4449	7060
24.	Number of prawns analyzed	477	600	748	573	2418
25.	Number of prawns measured	600	1350	1382	300	3637
26.	Number of prawns weighed	600	1350	1378	300	3642

Table 2– LIST OF RESEARCH GROUP OF THE EGYPTIAN SIDE PARTICIPATING IN THE EXPEDITION

Name	Speciality	Cruise number joined			
		I	II	III	IV
Dr. Mohammad Talaat Hashem,	Ichthyology.	+			
Dr. Mohammad Ali El-Hawary,	Crustacea	+	+		
Mr. Ahmed Hamdi, Shahin	Ichthyology			+	+
Miss Fatma Ali Abdel-Rasek,	Crustacea	+	+	+	+
Mr. Monir Hilal,	Ichthyology	+	+	+	
Mr. Sami Fayek,	Ichthyology	+	+	+	+
Mr. Wasfi Abdel Salam Eliwa,	Technician	+			
Mr. Hassan Mostafa Hasan,	Hydrology	+	+	+	+
Mr. Hosni Ibrahim Omara,	Hydrochemistry	+	+	+	+
Mr. Mohammad Hussein,	Hydrobiology (zooplankton)	+	+	+	+
Mr. Sherif Fahmi Badawi,	Hydrobiology		+	+	+
Mr. Mamdouh Abdel Maksoud,	Geologist			+	
Mr. Mohammed Amin Karam,	Hydrography			+	
Mr. Ahmad Irbahim,	Hydrobiology			+	
Mr. Mohammad Hegazi Sultan,	Skipper	+		+	+
Mr. Mohammad Ihab Bebars,	Ichthyology	+			+
Mr. Nabil Mansur,	Technician				+
Mr. Said Abd-El-Halim Kamel,	Plankton				+
Mr. Salah Mohammad Negm,	Algae				+
Mr. Mohammad Abdel-Monem	lab.. assistant				
Mr. Ezzat Awad Ibrahim,	Hydrbiologyt				+
Mr. Michel Kamel Abdel-Misih,	Ichthyology.				+

Chaper VII was prepared by research workers A.S. Piotrovsky, P.B. Tankevich, S.F. Badawi, S.F. Yosef, M. Helal, M.E. Bebars as well as Mr. A. H. Shahin and Dr. M. T. Hashem. The conclusion was prepared by A.G. Grobov, S.S. Drobysheva and V.A. Bybik.

The general editing of oceanographic sections was done by V.A. Bybik, and the biological one - by S.S. Drobysheva.

Apart from the materials of the 1970-1971 expedition, the authors of the report analyzed data of preceeding investigations carried out in the area under study on board the researsh ship "Ichthyology" in October 1964 and from December 1965 through December 1966, as well as literary data.

This report presents the results of investigations undertaken within the period of low drainage resulting in certain change of the conditions of existence and reproduction of marine orgainsms.

The investigations give a presentation of the up-to-date state of the oceanographic and biological characteristics of the area examined on which basis there are certain possible perspective assumptions.

In conclusion the authors of the report would like to express their gratitude to all the staff members of Azcherniro and the Alexandria Institute of Oceanography and Fisheries who took part in the collection and treatment of materials which were used in the course of writing this report.

Procedure of Collection and Treatment of Material

(a) *Technical and Navigational Backing.*

All investigations and researches by this expedition were craried out by an average fishing trawler with a board trawler (SRT-R) "Ichthyology" which has the following tactico-technical data :

1. The ship was built in accordance with the standards of the Register of Shipping of the USSR for unlimited sailing in 1957 at the works "Leninskaya Kuznitsa" in the city of Kiev; USSR.

2. Max. length 43.6 m.

3. Max. ship width 6.7 m.

4. Board height 3.8 m.

5. Total register capacity — 334 register tons.

6. Dead weight — 179 tons.

7. Max. cruising speed — 10 knots.

8. Prow immersion — 2.6 m.

9. Stern immersion — 3.25 m.

10. One engine, 6 DR 30/50 type, 400 hp capacity, available on the ship, propelling screw r.p.m. (max) — 230.

11. Fuel stock — 59 tons.

With full fuel and water stock the independent ship's sailing is 30 days.

For the purpose of implementing a whole complex of research vessel SRT "Ichthyolog" is equipped with the following fishing equipment.

1. Electric trawl winch with a tractive effort - 4 tons.

2. Trawl ropes from a flexible steel rope with a diam. of 20 mm and a length of 200 m.

3. Slot oval boards, Materosov type, an area of 2 m^2 each.

4. Loader beams 7 m long each to hold a board trap, holding capacity being 1 ton.

5. Bottom trawls 20 m - 3 pcs.

6. Board trap with a light train (300 m) and a set of spare parts thereto.-1 pcs.

Search gear comprised the following :

1. Hydroacoustic station "Halibut-M" design to locate horizontal fish swarming to a radius of 2 thousand meters and vertically to a depth of 600 m.

2. Sounding device, NEL-5r type, permitting to make a search for fish swarming under the ship's keel to a depth of 500 m and to determine the length, density and thickness of a fish swarm vertically.

3. Sounding device, HAG-240 type, with an electronic indicator permitting to see depths within a range of 1250 m on its screen.

Research Instruments used :

1. LG-100 hydrological type winch, 5 kw capacity.
2. Winch of hydrobiological design, type "Thompson" electrically driven.
3. Nansen bottle-20 pcs.
4. Thermometers-50 pcs.
5. Aneroid-lpc.
6. Psychometer aspiration-type-1 pc.
7. Bathythermograph-1 pc.
8. Surface thromometer-1 pc.
9. Jedy nets, big model, with a diameter of the water intake of 36 cm.
10. Fish egg nets, IKS 20 × 113 - 3 pcs.
11. Bottom-grab (ocean-50") - 2 pcs.
12. Dredge - 1 pc.

The research vessel "Ichthyolog" was supplied with navigational manual maps and sailing directions in accordance with the catalogue of maps and books. During the sailing, the maps and manuals were corrected as per the data broadcast over the radio.

The ship equipped with all navigational devices providing for the safety of sailing and the exactness of bearings.

(b) **Oceanographic Data.**

The occeanographic research in the south-eastern part of the Mediterranean Sea in 1970-1971 was done within an area limited by meridans 25° and 31°35 of eastern latitude, the northern boundary going at a distance of 75 to 100 miles from the shore. During September-October 1970 and February, May and August 1971 four surveys were undertaken in this area. During each hydrological survey, observations were taken at stations located at cross-sections Damietta coast - sea, Borullos cape-sea, Abukir bay-sea, Arab bay-sea, Mersa-Matruh bay-sea, Sallum bay-sea. In September October, 1970, and in February, 1971 the occeanographic stations at the cross sections were located at 5, 10, 20, 30, 50, and 70 miles from the shore.

At the cross-section of Mersa-Matrouh bay-sea (during the first cruise) and at the cross-section of Abukir bay-sea (during the second cruise) no observations were undertaken at stations at a distance of 75 miles from the shore. In May and August, 1971, observations were carried out at 7 stations.

As recommended by the Oceanographic Lab. of Azcherniro, in addition to the standard scheme of stations accepted during the previous cruises, the programme of work of the third and the fourth cruises included observations at stations located at a distance of 100 miles from the shore.

Fig. I shows the location of oceanographic stations in the southeastern part of the Mediterranean Sea in 1970-1971.

The number of stations worked during the first survey is shown on the left of the scheme, the stations worked in February, 1971, are shown in the second row ; the stations worked during May in the third row ; the number of stations worked in August 1971 are shown on the extreme right.

The wind swelling sea, air temperature and cloudiness were observed at each station. Hydrological observations were done at standard levels of 0, 10, 20, 30, 50, 75, 100, 150, 200, 250, 300, 400, 500, 750, 1000 and 1200 m. Nansen bottles (BM-84) were used to sample sea water for determination of its physicochemical characteristics. The air temperature was determined with the aid of deep-sea thermometers, whereas at certain stations with the aid of bathythermograph.

The calculation of catual temperatures was done by means of introducing instrumental and reduction corrections to thermometer readings. The actual temperature was taken to be the arithmetic mean of the temperature values shown by each of the couple of thermometers placed at same level. The water chlorinity was determined by the method of Mohr-Knudsen. The salinity, conventional density (δt) and stability of the stable water mass in strata between the standard level were determined with the aid of the "Oceanological Tables" by Bubov, 1957.

Under favourable conditions (absence of swells and presence of good illumination) prevailing at the hydrological stations, observations were made for the water transparency with the aid of the Sekki disc.

The hydrochemical research comprised determination of the following items dissolved in water : oxygen, phosphates, silicates, nitrites, nitrates, as well as oxidation of the sea water and active recation of the water (pH).

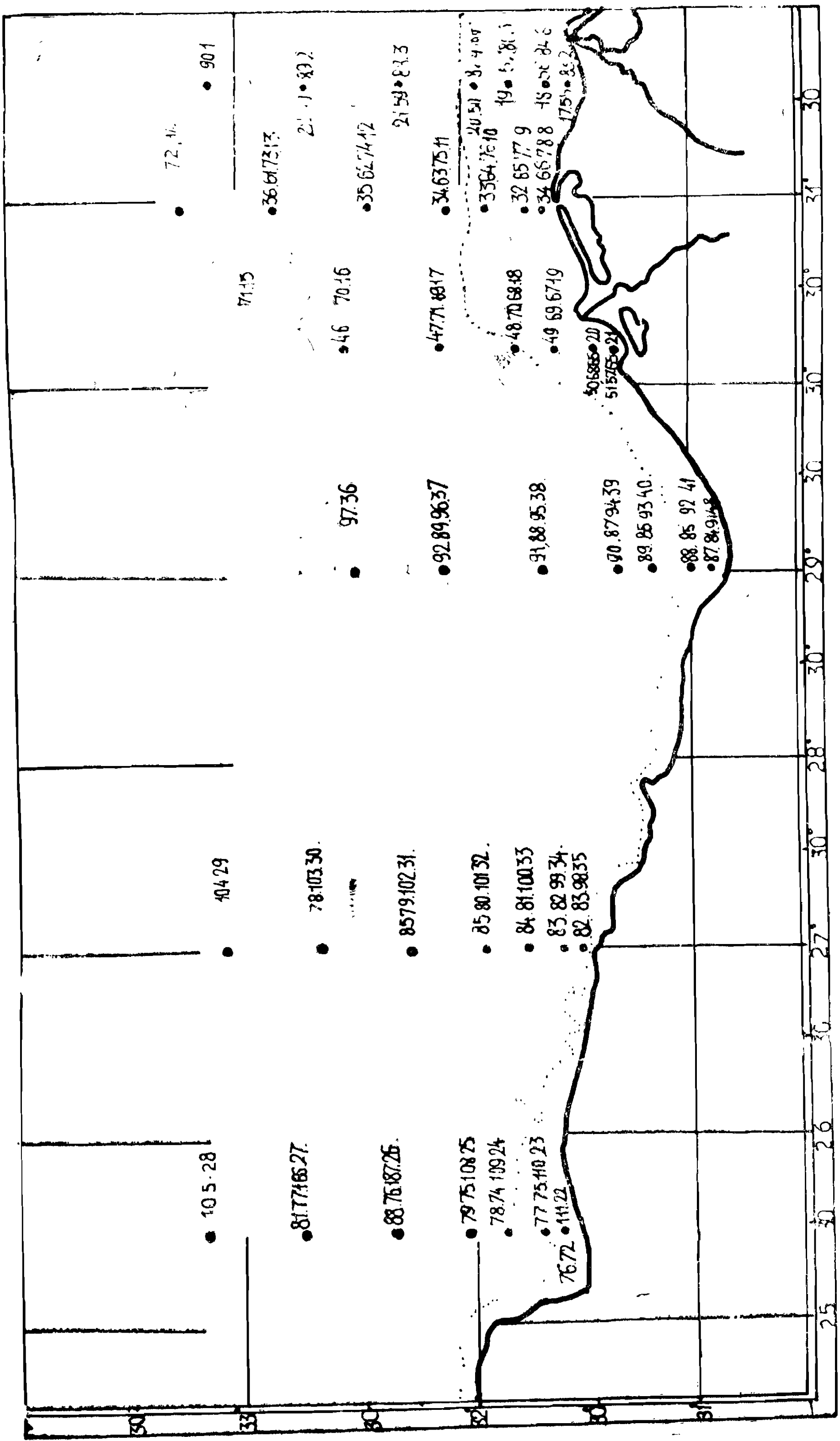


Fig. 1. Schematic map showing the location of Oceanographic stations worked by Ichthyology in 1970—1971

Water asmples for hydrochemical analyses were taken at a levels to a depth of 1200 m.

Biogenic elements (phosphates, silicates, nitrites and nitrates) mined at stations 1, 3, 5, and 6 of the cross-sections, the per oxidation being determined at stations, 2 and 4. Dissolved determined at all stations, except for the summer season.

In the course of determination of oxygen the Winkler's iodime was used. To determine oxidation, the Skopintensev method medium was used ; phosphates and silicates, were determined f Strickland and Parson method ; nitrites, was determined following Armstrong method ; as to nitrates, the Wood and Richard followed.

For the purpose of analyzing biogenic elements Mr. Ho researcher of the Alexandria Institute of Oceanography and Fi the Japanese electrocalorimeter by the firm of Tokyo Koden ; th of the elements' concentration being also done by him. The active water reaction (pH) was determined with the aid of pH-meter PCR-L2 by Mr. Hasan, a researcher of the Alexan of Oceanography and Fisheries.

However, the methods did not foresee the introduction of and salt corrections for biogenic elements and active water re The standard solutions to elaborate a calibration chart were p distilled water.

The oxygen percentage saturation calculated on the basis of Carrit tables.

In 1966 the water percentage saturation with oxygen was cal on the Trusdale table. To compare the data for 1966 and 197 oxygen saturation for 1966 was recalculated with the aid of the G tables.

In the text of this Report and in Figures hereof the content oxygen is represented in ml/1, the concentration of biogenic elem in microgram-atom per liter Ug-at/1), oxidation - in Ug O_2/1.

(c) **Hydrobiological Data**

The hydrobiological research comprised the collection of zooplankton as well as the study of prawns, Plankton samples were collected at the oceanographic stations of the standard cross-sections, simultaneously with the hydrographic work.

1. Water samples for the quantitative assessment of phytoplankton were taken with the Nansen bottle (BN-48) from levels 0, 10, 25, 50, 100 and 200 m. The samples were fixed by alcohol iodine solution and iodine potassium (lugol's solution). This is the best fixer for such fragile forms of phytoplankton as flagellate (Salah, 1963). Cells were calculated with the aid of an inversion microscope in a calculation chamber, 50 or 100 m^3 capacity as per the Utermohl method (Utermohl, 1936 and 1958).

Each sample was inspected twice and 1 litre of water was calculated for all organisms.

This method gives the most reliable results of quantitative assessment of samples (Kreg, 1953, Joseph, 1953 ; Laevastu and Barnes, 1958).

2. Zooplankton samples were collected by the Jeddy net (silk bolting cloth No. 38, water inlet diameter 37 cm). The samples were collected in layers between standard levels : during 1st and 2nd cruises — in layers 200-100, 100-50, 50-25, 25-0 ; during 3rd and 4th cruises — in layers 200-150, 150-100 ; 100-50, 50-25, 25-0. Apart from that, at all the stations total catches were carried out on level 100-0 and on the bottom — 0 (provided the depth was less than 100 m). The net was closed at the necessary depth with the Nansen locking device. Samples were kept into glassware with a capacity of 250 ml. and fixed by a 4 per cent formaline solution.

In field conditions the total samples were preliminarily treated with the aim to find mass of zooplankton and determine the level of biomass. With this purpose in view samples were examined through a binocular and their volume was measured by the Yashnov voluminometer (1959) thus enabling to undertake corrections of field work depending on the result.

In the laboratory, the weight of total samples was determined and a good treatment of all samples was undertaken. To determine the weight, the sample was filtered through silk bolting cloth No. 25 (200 holes per inch), the sediment was dried on a filter paper for 2 minutes and weighed on an analytical balance. The result was recalculated in terms of 1 cu.m of filtered water.

The count method was used for the final analysis of zooplankton. The content of each sample was concentrated up to a volume of 100 ml. Part of the sample (1 or 5 ml) was taken to a count chamber (Soviet specialists made use of the Bogorov chamber) and organisms were determined and counted through a binocular. The results were recalculated in terms of 1 ml. of filtered water.

Big organisms (Sagitta, and big larvae etc). were counted through a whole sample. Admixtures were separated from the mass of plankton and excluded from the total biomass.

3. The trawl catch* served as the material for prawn biology studies. In the case of small catches (less than 5 kg) all the samples caught were treated, whereas in the case of big catches — only part of the catch was subjected to treatment.

The treatment presented as follows :

(a) The total quantity of all prawns caught was calculated.

(b) The species quantity and the sex relationship of each species were determined.

(c) Differentiated mass measurement (as per species and sex) of all prawns was done, the precision of measurement being accurate to 1 mm. Two lengths were taken into account : (I) the total body length from the outer edge of the eye to the end of the telson ; (II) the length of the carapace from the outer end of the eye to the middle of the end of the carapace.

(d) All prawns were weighed and counted separately as per species, sex and size.

(e) The females were bilogically analyzed, including individual measurement, determination of the maturity stage, the ventricle content and the testa condition.

The female maturity was determined visually according to the 5-mark scale of the ovary maturity which is based on the results of histological studies of Penaeus prawn gonads carried out in 1970 by Mr. R.N. Burukovsky, a researcher of the Atlantic Research Institute of Oceanography and Fisheries (Kaliningrad, USSR).

(*) The scope of the work implemented, location of side-trawling and their timing are refered to in the Section "Search and Commercial works"

Table 3.—GONAD MATURITY SCALE OF PENAEUS FEMALE PRAWNS

Stages	Visual Condition of Ovaries
I	Form of thin transparent threads
II	Thin and turbid
III	Visibly thickish of pinkish colour
IV	Aspect of thick smooth pies lying over the intestinals, bright colour.
V	Very thick with transverse creases and cripms, of bright colour, visibly granulated.

It should be kept in mind that the post-spawn gonad condition ("beat out") as per its histological structure is very much similar to the 2nd stage of development and thus it is united with the latter. Hence, the 2nd stage of this scale unifies both first matured and secondarily matured.

Apart from the visual determination of the prawn maturity, (table 3) histological ovary samples were collected and will be treated later by Dr. El-Hawary and used to determine in more detail the spawning seasons.

Stomach and intestine contents were determined visually based on a 4-point scale generally accepted. (Table 4).

Table 4.—DIGESTIVE TRACT FILLING SCALE

Points	Visual filling of Stomach and Intestine
0	Empty
1	Filled-up far less than half
2	Half-filled
3	Full-up

Based on the above data the maturity index was calculated.

All material was statistically treated, tabled, and mapped.

(e) **Ichthyological Data**

The ichthyological material was collected and treated according to the procedure commonly accepted. The catch of each trawling was subjected to a qualitative analysis. Mass measurement and weight was effected to the different classes. The main commercial fishes were sampled and bilogically analysed. The biological analysis of fihses included the following :

1. Measuring and weighing.

2. Determining the maturity stage based on the 6-point scale (juv II, III, IV, V, VI) and weighing the gonads of mature fish.

3. Determining the stomach based on the 4-point scale (0, 1, 2, 3) and the visual qualitative composition of food.

4. Sampling the scale and otolith to determine the age.

5. Determining the fatness based on a 4-point scale (0, 1, 2, 3).

In the course of oceanographic work, collection of ichtyoplankton was made in the surface layer and in the layer of 0-25 cm. Samplss were taken with a Russ standard ova net (water inlet 80 cm) while the ship was cruising at a low speed.

(b) **Procedure of Carrying out Search and Commercial Work.**

Search work was carried out with the aid of hydroacoustic apparatus, trawl laying and attracting the fish by electrical light.

Depending upon the object, search was made as follows : prawn search by means of control bottom trawling, bottom fish search by means of acoustic apparatus and control bottom trawlings ; Pelagic fish search by means of acoustic apparatus and control fishing gear laying with the utilization of light (side or board trap).

The main objective of the work on the technology of commercial fisheries was to provide for the normal performance of fishing gear in the course of implementing research connected with catching fishery objects.

To attain the final goal, the programme of the expedition visualized the collection of data on oceanography, hydrobiology and ichthyology during the four seasons of the year of study.

The research programme was executed by two research institutions : on the Soviet part - the Azov Chernomorsky Research Institute of Fisheries and Oceanography, Kerch, and on the Egyptian part - the Institute of Oceanography and Fisheries, Alexandria.

Investigations were carried out from borad the Soviet research ship "Ichthyolog" from September 1970 up to October 1971 in the south-eastern part of the Mediterranean Sea between latitudes 25°20′ North and 31°35′ East. A more detailed work was carried out on the shelf area north of the Nile Delta - the main fishing area of Egypt.

Four cruises were undertaken in the above area during the following periods :

1 cruise — from Augsut 20 through October 20, 1970.

2. cruise — from January 5 through March 1, 1971.

3 cruise — from April 5 through June 10, 1971.

4 cruise — from July 25 through October 9, 1971.

The participants on the Soviet part were as follows : Azcherniro- V.A. Budnichenko, ichthyologist, chief of the 1st cruise, A.G. Grobov, Cand. Biol. Sc., chief of the 2nd cruise, Y.P. Asseyev, hydrobiologist, A.S. Piot-rovsky and P.B. Tankevich, ichtyologists ; 3rd cruise and 4th cruise ; K.T. Khunov, V.I. Dannikova, N.A. Ryabchikova and L.A. Kovalchuk, oceanologists; V.K. Yashkind, specialist on fishing gear, and S.V. Galkin, (translator-interpreter), took part in cruises 1 & 2.

The list of the Egyptian participants from the Institute of Oceanography and Fisheries, Alexandria is given in Table 2. They changed depending on the objectives of each curise. In addition to the participants listed above, Makram Amin Gerges, a post-graduate student at Moscow University took part in cruise 3, Wagdi Fahmi, Wadi a post graduate student at the All-Union Research Institute of Fisheries and Oceannography (VNIRO) also took part in cruises 3 & 4.

Before the beginning of the search and commercial work the preparation and adjustment of TAG-200 devices was affected to make vertical control measurements of vertical opening of trawls and their adjustment.

The trawl stations were located in such a way so as to cover uniformly the area under study. The sites and routes of trawling were chosen based on the bottom relief, currents etc. investigated as a result of sounding device survey. The trawling routes were chosen so that the trawling depths should not vary to a substantial degree with only a gradual increase.

During the autumn season the trawling was done with Polish trawls : a 20-meter bottom trawl and a 27.1 meter one.

The 20-meter bottom trawl was equipped on the upper side with fifteen plastic units (the huoyancy of each being 14 kg), the lower side of the trawl *was equipped with a soft ground rope (steel wire rope with a diameter of 18* mm, covered around with a tarred hemp rope), consisting of three sections. The total weight of the soft ground rope is 240 kg, in the air and about 170 kg in water.

In addition to that, the ground rope was tied with small chains, the total chain weight being 80 kg. Such gear was used during work at depths of 10 to 100 m. At depths of 100 to 400 m. 80 metal pieces (200 mm long each) were attached on the upper side instead of plastic ones. The vertical trawl opening was of the order of 4.4 m.

The laying-out pattern and gear of the 20-m bottom trawl is shown in Figs. 2 & 3.

The 27.1-m Polish-made trawl was equipped on its upper side by ten plastic pieces, the lower one being attached with small chains, weighing about 20 kg in totto. Instead of cables, 15-m bare ends were used. The vertical opening of the trawl was of the order of 6.0 m. The laying out pattern and gear of the 27.1-m Polish-made trawl is represented in Figs 4 & 5.

The two later trawlings during the autumn season were executed under emergency conditions. During the first trawl which took place in the bay of Abukir, the lower plate, the square and the wings were damaged, the top and the bottom sets of the 27.1-m Polish-made trawl were torn. Instead of the torn trawl a 20-m bottom trawl was equipped. During the second sweep which took place in the gulf of Salloum the lower set and the trawl plate were torn.

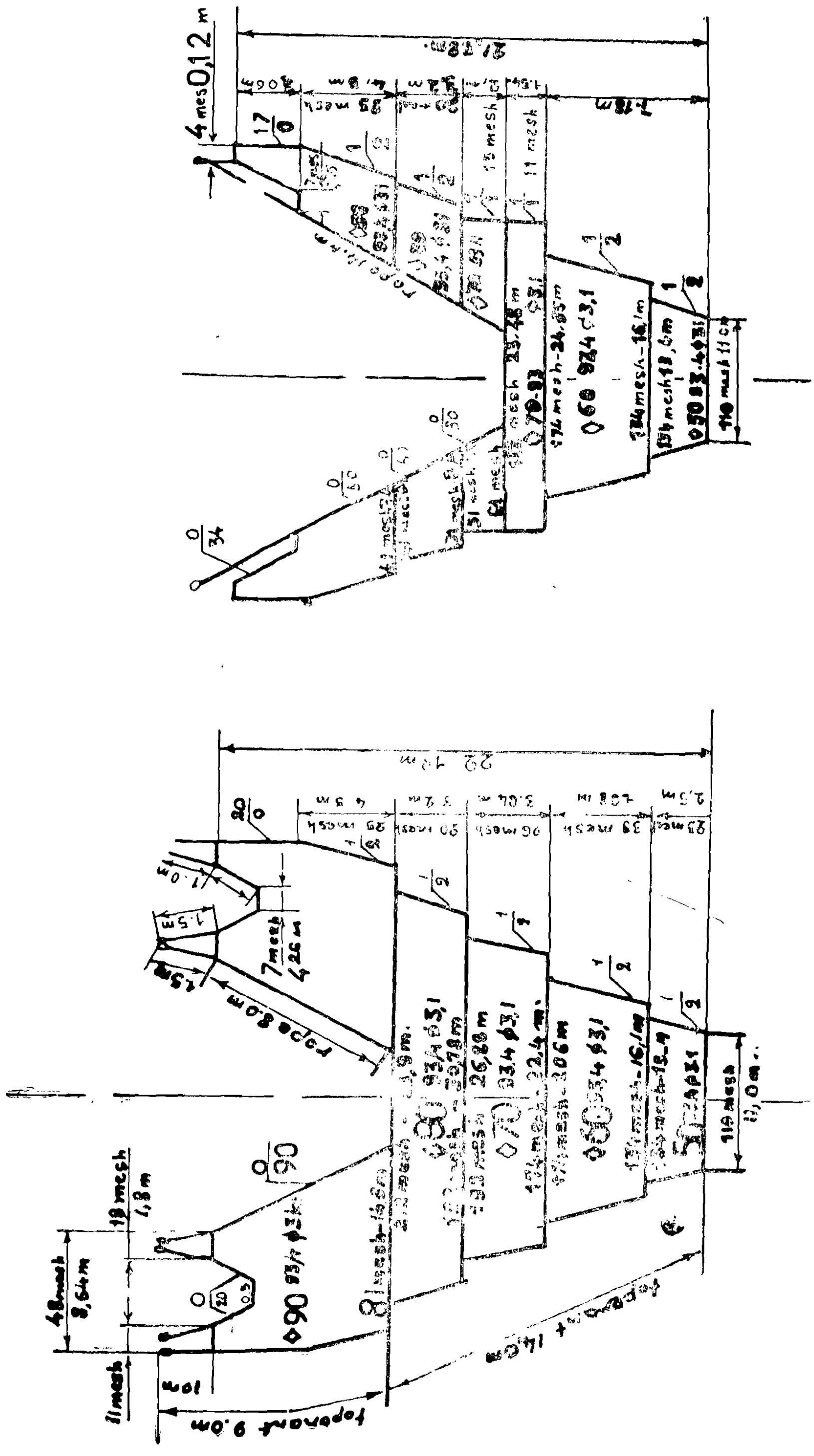


FIG. 2. Shematic diagram showing the construction pattern of the 20 m bottom trawl. Left : the top panel ; right : the belly.

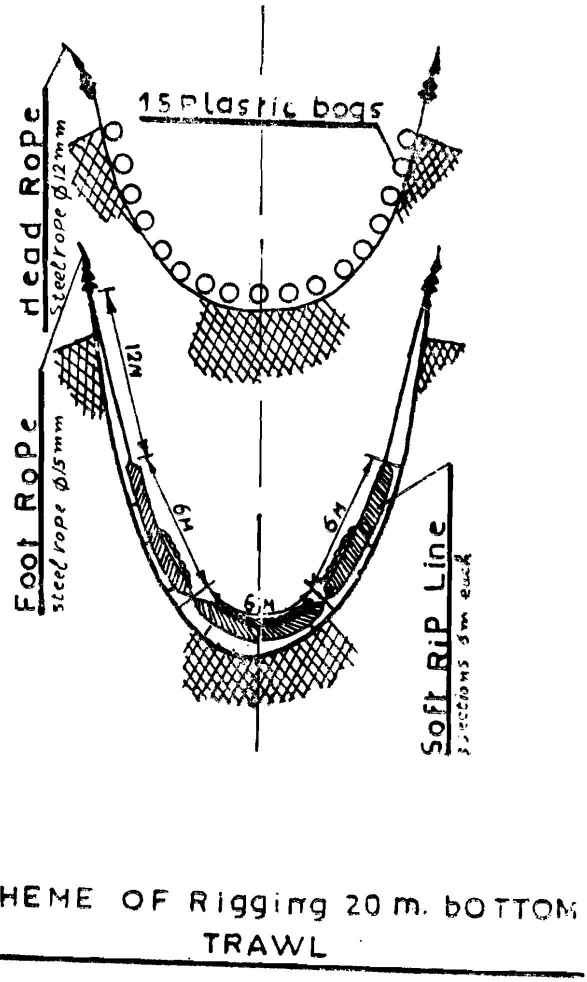


FIG. 3.—Schematic representation of the 20m bottom trawl rigging.

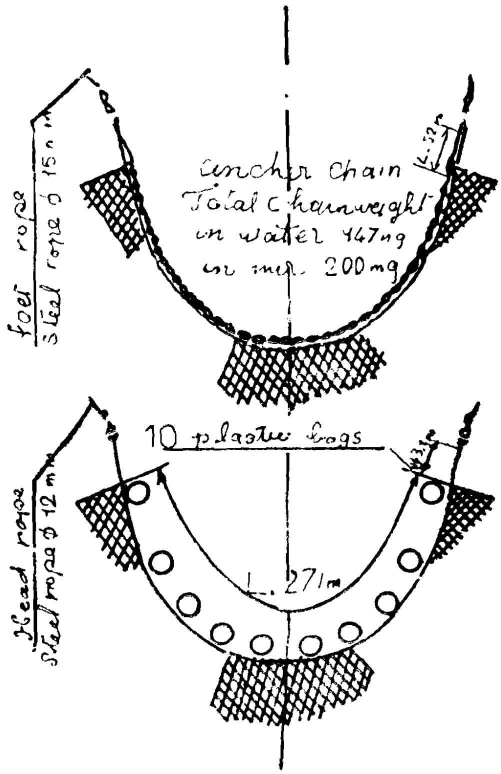


FIG. 4. Rigging plan for the 27.1.m Polish trawl.

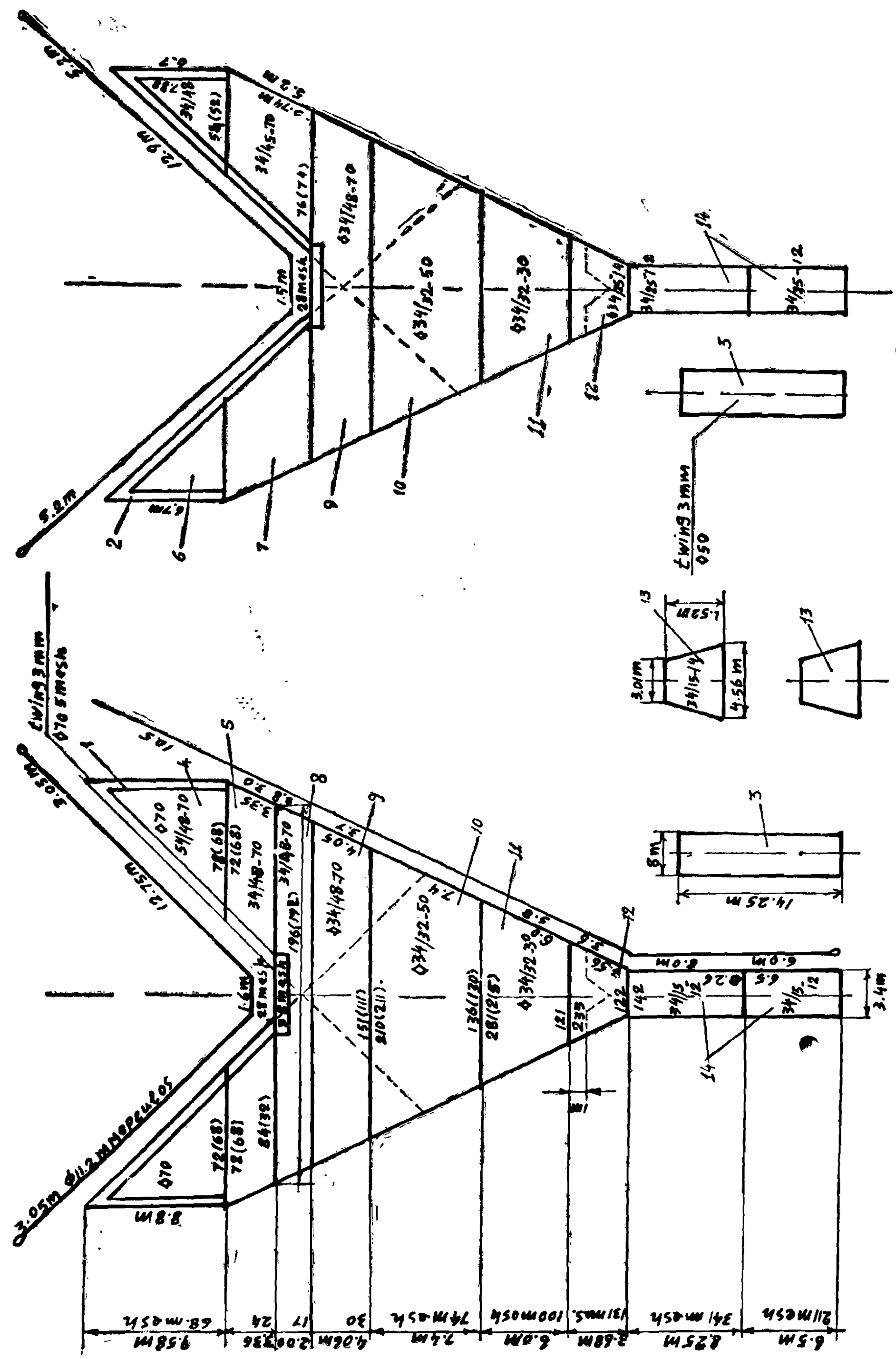


FIG. 5.—Construction plan for the 27.1m. Polish trawl.

In addition to that (on September 24, 1970) one trawling was carried out by the Egyptian side. This trawl was equipped and worked under the guidance of the Egyptian specialists. The value of the Egyptian trawl did not exceed the ones of the above types of trawls, however the strength of the Egyptian trawl did not meet the demands of the operating conditions from board the ship "Ichthyolog". Thus, it was not used in the course of further work.

During the winter, spring and summer seasons, trawling operations were carried out by a 20-m small-mesh bottom trawl designed by the Laboratory of Commercial Fisheries Engineering of the Azcherniro in 1966 (Fig. 6). The gear of the top and bottom sets of this trawl was in line with the equipment of the 20-m bottom trawl. During the said period all the work was carried out by the trawl with such equipment. Trawlings undertaken within an area 100 m to 300 m deep constituted an exception. At these depths the trawl was equipped on the upper side with 80 metal pieces and the central section of the soft ground rope was replaced by a stiff ground rope (Fig. 7) owing to the fact that the ground in this area was hard. The vertical opening of the trawl was of the order of 3.8 m.

All the trawls viz. the 27.1-m Polish-made one, the 20-m bottom trawl and the 20-m small-mesh bottom trawl which had been used both in the previous expedition by R/V "Ichthyolog" in 1965-1966 and in the present expedition proved to be up to the mark.

Along with the trawling work in the areas under study there was a series of light stations for the purpose of finding a possibility of fish concentration with the artificial light sources. At all the light stations, observations were taken for the fish behaviour within the light zone with the aid of a sounding device and visually.

Each region was allotted two to three light stations. All in all in the course of the expedition, research work was carried out at 7 light stations, 2and five side traps were installed.

Underwater light sources of 1500 w lamps, S ts-83 type, of white colour, and 500 w lamps, RL type, of blue colour were used. Pelagic fish attracted by light were caught by a cone net and side trap, whose pattern is presented by Fig. 8 & 9.

The side trap represents a flat net (del caprone 10.7/8-8- the drainage part and 10.76-10 - the main part), set on supports from the "Gercules" 22-m wire rope with different setting coefficients vertically and horizontally. The trap has the following dimensions while in setting :

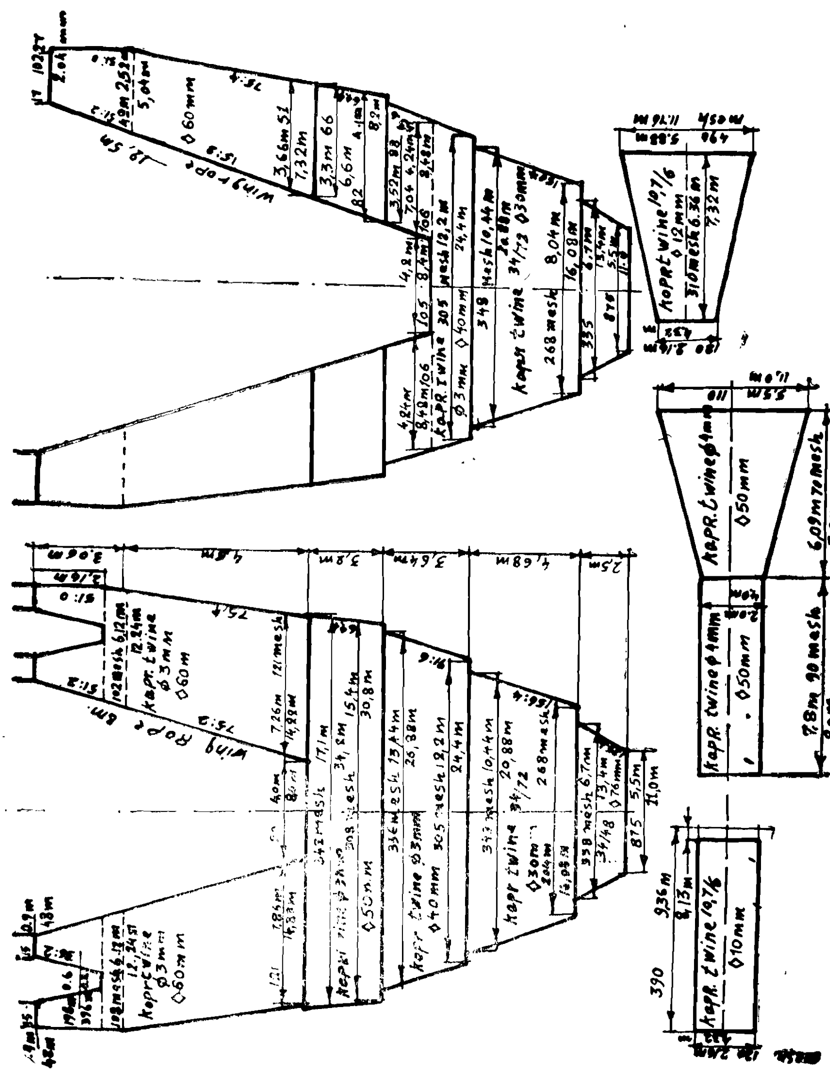
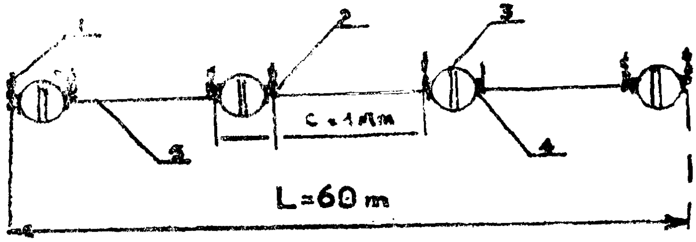


FIG. 6. Construction plan for the 20 m. small mesh bottom trawl.



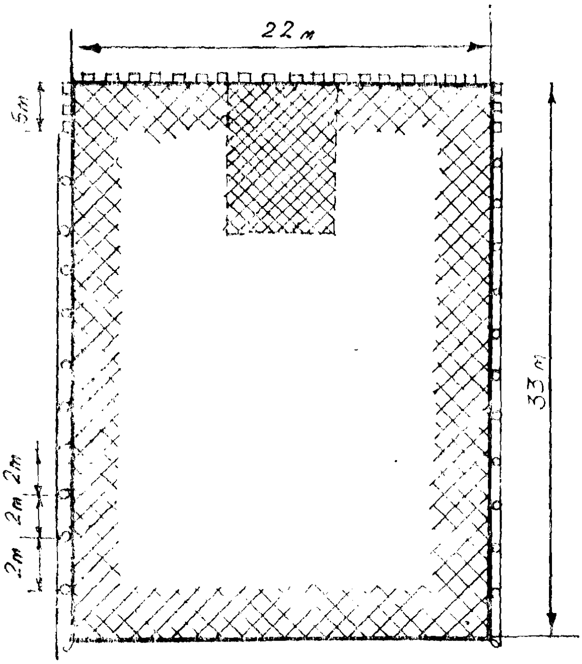
Weight in air= 17kg in water=44 kg.

1-connecting chain. 3-bbobin 400 mm.

2-staple N 2,5 4-Rubber washer.

5-steel rope ϕ 15,5 mm.

FIG. 7. Central section of the rigid ground rope.



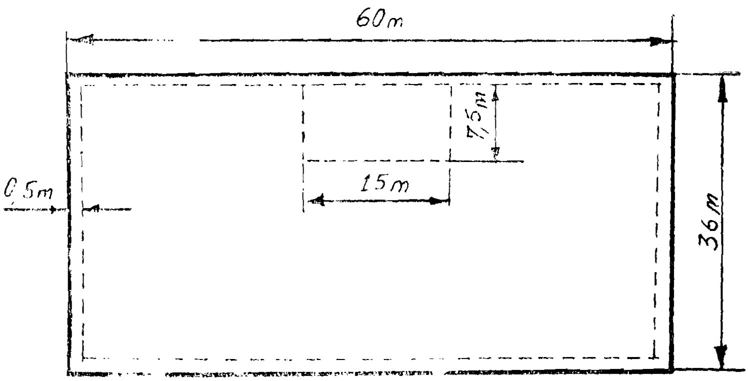


FIG. 8 and FIG. 9. Construction plan for the left net for a medium size refrigeration trawler.

33m- on the vertical.

22m- on the top and bottom support.

The upper support and the 5-m side support on each side are equipped with 120 pcs. of foam plastic floats (dimensions 125 × 220). Binding rings were tied to the side sets every 2 m to pass binding ropes 70 m long. The middle of the top set is attached with a ring passing an endless loop serving to install and move a lamp.

To deepen the bottom set of the trap, use is made of two weights, 250 to 400 kg each. The weights are lowered on cushions held by the guiding rollers acording to the traweler scheme. The cushions are connected with the lower trap corners. The trawl winch takes care of the up-and-down movement of the cargo.

In the case of formation of commercial fish concentration near the ship board a side trap is placed in position.

The trap installation operation takes place as follows :

The top set and part of the dell are thrown overhoard manually, the top set is drawn away from the board with the aid of the guy ropes upto the end of the discharge with a simultaneous loosening of the dell. After the trap is straightened up in the water the guy ropes are fixed followed by the loosening of the cushions with the weights and the lower set attached to them. At large depths not more than 33 meters of cushions are loosened (counting from the water surface).

When fish is attracted by the light of the movable lamp at the top set of the trap, trapping is started.

The trawl winch is switched on, the weights are raised, the guy ropes of the trap are loosened and the binding ropes start to be removed. The lower set is raised overboard and the trap starts to be driven from the prow and the stern. The fish is driven to the central part of the trap. Having drawn the catch to create the necessary concentration, it is necessary to get down to pouring out the fish by means of a dropper.

For the purpose of drying and bracing the side trap, on the right stern of the ship two metal booms, 8 to 10 each, are installed and braced by means of guy ropes.

One rigging block is fixed at each end o fthe boom to pass guyropes of the trap.

III.- Oceanographic Characteristics of the south-eastern part of the Mediterranean Sea in 1970-1971.

The oceanographic regime of the area in question falls under the influence of a number of factors which are determined first of all by its geographic position. Among other things, first of all it is necessray to point out a highly positive radiation balance, the value being 70.000 cal/sq. cm per annum for this area. This fact accounts for a high water temperature and a strong evaportaion exeeding 1200 mm per annum.

Another factor determining the peculiarities of the regime in the south-eastern part of the Mediterranean sea is the neighbourhood of land with a dry continental climate. This accounts for a substantial prevalence of evaporation over precipitation, which resulted in a lower position of the level of the area in question as compared with the position of the west part of the Mediterranean Basin and the Atlantic Ocean. Therefore the Atlantic waters entering the Mediterranean sea are traced in the upper layers along the coasts of Egypt and are one of the factors determining the system of currents in this area.

Below is given a description of the main features of meteorological and oceanographic conditions of the south-eastern part of the Mediterranean sea in 1970-1971 and a comparison of these conditions with those which took place in 1966 (for analysis of interannum fluctations of the regime).

(a) *Meteorological Conditions* :

A specific feature of the wind regime over the water area of the Mediterranean sea is a prevalence of north-westerly winds over the greater part of the year. North-west and west-north-westerly winds prevail over the south-eastern part of the Mediterranean sea during the winter time. During the summer time the winds keep to the said direction, however, the velocity is much smaller than that during the winter (Selyashin, 1949).

During the autumn oceanographic survey of 1970, in September and the first half of October, moderate north-westerly winds prevailed in the area under study : the average velocity being 5 m/sec and the wave disturbance being 3 points. The air temperature gradually dropped from 27°C in September to 20°C in mid October (Fig. 10). In the autumn of 1970 the cooling of the surface waters started earlier than in the autumn of 1966 and was more intensive. In january-February 1971 prevalence was ob ved of the winds of the westerly and north-westerly directions. The ave monthly wind velocity in January was equal to 4-5 m/sec, and in Febru 8 m/sec. The wind disturbance amounted to 4 balls at an average, so times 6 to 7 balls. The air temperature changed within 14.0-18.5°C 10). In the spring (in April) winds of small intensity and calms observed (2-4 m/sec), whereas in May the wind velocity increased up 5-6 m/sec. Its direction just as well as in the winter season remai north-westerly one. The wind disturbance varied from 2 to 4 balls. April-May the air temperature raised gradually to reach 24°C in (Fig. 11). In August 1971 in the course of the oceangraphic survey prevaling winds were northwest with an average velocity of 4-5 m/ being lowered to 3 m/sec in September. During August-September wave disturbance equalled 1-3 points, 2 points at an average. The temperature changed within 25.5°C to 29.0°C, the highest tempera values being observed in the last third of August. During this time biggest changes of air temperature within 24 hours took place, in cer cases these changes reached 4°C (Fig. 11).

Besed on the analysis of meteorological conditions which were obser in the south-east part of the Mediterranean Sea in 1970-1971 and in 1 it can be inferred that the air temperature substantially varied only du the summer and the autumn seasons, whereas the wind regime varied dur the winter season. In August and October 1971 the air temperature 1-3°C lower as compared with its values in the corresponding months 1966.

The wind activity in the winter of 1971 was higher than that in winter of 1966.

In the course of the expedition several cases of unfavourable mete logical conditions were registered to have seriously hampered the per mance of commercial fisheries in the area of research.

(b) Distribution of Physico-chemical Characteristics of Sea water.

Temperature

The oceanographic feature in question is one of the most import physical charcateristics of sea water. The south-eastern part of the M terranean Sea is subjected to great seasonal changes which amount to to 10°C. These changes are determined in the main by the annual cou of solar radiation.

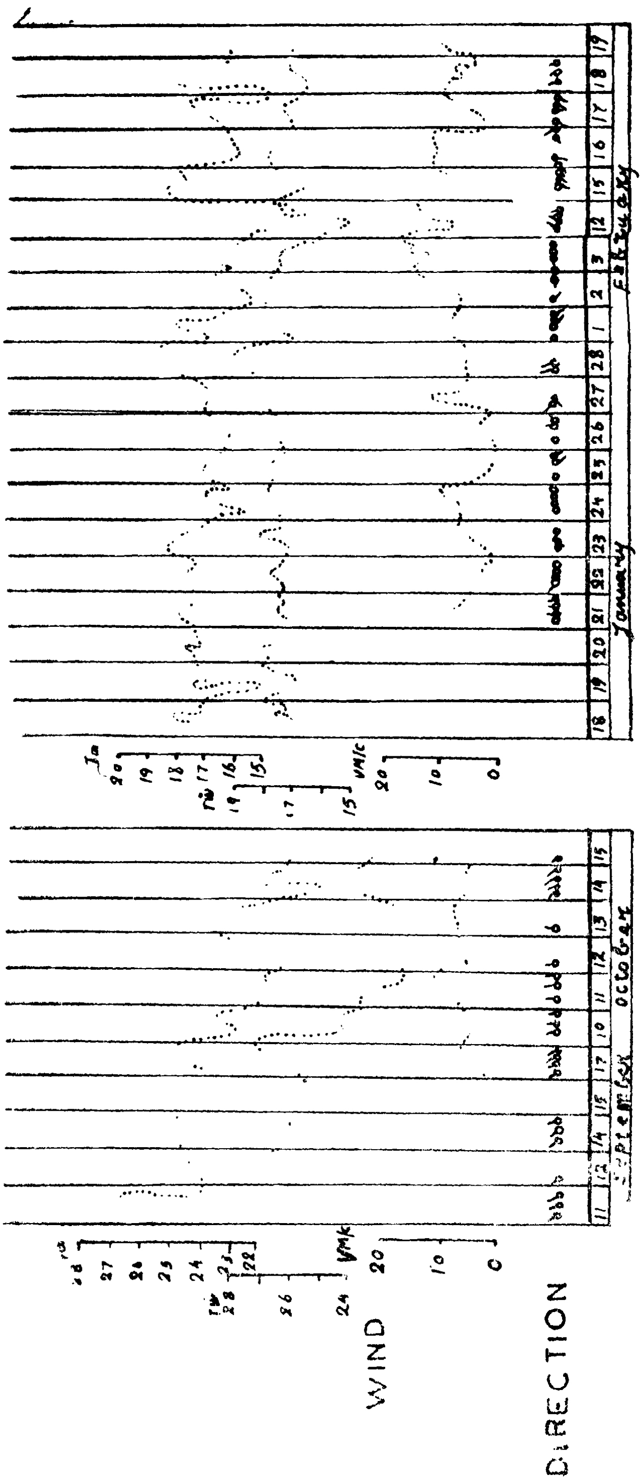


FIG. 10. Variations of air and surface water temperatures, wind direction and speed in September—October, 1970, and for the winter time of 1971.

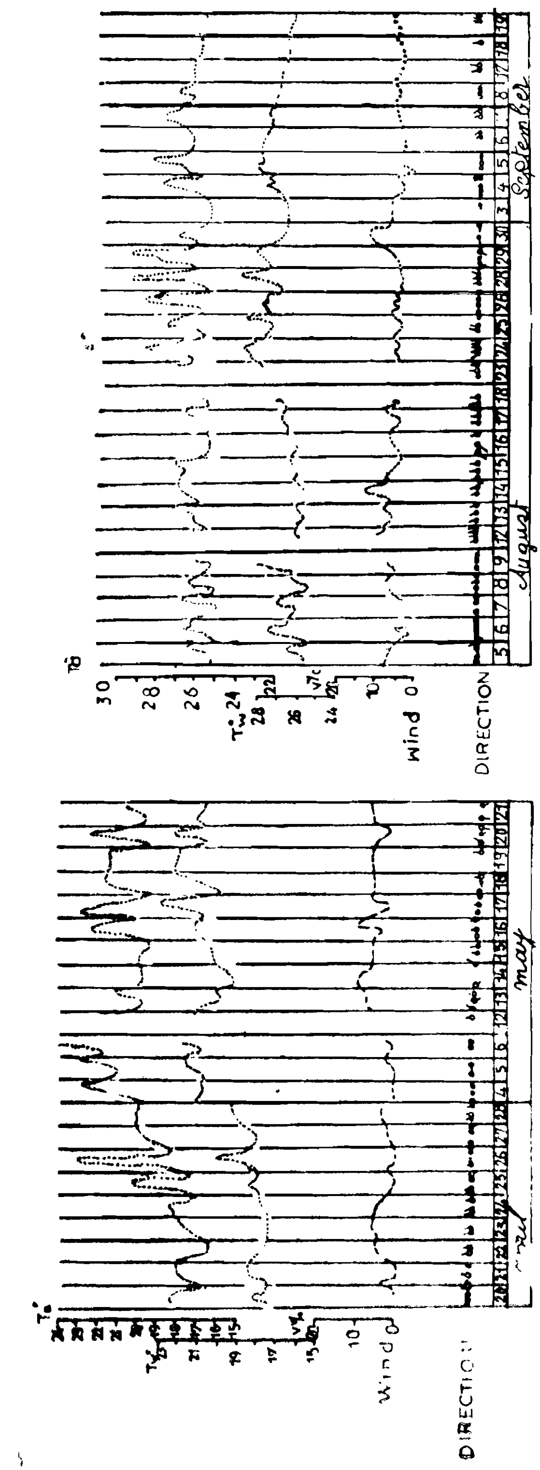


Fig. 11. Variations of air and sea surface temperatures, wind direction and speed during April — May and August — September, 1971.

The peculiarities of seasonal water temperature distribution in the area of study are given below.

The autumn oceanographic survey in the south-eastern part of the Mediterranean Sea was carried out in September-October. Observations at the cross-sections from the Damietta mouth of the Nile, the cape of Borullos and the Bay of Abukir were carried out in mid September, and those on the cross-sections located west of the bay of Abukir, took place a month later. The surface water temperature in September in the area adjacent to the Nile mouth remained high as about 26.0°C in the open part and 26.5-27.0°C near the Delta, (Fig. 12). However, the vertical distribution of the water temperature differed in the upper 100-m layer from its typical summer distribution by a deeper location of the leap layer (Fig. 13). By the middle of October, due to a sharp decrease in solar radiation, the air temperature dropped substantially. Within the sea area between the bay of Abukir and the bay of Salloum the temperature values varied within 20° to 24°C. In November 1966 in the course of the oceanographic survey the water temperature everywhere on the surface exeeded 24°C. At other levels in 1966 these were also higher than in 1970. Hence, it can be mentioned that the autumn in question was much cooler than that of 1966.

The biggest vertical temperature gradients in the area under study were observed between the levels 50-75 m (on the cross-section along the meridian of 29° Eastern latitude-in the layer of 75-100 m) and totaled 0.20-0.25 degree per meter.

According to the data of the winter oceanographic survey, the surface water temperature in February 1971 varied from 15° to 18°C. Its minimum value (about 15°C)was observed in the bay of Abukir and the maximum ones (17.8—18.0°C) — at stations located on the cross-sections from the mouth of Damietta to the bay of Salloum. The water temperature almost everywhere increased as you go away from the shore to the open sea (Fig. 14). The surface water temperature distribution was almost similar to that prevailing in February 1966. The vertical water temperature variations in the winter season of 1971 are shown on the cross-sections represented on Fig. 15. At the stations located in the western part of the area under study the homothermic layer was observed at a depth of 50-75 m. The majority of stations in the western part of the area showed almost unchanged water temperature vertically to depths of 100, 150 and even 200 m. Below the said levels the temperature slowly dropped and at a depth of 1000 m reached 13.6°-13.7°C.

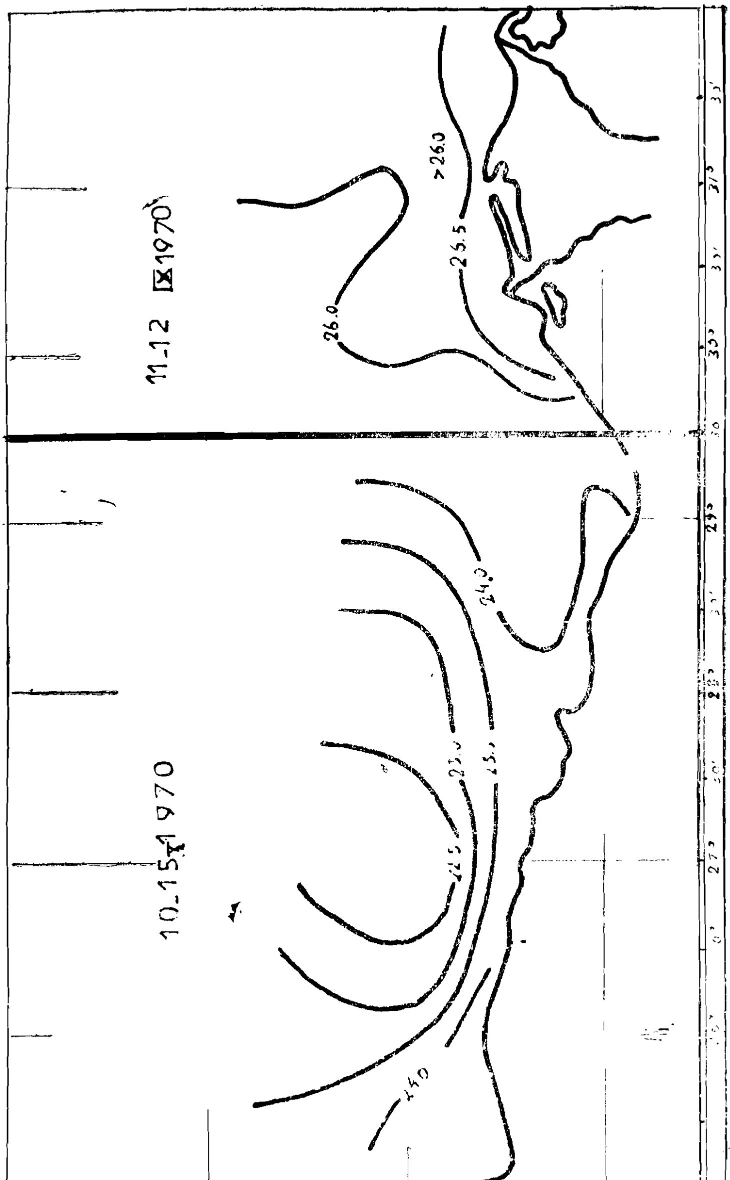


Fig. 12. Distribution of surface temperatures for September—October 1970.

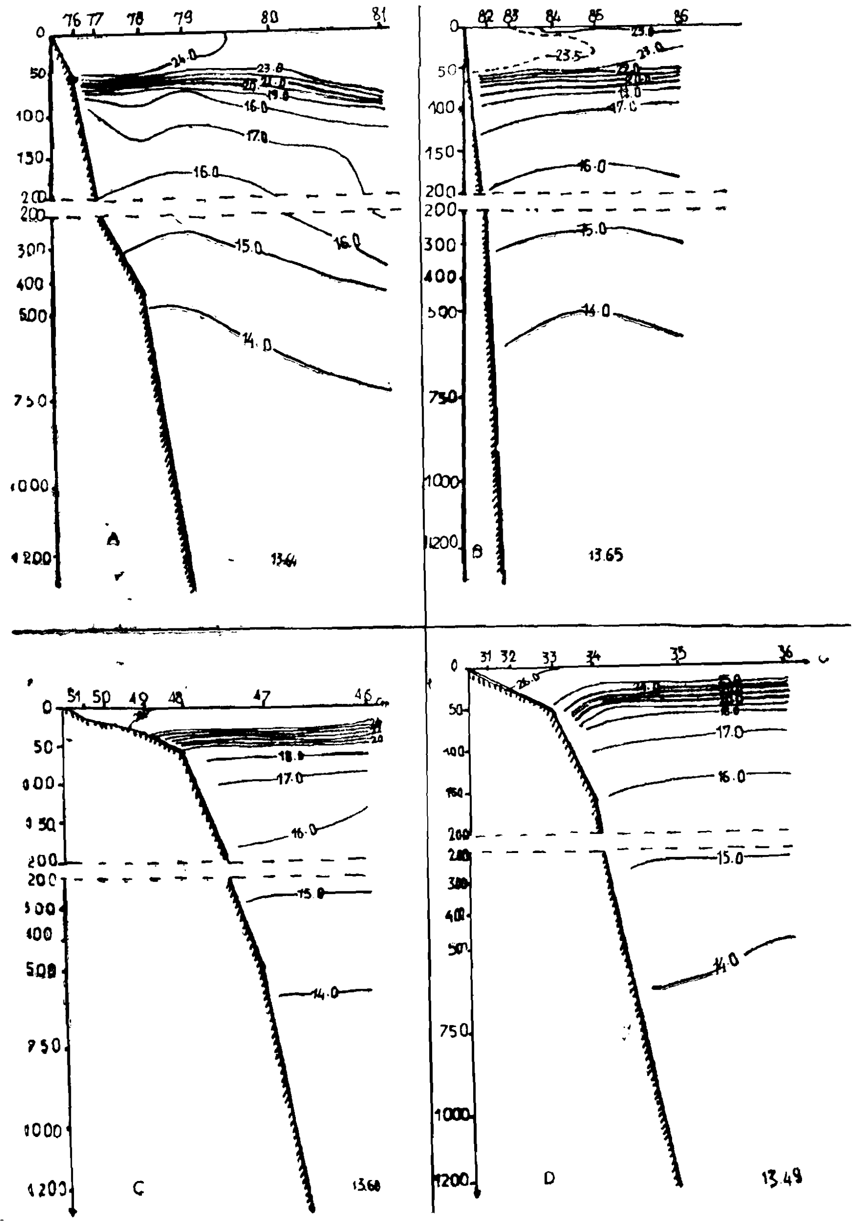
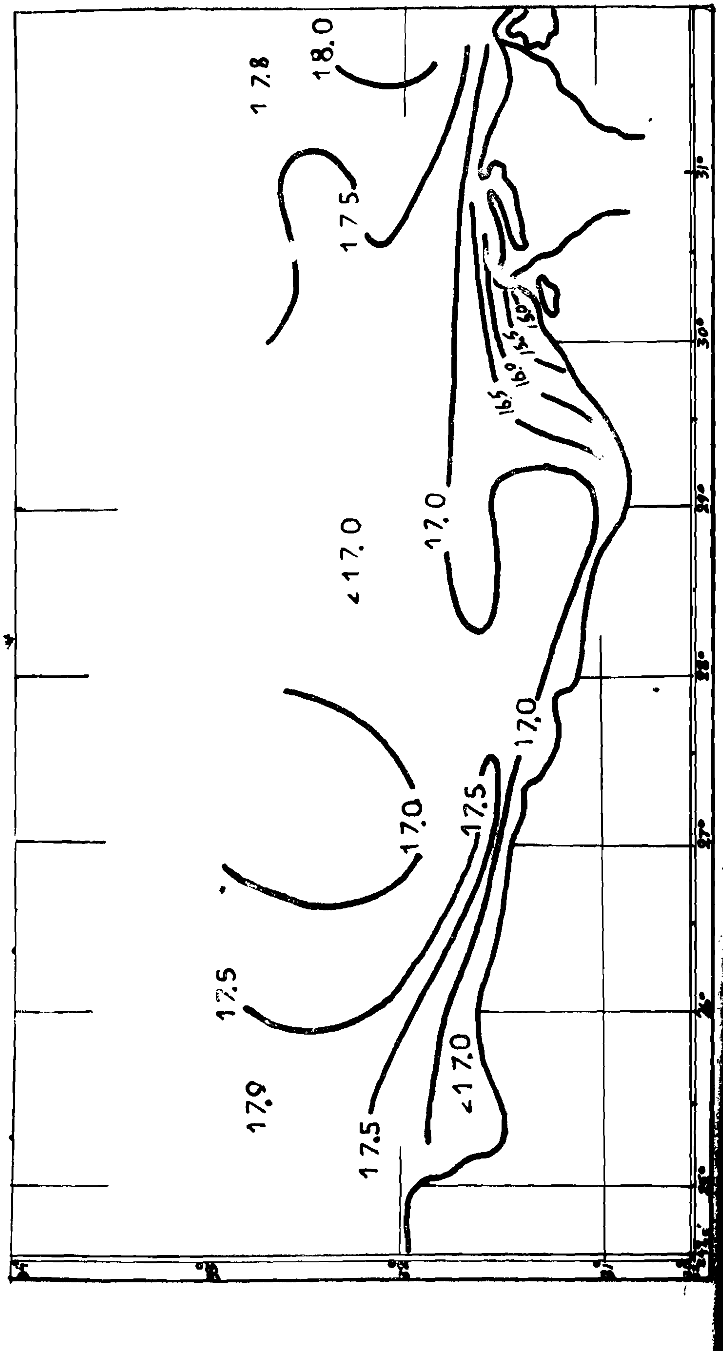


Fig. 13. Vertical distribution of subsurface water temperatures in the sections :
(a) Salloum — seaward,
(b) Mersa Matrouh — seaward,
(c) Abu Kir Bay — seaward, and
(d) Cape Borullos — seaward, in September — October, 1970.


18.0
17.8
17.5
16.0
16.5
17.0
<17.0
17.0
17.0
17.0
17.5
17.5
17.9
<17.0
17.5

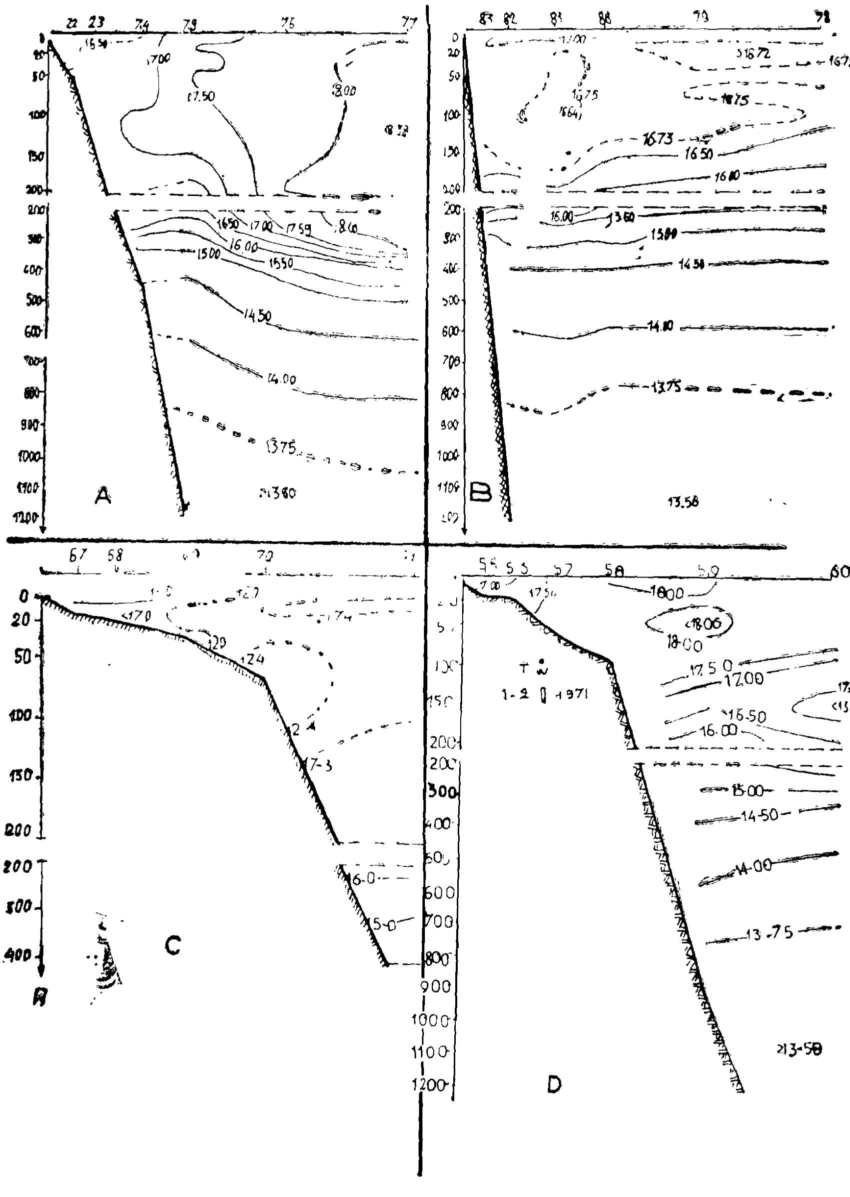


FIG. 15. Vertical distribution of subsurface water temperatures in the sections :
(a) Salloum Bay — seaward (b) Mersa Matrouh — seaward
(c) Abu Kir Bay seaward and (d) Damietta—seaward during the winter of 1971.

During very cold winters the surface waters of the area un are likely to go down much deeper than the *level of 200 m and* the formation of deep waters of adjacent areas of the Mediterra

A steady rise of the water temperature in the south-eastern pa Mediterranean Sea normally starts at the end of March. (Rzhonsnitsk Data of the spring oceanographic survey showed that the surfa temperature in the second half of May, 1971, varied within the 19.6°—22.0°C, but near the bottom (at a depth upto 50 m), it exceeded the temperature which was observed in January. It was th in the littoral shallow areas in the South of the Bay of Arab and in near the mouth of Damietta. The temperature values in the were almost similar to those in April, 1966. Only in the open under study, the water temperature in May 1971 proved to be a higher than that in April 1966. Thus the heating-through of th water of the south-eastern part of the Mediterranean Sea in 1971 active than that in the *spring of 1966.*

The temperature leap layer which practically disappears in wi observed in May at all stations. The depth of its lower boundary in the western direction from 20 to 25°C on the cross-section from D upto 50 m on the cross-section from the Bay of Salloum. The values o gradients were very small in the open areas of the sea and somewhat near the shore (Fig. 16).

From the observations recorded at the multi-stage station im in may 1971, the daily temperature *changes in the* surface 10 amounted to 0.5-0.7°C and were determined *by the daily cours radiation balance. The 25-m level showed very negligible* daily te *fluctuations (Fig. 17).*

At later dates in August 1971 the water temperature in the south part *of the sea* increased and the surface temperature values *in* t part of the water area reached *25.5°-27.0°C.* Similar to the case in the water temperature increased as the distance from the shore d especially in the area adjacent to the Nile Delta (Fig. 18). The temperature distribution in August 1971 proved to be similar to that in 1966, but its absolute values were lower by 0.5°-1.5°C.

In the *autumn of 1970, in* the spring and the *summer of* 19 water temperature in the *surface layer* was lower than *that* in the *ponding seasons of 1966* by *1°-2°C at* an average.

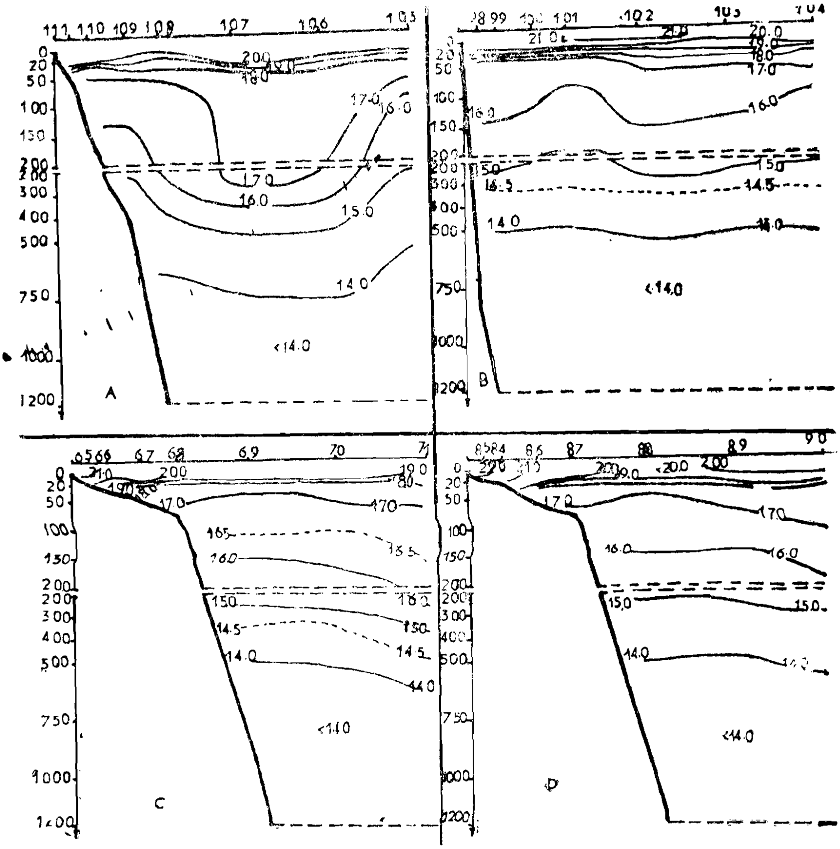


FIG. 16. Vertical distribution of subsurface water temperatnre in the sections :
(a) Salloum Bay-seaward (b) Mersa Matrouh—seaward
(c) Abu Kir Bay-seaward (d) Damietta-seaward,
for May, 1971.

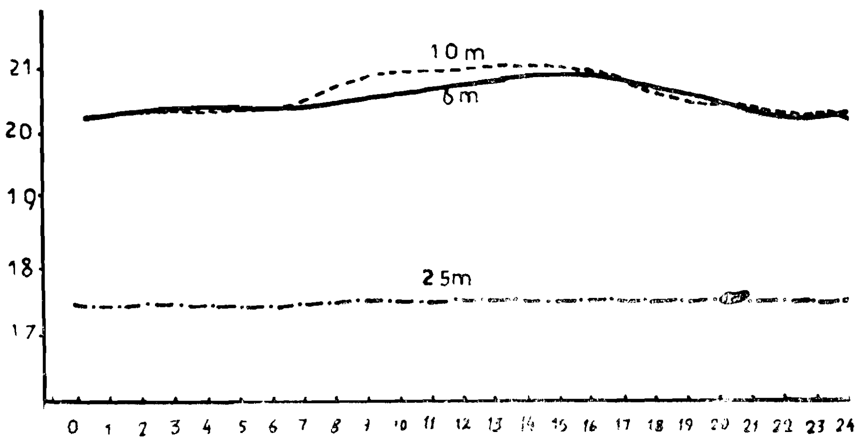


FIG. 17. Diurnal variation of sea water temperature at different depths in May, 1971.

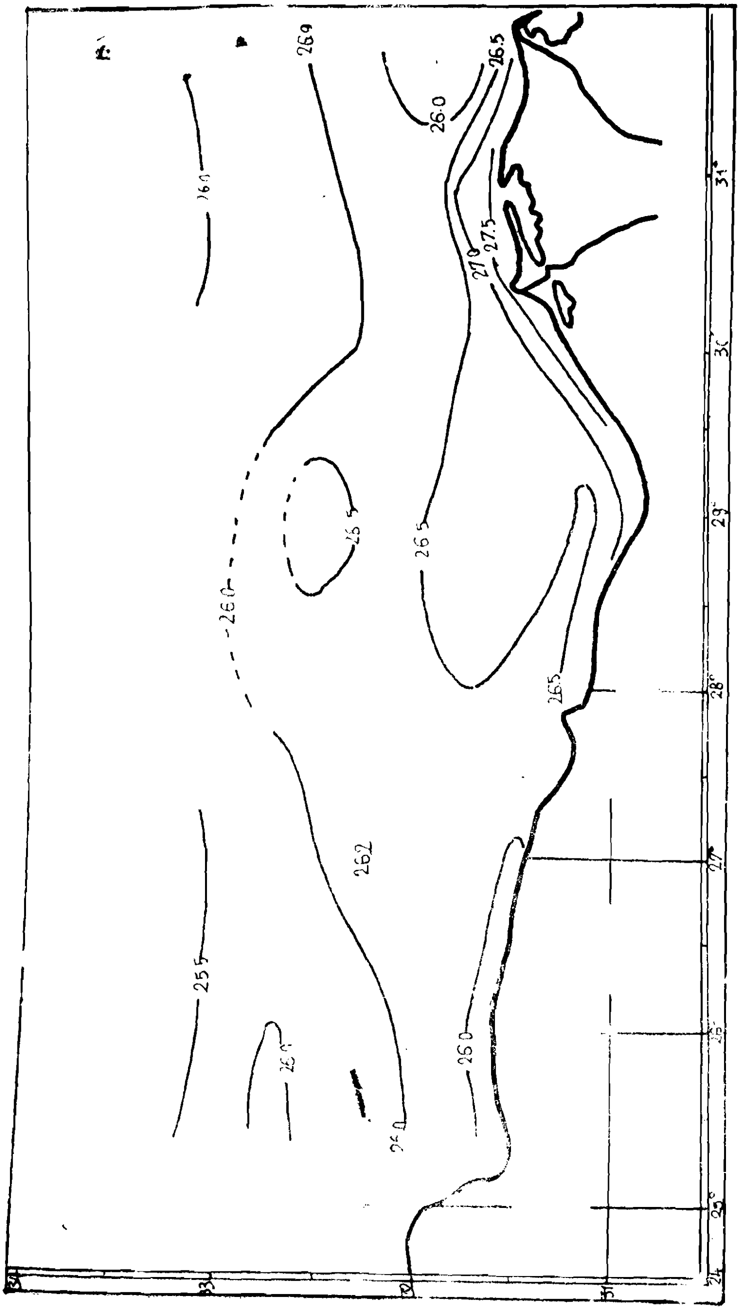


FIG. 13. Distribution of surface water temperatures in August, 1971.

The greatest vertical temperature gradients in August, 1971, were observed between levels 20-40 and 20-50m. (Fig. 19). In the littoral zone the lower boundary of the temperature leap was found to be at a depth of 75 m. The maximum values of vertical gradients at certain stations were 0.5°C m. The increase in the thickness of the warmed-up layer near the shore in the Nile mouth area during the Summer of 1971 as compared to the position of the leap layer in the years preceding a sharp drop of the continental drainage, can be explained by the improvement of conditions of vertical water intermixing determined by an increase in the water density on the surface on account of the drainage drop.

Below the 100-m level the water temperature in the Mediterranean Sea decreases slowly with depth and its values change slightly during the year (Fig. 20).

Salinity

The distribution of salinity in the south-eastern part of the Mediterranean Sea is very complex. This is caused by the interaction of various processes ; evaporation intensity, influx of waters as well as waters of high salinity from the Levant Sea and at last by land water influx which is however, greatly reduced for the last years. The surface water salinity distribution during the different seasons of 1970-1971 is shown in Figs. 21 — 24. In September-October 1970 the salinity values were high everywhere. In the greater part of the water area these values exceeded 30.0‰ and only near the mouths the salinity ranged between 38.8 and 38.9‰. In winter the salinity dropped everywhere, to 34.6 ‰ especially in the Bay of Abukir. In the littoral zone this decrease was caused by the river drainage rise ; whereas, in the remaining part of the sea area under study by the intensive replacement of the surface more saline waters with the underlying less saline waters. As a result of this the salinity dropped greatly whereas on the lower boundary of the winter convection spread, a layer of maximum salinity was formed. In spring the salinity reserved its winter values in the greater part of the area except for the Bay of Abukir. In summer time the surface water salinity tended to increase everywhere, especially in the east part of the area 39.5-39.8 ‰. Only in the Bay of Abukir it dropped by 0.5 to 0.8 ‰ as compared to its values in spring on account of the entrance of great quantities of brackish waters from Lake Edku. In summer, inspite of the increase in salinity the surface waters do not submerge as they do in winter, since owing to the high temperature their density is less than the density of underlying waters of Atlantic origin.

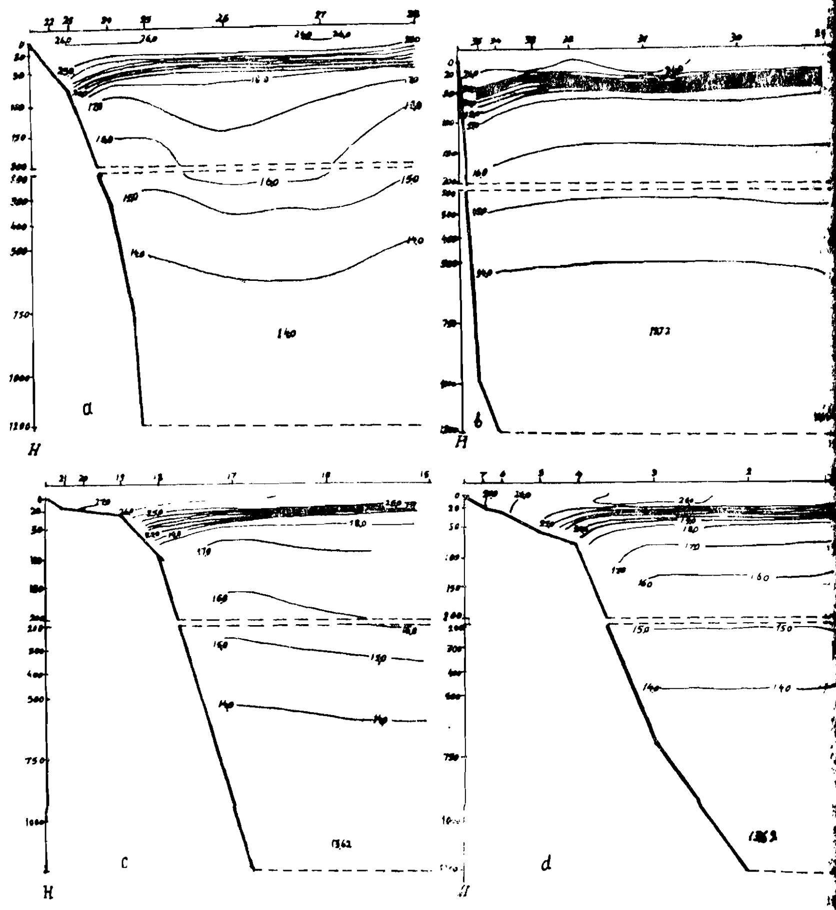


FIG. 19. Vertical distribution of subsurface water temperatures in the sections: a) Saloum Bay — seaward b) Mersa Matrouh — seaward c) Abu Kir Bay — seaward d) Damietta — seaward, during the summer of 1971.

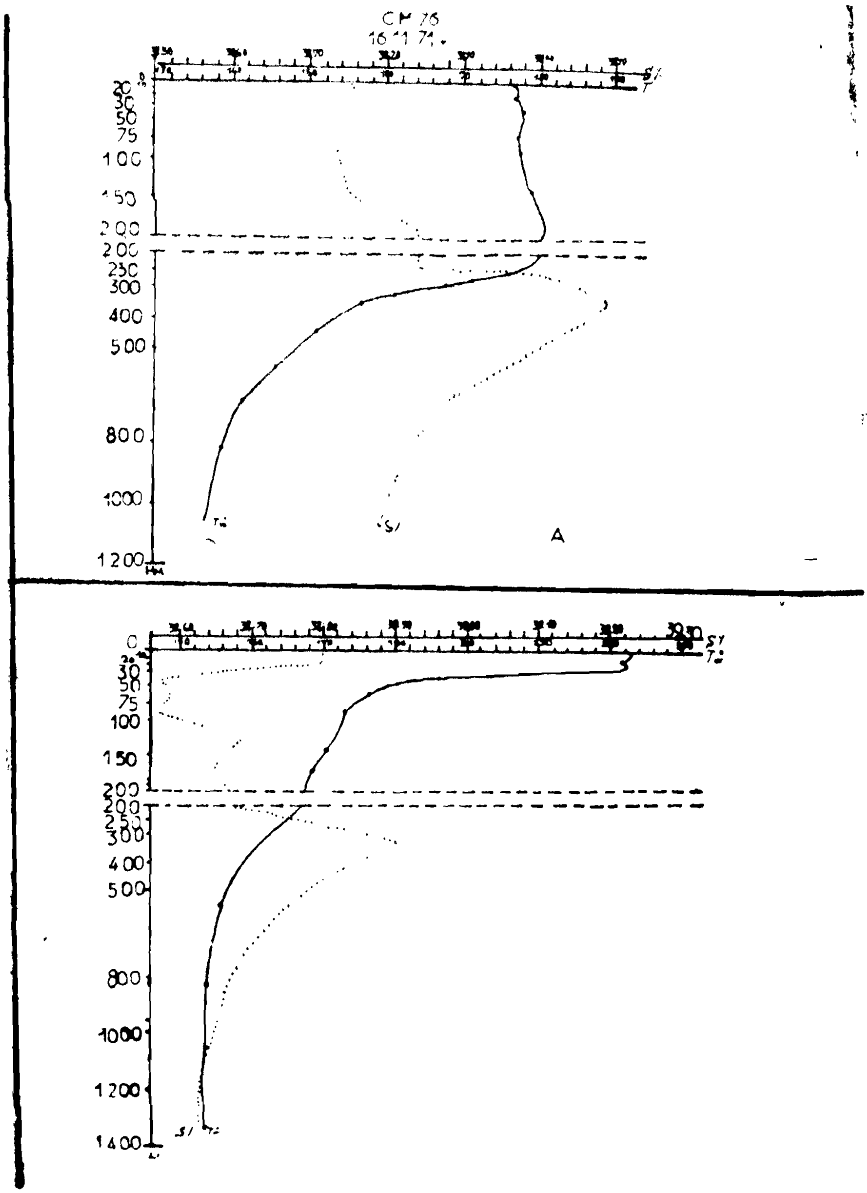


Fig. 20. Vertical distribution of water temperatnre and salinity in a) the winter time and b) the summer time of 1971.

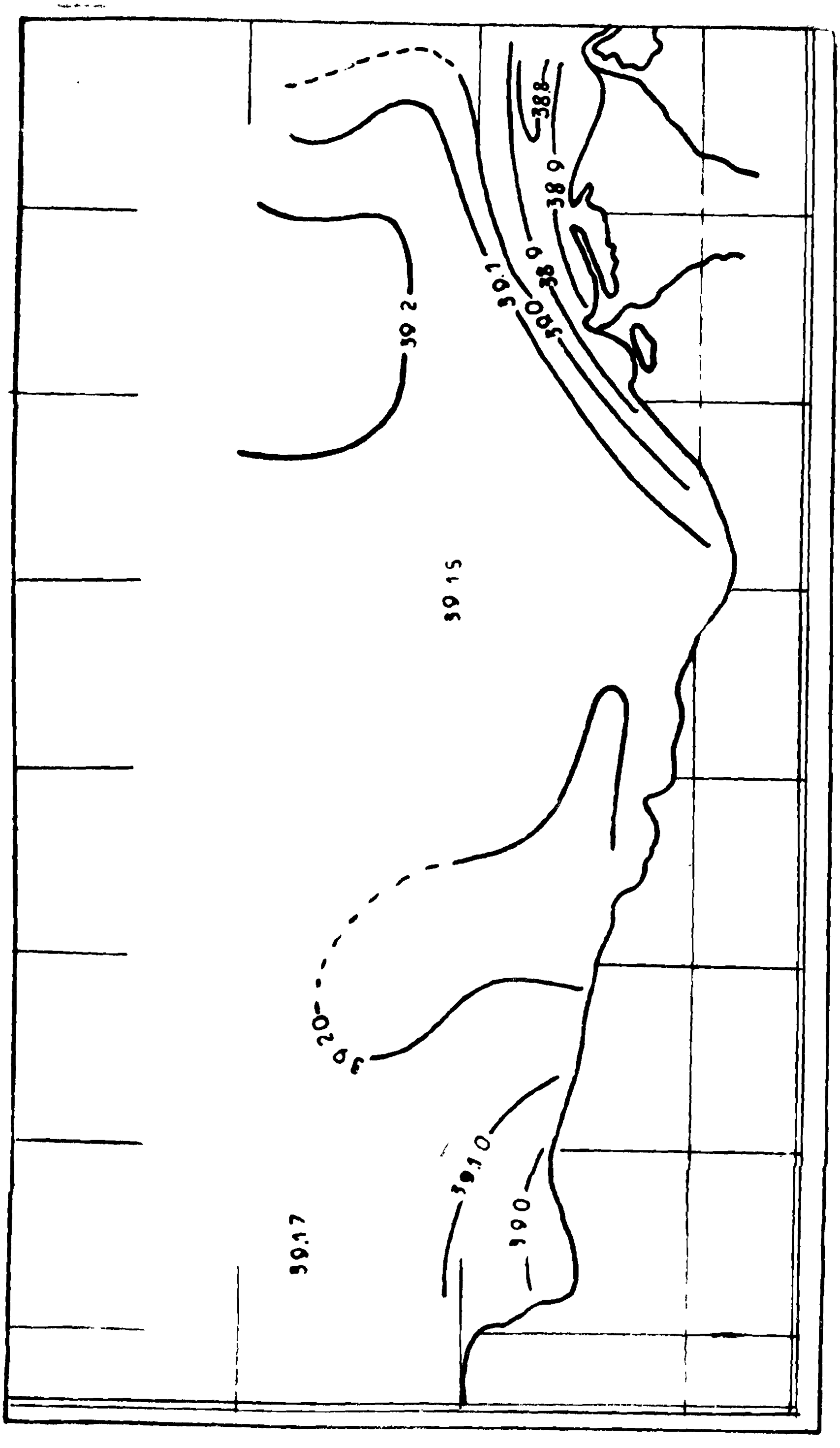


FIG. 21. Distribution of surface water salinity in S

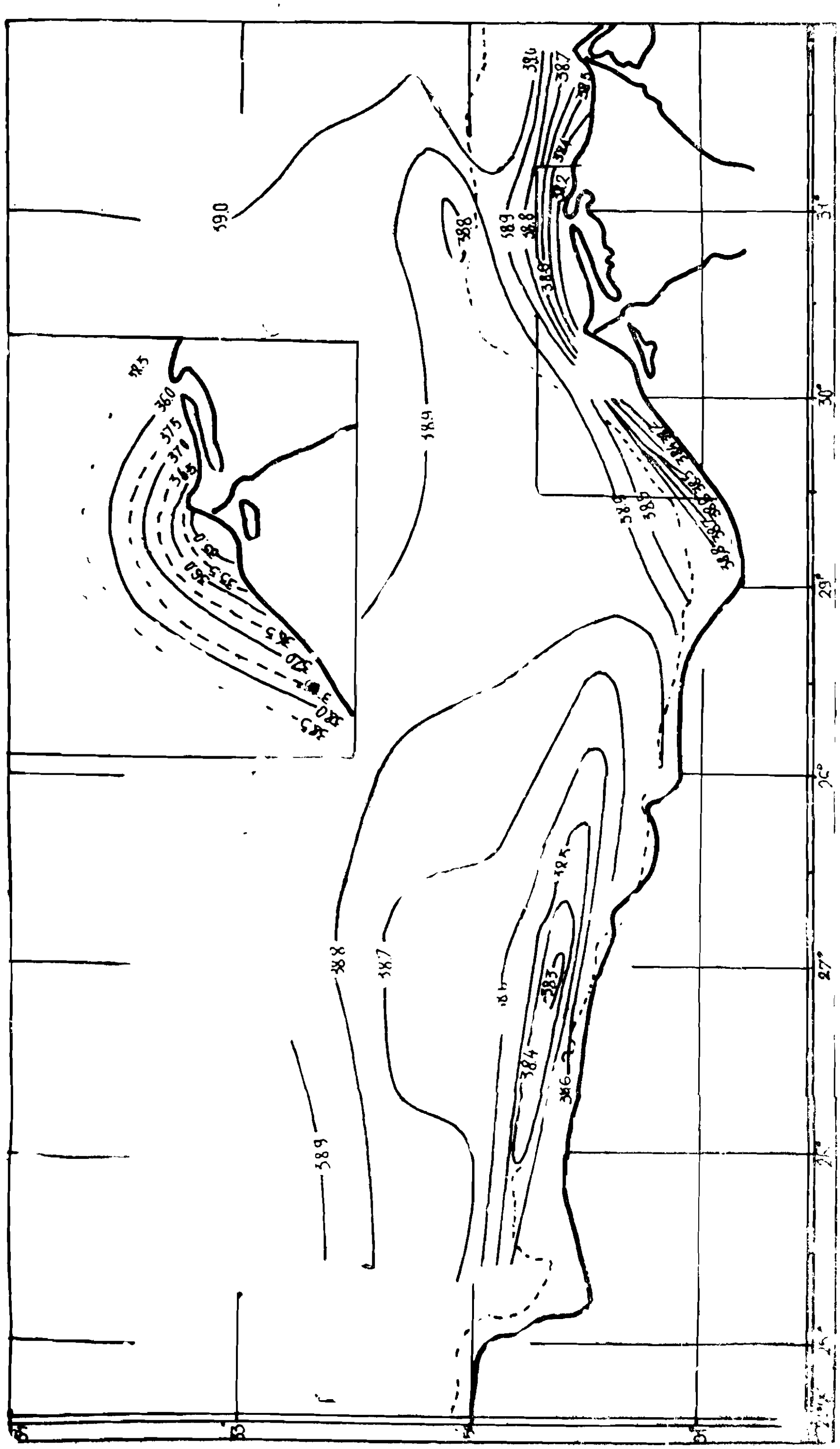


Fig. 22. Distribution of surface water salinity in February, 1971

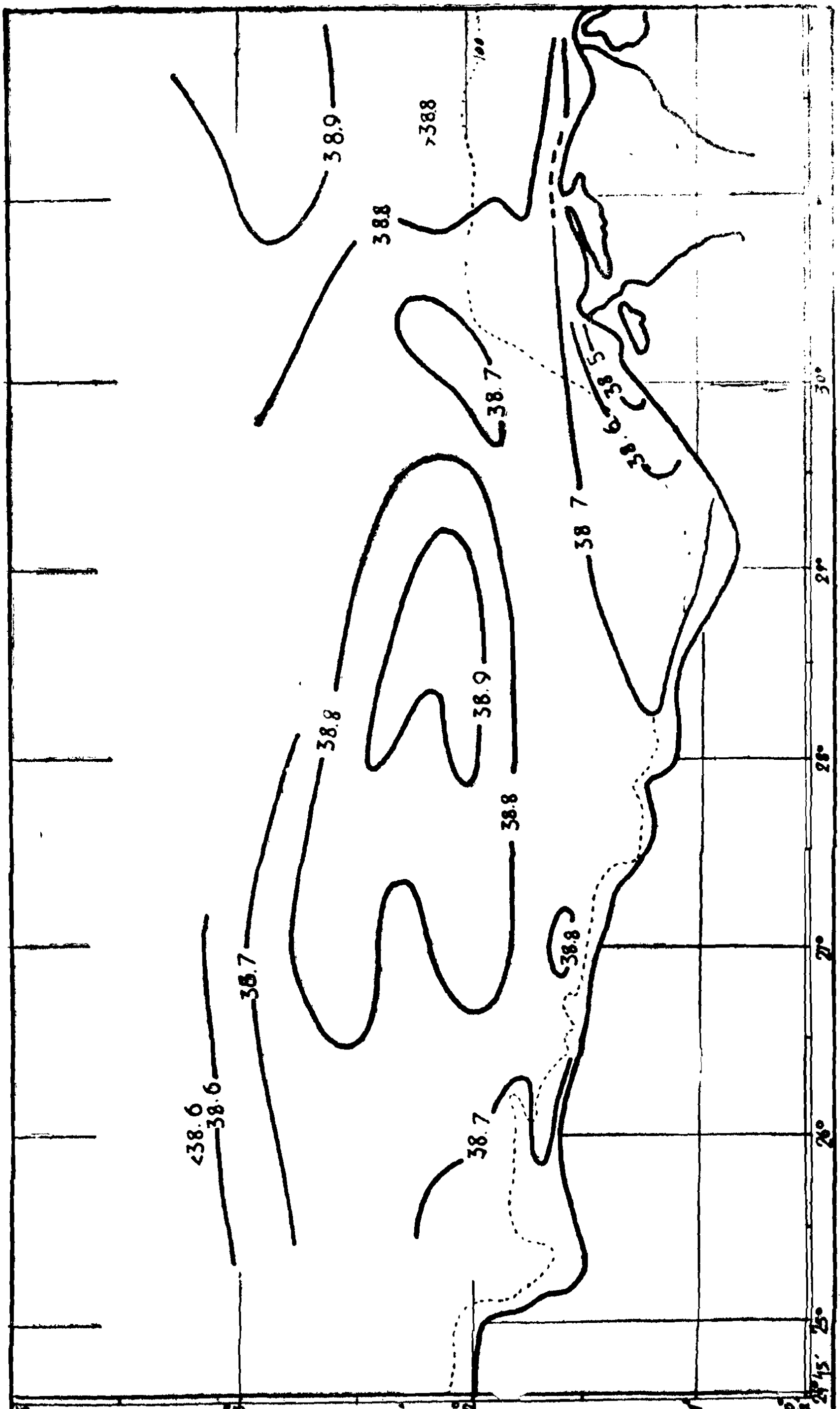


Fig. 23. Distribution of surface water salinity in May, 1971.

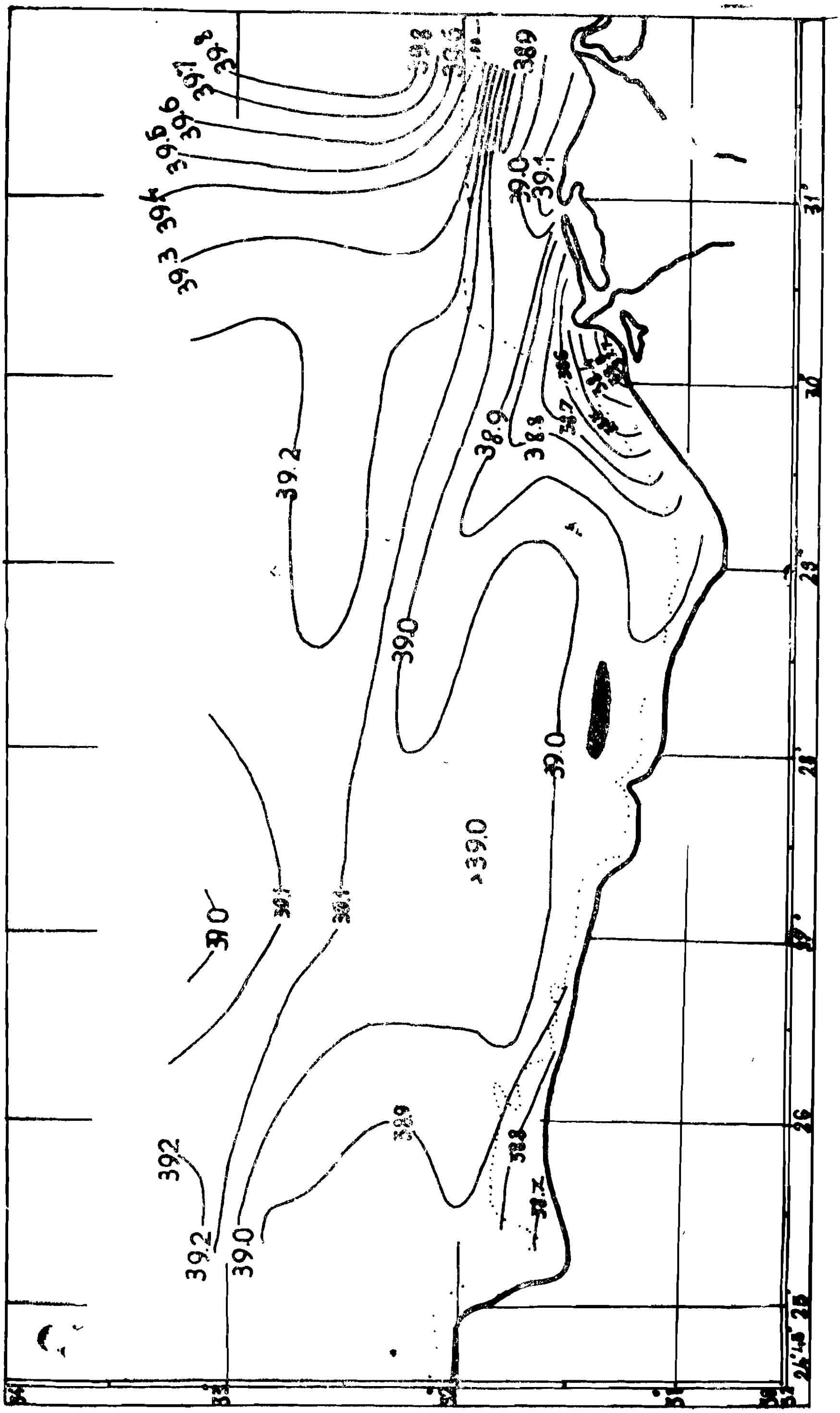


Fig. 24. Distribution of surface water salinity in August, 1971

The horizontal gradients of salinity in the most part of the area under were negligible. Salinity, as a rule, increased slowly so long as the li line was farther and farther behind.

The seasonal salinity changes as a whole are not great, except i Nile mouth area where the highest salinity values were observed in su the lowest ones in the littoral zone in winter, and beyond its lim spring.

The curves presented in Figs 20,25 & 26 show the vertical distribut salinity. During summer time, transformed Atlantic waters with salinity can be distinctly traced at depths of 50 to 100 m with an lying layer of water with a higher salinity (38.9 to 39.0 ‰). S values in the minimal salinity layer gradually increase from 38.4 ‰ in the West up to 38.70-38.90‰ in the East. In winter this l hardly traced on account of the intermixing of waters down to a depth of at an average. The existence of layers with lower and higher salini a great influence on the density distribution and the water intermixin

Below the level of 300 m the salinity drops slowly until at a d 1200 m where it reaches 38.7 ‰.

Density and Stability

The distribution of density in general depends upon two factors, and temperature of the water. During the warm season of 1970-1 water density increased away from the shore in connection with the tem drop in this direction. In the Nile mouth area where the salinity an the density are smoewhat influenced by the land drainage, these di are more distinct (Table 5).

In winter the density as measured farther and farther away littoral line decreased on the Arab Bay cross-section and on the cro west of it. On the contrary, the density increased in the said in the Nile mouth area, since the predominant influence on it was exerted by salinity. As noted, in February, 1971, the spread of waters in the area adjacent to the Rosetta mouth was rather great,

(*) The question of layers with higher and lower Salinity is additionally below.

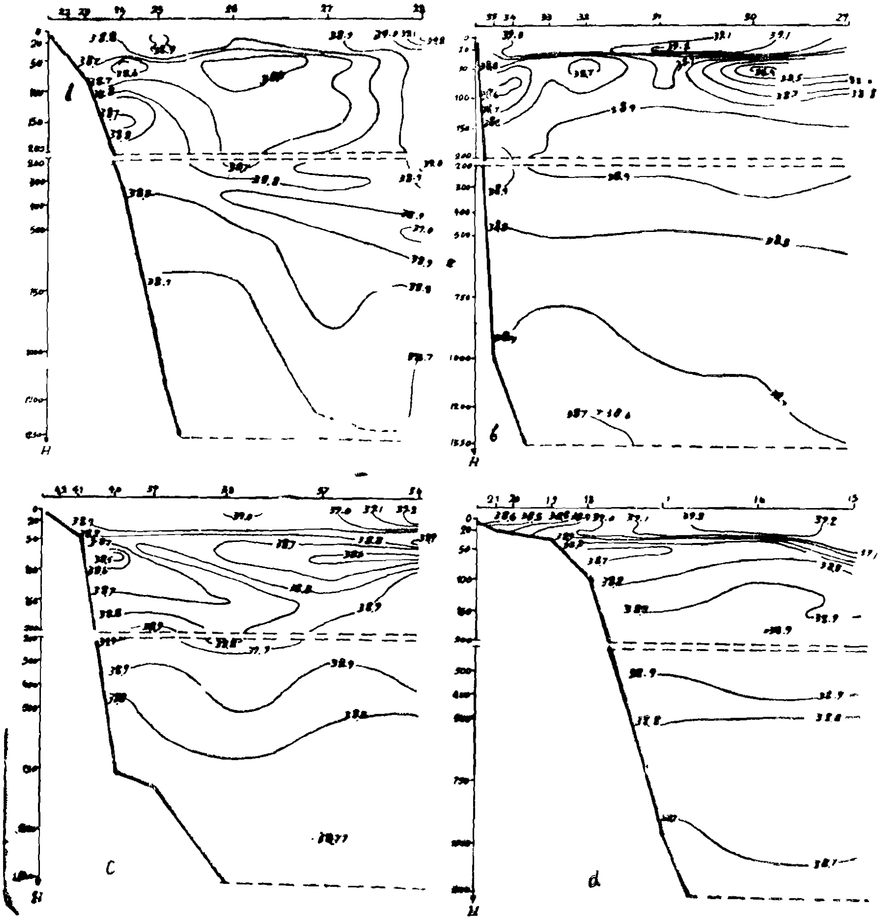


FIG. 25. Vertical distribution of salinity in the sections : a) salloum Bay — seaward b) Mersa Matrouh — seaward c) Arab Bay — seaward and d) Abu Kir Bay — seaward, in August 1971.

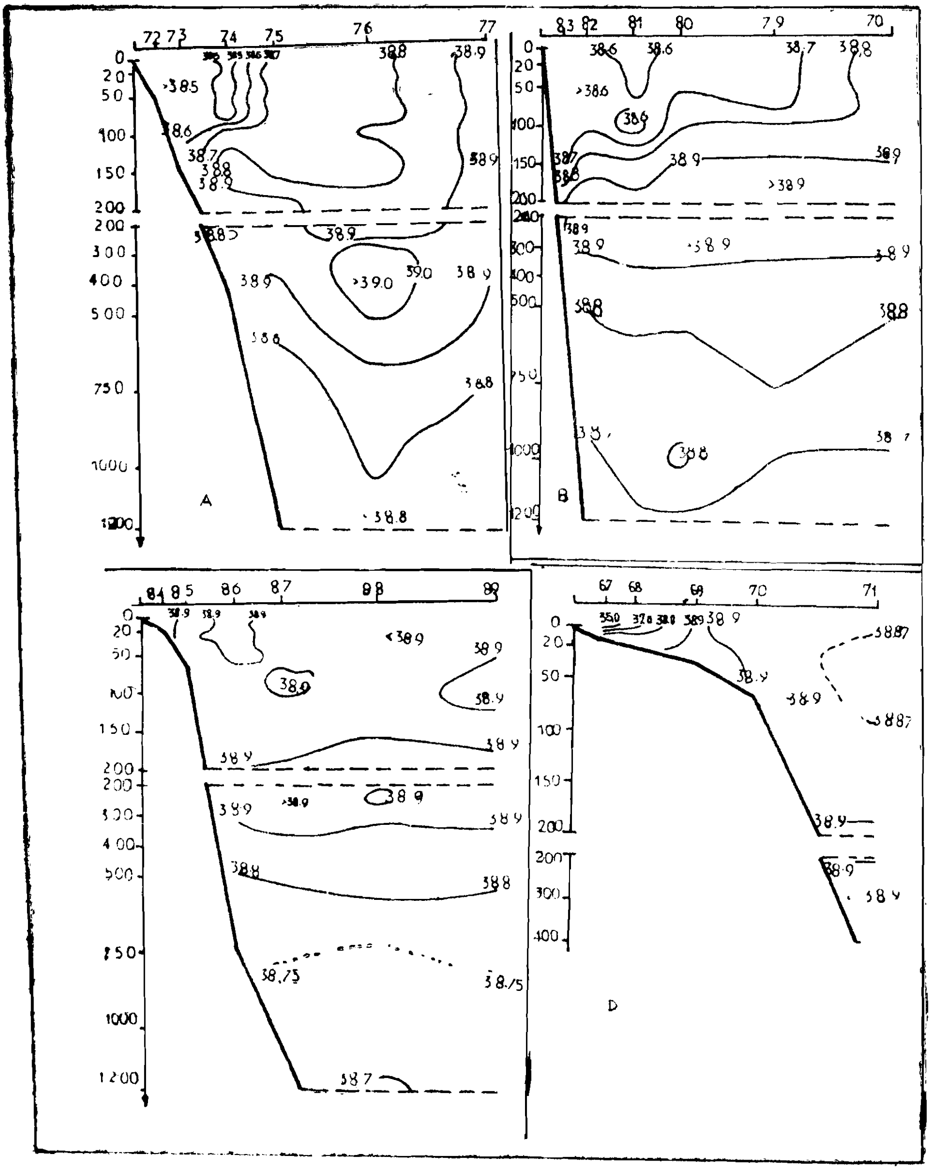


FIG. 26. Vertical distribution of salinity in the sections: a) Salloum Bay—seaward b), Mersa Matronh—seaward c) Arab Bay —seaward and d) Abu Kir Bay—seaward, in February, 1971

Table 5.—VALUES OF σt IN CERTAIN REGIONS OF THE SOUTH-EASTERN MEDITERRANEAN SEA IN DIFFERENT SEASONS OF 1966 AND 1971

Description of cross ection	Damietta-Seaward	Cape of Borullos Seaward	Bay ob ukir Seaward	Arab Bay Seaward
Winter (February, 1966)				
5 miles				
Om	28.22	28.77	28.70	28.76
50 miles				
Om	28.89	28.94	28.74	28.74
300m	29.33	29.34	29.14	29.34
(*Febrwary* 1971)				
5 miles				
Om	28.27	28.02	25.71	28.63
50 miles				
Om	28.33	28.43	28.39	28.50
300m	29.02	29.03	28.93	29.03
Spring (April, 1966)				
5 miles				
Om	27.15	27.63	27.20	28.27
50 miles				
Om	27.93	28.00	28.06	28.18
300m	29.19	28.28	29.04	29.01
(*May,* 1971)				
5 miles				
Om	26.77	27.44	27.10	27.15
50 miles				
Om	27.76	27.69	27.64	27.06
300m	28.94	28.95	29.00	28.76
Summer (August, 1966)				
5 miles				
Om	25.37	25.73	24.30	25.55
50 miles				
Om	25.98	26.11	25.62	25.97
300m	29.01	29.09	28.99	29.06
(*August* 1971)				
5 miles				
Om	25.80	25.66	24.40	25.64
50 miles				
Om	26.59	26.29	26.07	25.84
300m	28.51	29.07	29.02	28.76

Seasonal density variations of the surface waters in the area of amounted to 2 points in most parts and about 3 points near the The highest values were observed in winter whereas the lowest ones in summer. The amplitude of the seasonal density changes decreased by mo away from the shore and with depth (at the level of 300 m. it cha during the year within 0.1 to 0.4).

Data of surface water density in 1971 as compared with the correspon values in 1966 was on the whole somewhat higher in summer and lowe other seasons, especially in the area from the Bay of Abukir to the Ba Borullos in winter.

The rise of density which takes place in the surface water layers in cold time of the year result a reduction of its vertical gradient and, he a decrease in the water mass stability within the area of study. Ther the stability values, especially in the upper layers down to the layer 150-200 m in February 1971 were very low, and in certain cases nega As a result of this, there existed good conditions for a convection intermixing during the winter period and a biogenic base restoration in upper layers of the sea. In spring, due to a water temperature rise, the stab in the layer of 0.-30-50 m. increased especially near the shore. In summer of 1971 the stability sharply increased, the maximum values b restored as a rule, in the layers of 30-50 and 50-75 m. At depths over 10 stability values were not great throughout the whole year.

In the area under study, since the temperature inversion is practi non-existent, the water temperature distribution cannot evoke a neg stability; the latter was caused only by the salinity distribution beyond the zone of prevailing land drainage.

The stability distribution in 1971 within the greater part of the was analogous to that in 1966. During the winter the conditions of cal intermixing substantially varied only in the area from the Bay Abukir to Borullos. The water stability in the upper 10-m layer in Febr 1971 was very high, which was attributed to the intermixing of the sur and the bottom waters in the said area. During the summers of 1971 1966 noticeable variations in the stability distribution of water mass observed mainly in the east part of the area of study whose greater except for the Bay of Abukir showed a lesser stability making for favourable conditions for water intermixing in the layers of 0-20 or 0-25

The best conditions for intermixing between the surface and the deep waters throughout the greater part of the year were in the littoral zone between the shore and the 30-50-m isobaths, excluding the area located between the Bay of Abukir and Rosetta.

OXYGEN

The Mediterranean Sea belongs to the well aerated regions of the World ocean. The oxygen concentration in the whole water column in the various areas changes from 3.3 to 6.6 ml/1 or 53 to 112 per cent of saturation (Green & Carritt tables, 1967).

The relatively high oxygen content in the whole water column is determined by their intensive dynamics and active water exchange with the Atlantic ocean. The Mediterranean Sea is one of the small productive regions of the World ocean (Zenkevich 1947, Vodjanitsky 1961 ; Greze, 1963). In this connection the oxygen consumption for the oxidation of organic matter is not substantial. (Egorova, 1970).

The research work carried out from September 1970 to August 1971 within the 100-mile zone of the south-eastern part of the Mediterranean Sea showed that the waters of the investigated area in all seasons of the year were also well aerated throughout the water column (0-1200 meters) subjected to observations.

On the whole, throughout the year, the concentration of dissolved oxygen in the surface waters varied from 4.45 to 6.35 ml/1, or 99-118 per cent saturation (Green & Carritt tables) whereas at a depth of 1000 meters it varied from 3.59 to 4.78 ml/1 (62-83 per cent).

In 1966 the oxygen content of the surface water varied from 4.42 to 5.96 ml/1 (100-115 per cent saturation) in the investigated 50-mile area from Damietta to the Arab bay at a depth of 300 meters being 4.43-5.27 ml/1 (78-96 per cent), whereas in 1970-1971 at the same depth being 4.35-5.38 (77-95 per cent). Hence, the dissolved oxygen content in water throughout the whole of 1970-1971 in the upper 300-m layer in the area of research was nearly similar to the one observed in 1966. In 1966 there were no observations deeper than 300-m. The analysis of the cruves and cross-sections of the vertical distribution showed that the seasonal concentration change of dissolved oxygen in 1970-1971 was observed in the layer of 0-200 meters. Below 200 meters there was a tendency for a gradual decrease of oxygen content to 3.59-4.78 ml/1 (62-83 per cent) with the increase of depth, as referred to above, at a depth of 1000 meters.

The dissolved oxygen content from September to October was sufficiently high (Figs. 27 & 28). On the surface the oxygen values varied within 4.4... ml/1 (100-102 per cent) whereas the oxygen concentrations in the area ... the bay of Abukir to Damietta somewhat lower than from the Arab bay ... Bay of Salloum. The autumn oceanographic survey was a double-stage proposition. In September the work was carried out in the area from the B... *Abukir to Damietta, while in October from the Bay of Salloum to the Arab* bay. On account of this the water temperature in the surface layer of these areas varied greatly. This caused the mentioned oxygen distribution in the above two areas.

A characteristic feature of the vertical distribution of oxygen was the presence of a layer of the subsurface maximum in the layers 30-50 — 150-200 meters with the oxygen content of 5.21-5.60 ml/1. Such a distribution of oxygen seems to be due to the fact that below the layer of temperature leap there is another water mass present (see Hydrological Section).

During Autumn, in the area of the Arab Bay, the Bay of Marsa-Matrouh and the Bay of Salloum the water saturation with dissolved oxygen was insufficient in the layer of 0-30, 0-50 (sometimes in the layer of 0-100 m).

In winter the dissolved oxygen content the surface was equal to 5.43-6.35 ml/1 (101-118 per cent) (Figs 27 & 28). The oxygen content in the area from Damietta to the Bay of Abukir being somewhat higher than in the Bay of Arabs and the Bay of Marsa-Matrouh. Going away from the shore there was almost no contcentration of oxygen, for the 5-mile stations in the Bay of Abukir and the Arab Bay.

Under the influence of convection intermixing, the upper 200-m layer showed comparatively uniform values of oxygen which are asserted by its small vertical gradients (2.10^{-3} — 6.10^{-3} $\frac{ml/l}{1}$). During the season in question there was supersaturation of water oxygen of 18 per cent at the surface, whereas at a depth of 150-200 m the water saturation with oxygen varied from 90 to 100 per cent (Fig. 29 C, & 30 C). In the Arab Bay the limit of 100 per cent saturation was at a depth of 50 m.

In spring the concentration of dissolved oxygen in the surface water layer varied from 5.45 ml/1 (100-112 per cent) and the oxygen distribution was characterized by small horizontal gradients (Fig. 27), and the vertical distribution was characterized by a steady increase of oxygen content with an increased depth. In the layer of 30-50 m it reached a maximum of 5.51-5.59 ml/1 (102-104 per cent). Down and deeper the oxygen content dropped where at a depth of 200 m it reached 4.64-5.22 ml/1 (87-96 per cent).

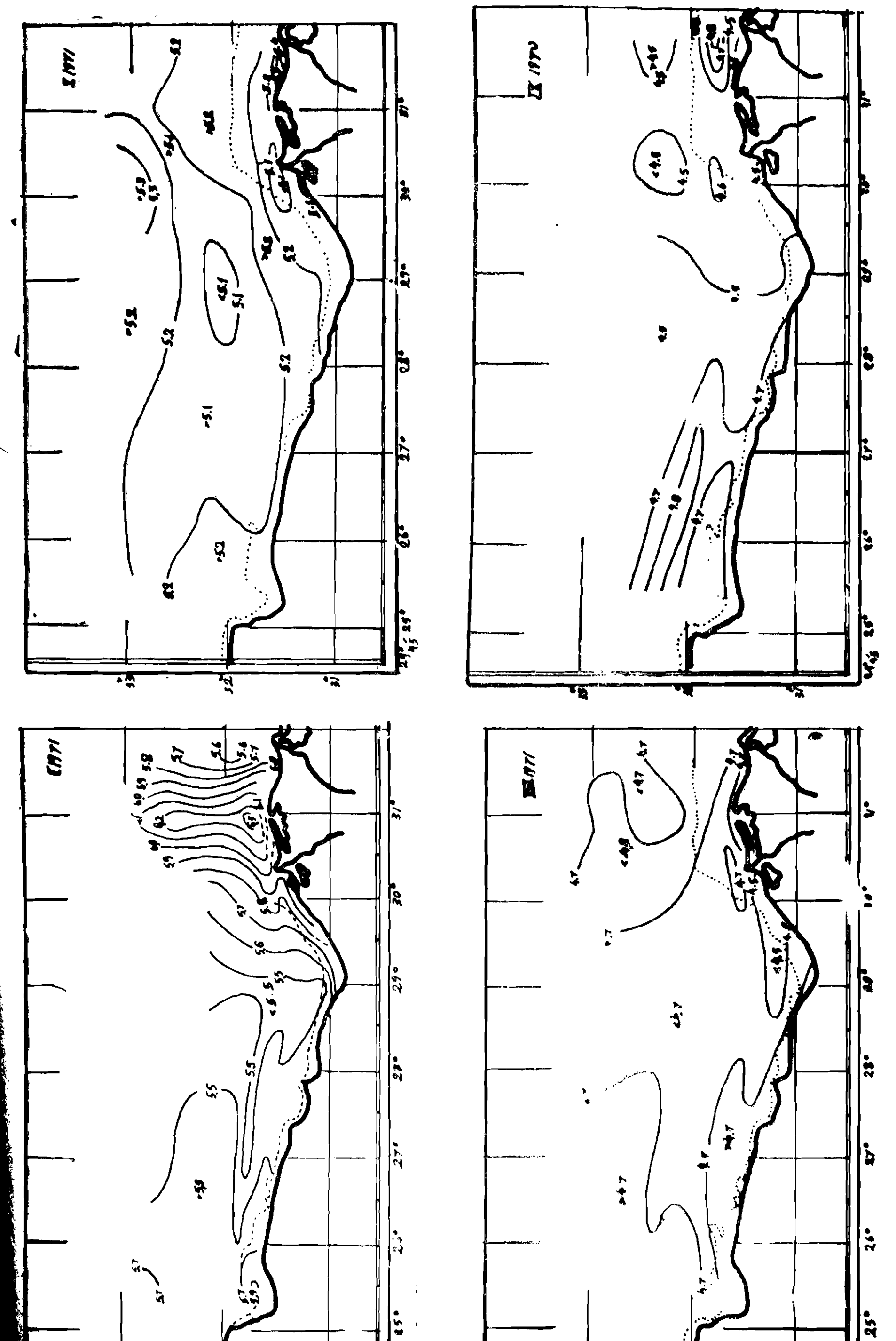
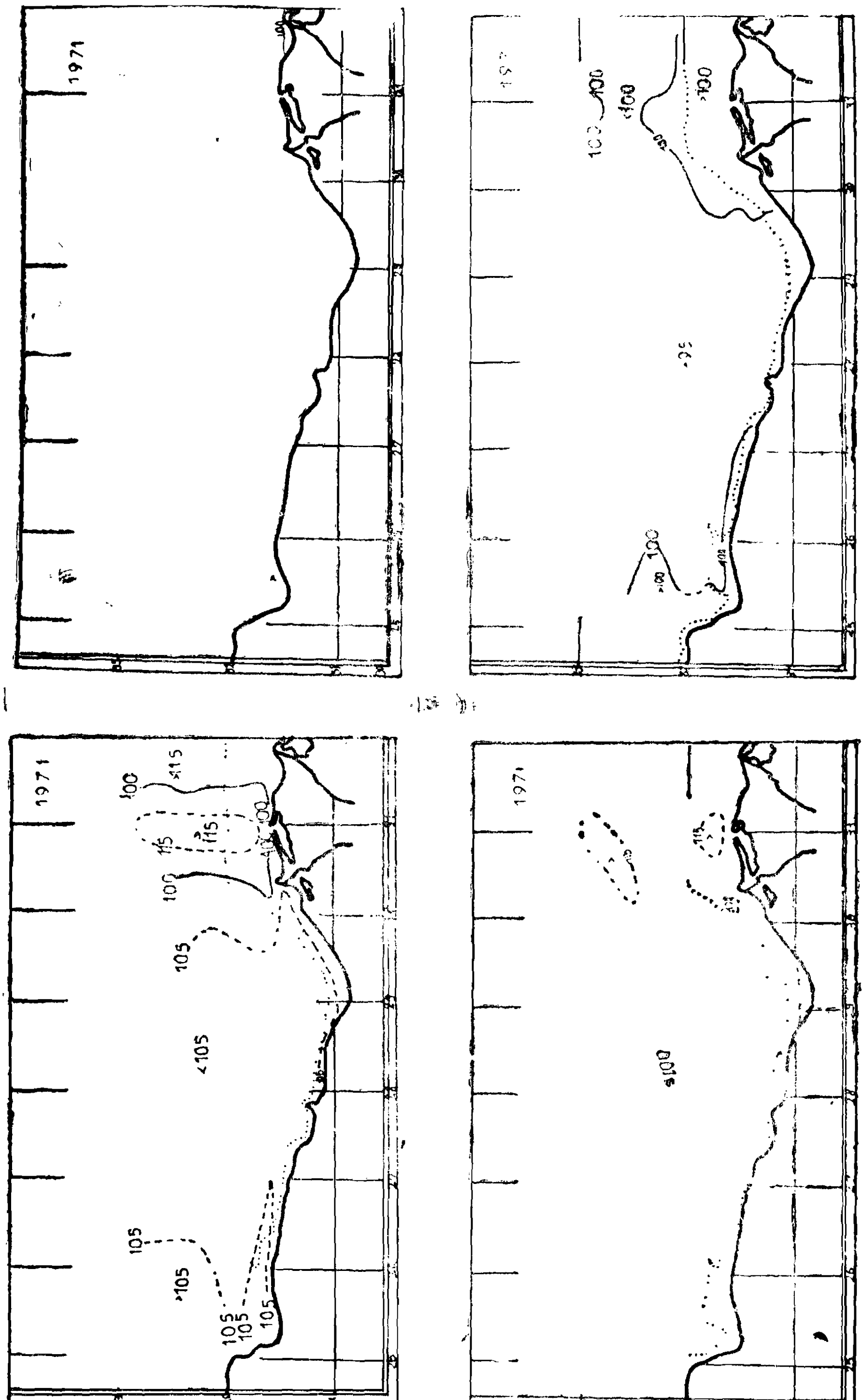


FIG. 27. Distribution of dissolved oxygen (ml/l) at the sea surface in the south-eastern Mediterranean during the different seasons of the year.


1971
1971
100
115
105
<105
1971
<100

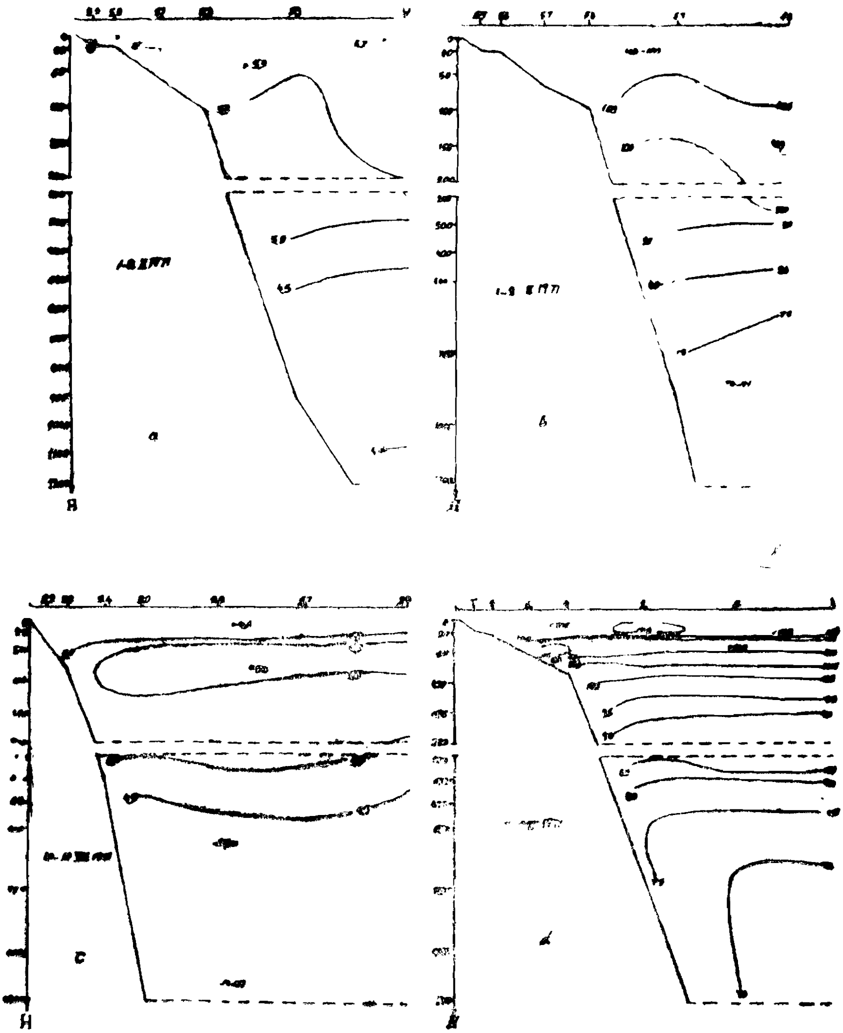


FIG. 29. Distribution of dissolved oxygen ml/L and in percentage saturation values, in the section from Damietta seawards in February (a,b), and August (c,d).

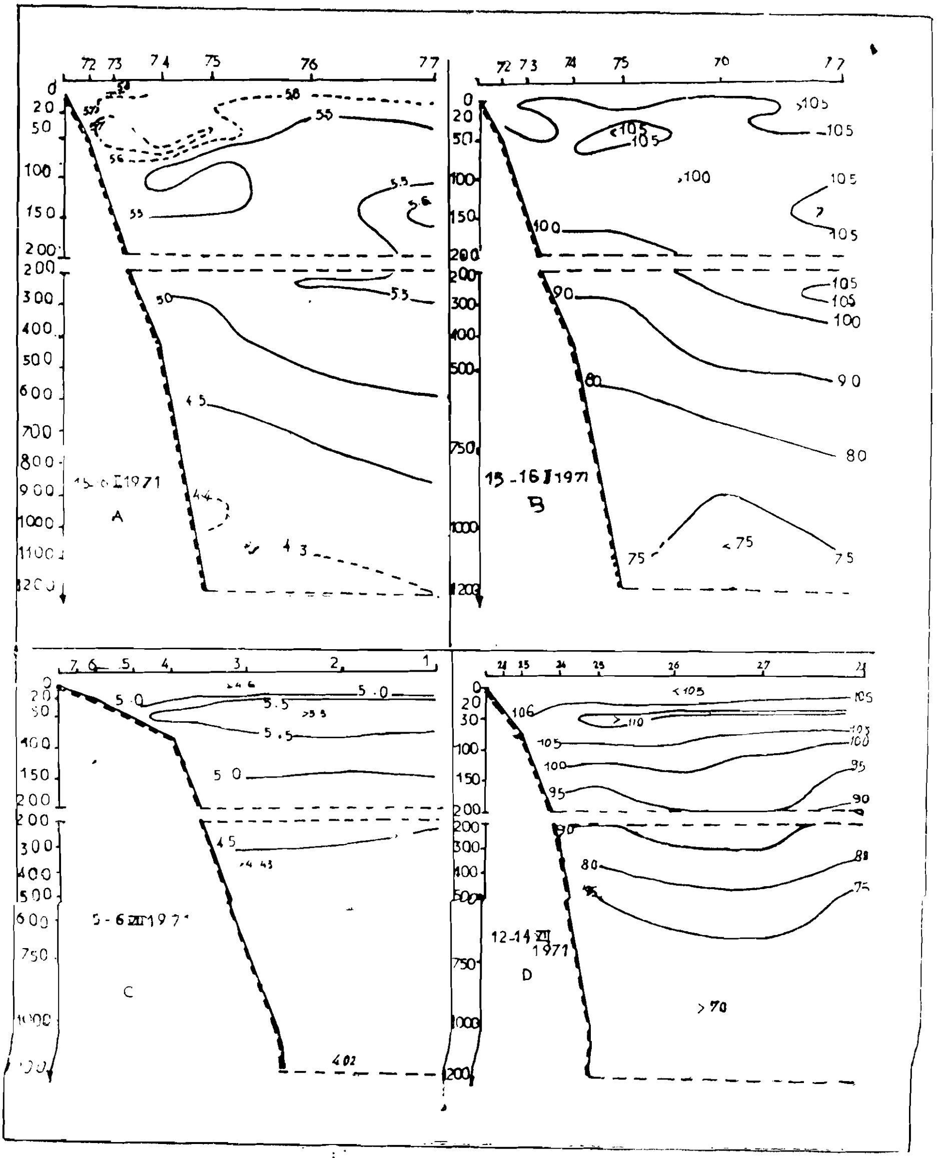


FIG. 30. Distribution of dissolved oxygen ml/L and in percentage saturation in the section from Salloum Bay seawards in February (a, b), and August (c,d).

As in the previous season, in spring there was an oversaturation of oxygen of 15 to 20 per cent, in the upper layer and a 100 per cent saturation was reached at depths of 50 to 150 m.

In order to determine the diurnal spring fluctuations of oxygen in the area of the Bay of Borullos, work was implemented at a diurnal station at a distance of 10 miles from the shore. Table 6 presents variations of hydrochemical characterists at the diurnal station. The main oxygen producer is known to be the process of photosynthesis. A high transparancy of the waters of the Mediterranean Sea favours the production of oxygen and organic matter in the layer till the depth of 150-200 meters (Grese, 1963, Belgorodskaja, 1965). The received data resulting showed that the process of photosynthesis influences very little the change of oxygen concentration in the open sea areas. These data are in full accord with Egorova's inference that "in the zone of photosynthesis of the Mediterranean Sea the consumption of oxygen for the oxidation of organic matter and its appearance due to the process of photosynthesis compensate each other" (Egorova, 1970).

In summer the content of dissolved oxygen in surface water was characterized by its uniform distribution all over the area and varied from 4.51 to 4.80 ml/1 (Fig. 27), the overstaturation of water with oxygen on the surface being 2-5 per cent (Fig. 28). Due to a higher temperature of the surface layer, part of oxygen from this layer is released to the atmosphere. In underlying layers high concentrations of oxygen do keep for some time. As a result, under the temperature leap layer, a maximum concentration results (5.27-5.92 ml/1 or 111-115 per cent) (Fig. 29 B, & Fig. 30 B). In the season in question in the layers of leap at a depth of 30-50 m, oxygen vertical gradients reached maximal values of 0.13-0.11 ml/1.

The lower limit of the sub-surface maximum was at a depth of 150-200 m. where the oxygen concentration was 4.64-5.22 ml/1 (87-96 per cent), whereas the maximum vertical gradient was 0.10 ml/1.

The boundary of 100-per cent saturation was observed at a depth of 100-150 m. (Figs 29 d, and Fig. 30).

Thus the dissolved oxygen content in water throughout the year was sufficiently high and was characterized by a uniform distribution throughout the whole area. In spring, summer and autumn the vertical superheating in the surface layer give rise to the maximum subsurface oxygen content with the upper limit at a leap upper depth (30-50 meters) and the lower limit at a depth of 150-200 meters. In winter the oxygen distribution in the layer of 0-200 meters was uniform.

TABLE 6.—VERTICAL DISTRIBUTION OF HYDROCHEMICAL CHARACTERISTICS AT DIURNAL STATION No. 77 IN THE AREA OF CAPE BORULLOS (31° 44′ N LAT. & 30° 54′ LONG.)
MAY 16, 1971, DEPTH 33 M

Time of Observation	23 50 15.V				06 00				12 00				18 00				00 10 17.V			
Depth (m)	O_2 ml/L	O_2 % m	pH	Oxidation mg O_2/1	O_2 ml/L	O_2 %	pH	Oxidation mg O_2/1	O_2 ml/L	O_2 %	pH	Oxidation mg O_2/1	O ml/L	O_2 %	pH	Oxidation mg O_2/1	O_2 ml/L	O_2 %	pH	Oxidation mg O_2/1
0	5.14	102	8.16	0.27	5.12	102	8.16	0.52	5.19	104	8.21	0.60	5.21	104	8.19	0.24	5.24	104	8.19	0.43
10	5.19	103	8.23	0.27	5.37	106	8.21	0.52	5.15	103	8.20	0.52	5.15	102	8.20	0.3	5.20	103	8.20	0.43
20	5.27	98	8.18	0.24	5.35	100	8.19	0.54	5.40	101	8.19	0.59	5.38	101	8.06	0.32	5.44	101	8.16	0.43
25	5.32	100	8.22	0.24	5.36	100	8.14	0.54	5.40	101	8.21	0.60	5.40	101	8.14	0.41	5.36	100	8.15	0.43

Hydrogen Ion Variation

Another ingredient along with oxygen is the hydrogen ion concentration of water (pH). An increase of pH value accounts for a consumption of carbon dioxide in the course of photosynthesis, whereas a decrease is a sign of its involvement in the course of oxidizing processes.

There are no available data on the pH distribution in the south-eastern part of the Mediterranean Sea. It is only known that in the northern part of the shallow-water area of the Adriatic sea (25-35 meters deep) waters of the near-bottom layer are characterized by very low values of pH — less than 8.0. In the Ionian sea at a depth of 1000 meters pH values are equal to 8.09 (Vitrock & Dobrzhanskaya, 1968). The horizontal distribution of pH values in the surface waters in different seasons in the south-eastern part of the Mediterranean sea is presented in Fig. 31.

On the whole during autumn, pH values in the surface waters varied within the range of 7.54-8.31. An increase in pH values took place from east to west both in the surface and throughout the whole water column. Higher pH values ($>$ 8.20) were observed within the area from the Arab Bay to the Bay of Salloum. Lower pH values ($>$ 8.00) on the surface were characteristic to the eastern part of the area from Damietta to the Bay of Abukir. At a depth of 1200 meters pH values ranged between 7.81 and 8.23.

In winter, the surface pH values ranged from 7.91 to 8.21 and were distributed uniformly throughout the water area. High pH values (9.14-9.16) were characteristic to the 10-mile zone near the Bay of Borullos. This is likely to have been caused by the influence of waters from the lake of Borullos. Here also lower values of salinity, density and higher oxidation values were observed. Just the same as it was in the photosythesis layer and in the whole of the water column, pH values used to be some-what lower than in autumn and spring and were equal to 7.73-8.20 at the level of 1200 meters.

In spring pH values at the surface changed within the range of 8.03 to 8.30. Somewhat higher values (8.21-8.25) as compared with the whole area were characteristic to the Arab Bay and the Bay of Borullos. In the whole of the water column, including the photosynthesis layer the pH values in spring were higher than in winter, however, along the cross-section from Damietta they were lower than in winter.

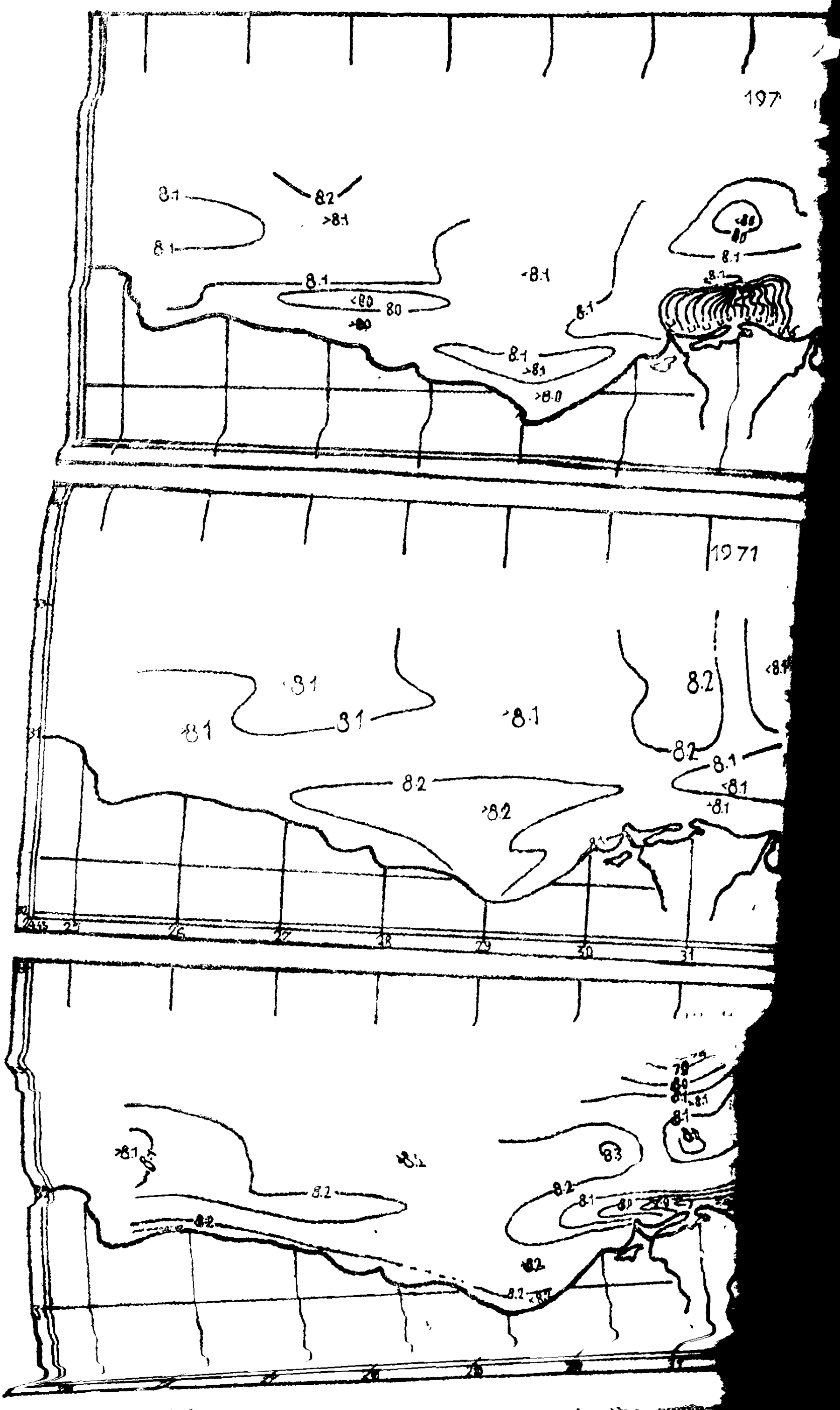


Fig. 31. Horizontal distribution of pH in surface waters in the south-

Diurnal fluctuations of pH values presented on Table 6, show that there were no substantial variations of pH values in the course of time. The analysis of pH value distribution in the plane of cross-sections indicates the fact that in the photosynthesis layers (0-50, 0-200 meters) comparatively high pH values (8.20-8.30) were observed. In general, pH values were of usual character, the deeper the lesser. At a depth of 1200 m throughout the year pH values ranged from 7.73 to 8.24 (depending on the season and the region of the water area investigated).

DISTRIBUTION OF NUTRIENT SALTS

Phosphates : According to published data, in the waters of the Mediterranean Sea the quantity of phosphates in the photosynthesis layer during most of the year does not exceed 0.03 ug-at P/1. Egorova (1966) points out that during the winter time in various regions an increase in the concentration of inorganic phosphorus from 0.03 to 0.26 ug-at P/1 was observed. The low concentration of phosphates in the Mediterranean Sea is mainly determined by the hydrological regime hampering their accumulation in the sea itself on account of their small ingress with the drainage waters and autflow to the Atlantic ocean and the Black sea (Egorova, 1966).

The distribution of phosphates in the surface waters in the different seasons of 1970-1971 is presented in Fig. 32. In autumn the phosphate content varied from zero to 0.27 ug-at P/1. In the circumlittoral 5-m zone in the area from Damietta to the Cape of Borullos, the phosphate values amounted to 016-5.23 ug-at P/1. However, there were no phosphates at all in the circumlittoral 5-m zone west of the cape of Borullos to the Bay of Salloum. At a distance of 10-20 miles from the shore throughout the whole area it was possible to trace the phosphate content from 0.03 to 0.23 ug - at P/1. North of 32°N Lat. in the area of the Cape of Borullos to the Bay of Mersa-Matrouh no phospates were present. Regarding the vertical phosphate distribution it should be noted that they are almost completely unavailable in the area of the Bay of Abukir, the Bay of Mersa-Matrouh, the Bay of Salloum down to a depth of 200 m. On the Damietta cross-section the phosphate concentration totaled 0.06-0.23 ug-at P/1, whereas on the cross-section from the Arab Bay 0.05-0.15 ug-at P/1. Over 200 m deep in the whole area the phosphate content tended to increase with depth (especially below 500 m) from 0.06 to 0.40 ug-at P/1 at the level or 1200.

FIG. 32. Horizontal distribution of phosphate in surface waters (in u-at P/L) in the southeastern Mediterranean in the different seasons of the year.

In winter the phosphate concentration at the surface (except for a 75-mile-station in the area of the Bay of Mersa-Matrouh) varied from 0.05 to 0.20 ug-at P/1. A slight increase in the concentration took place from east to west, and a decrease - from south to north in the area of the Bay of Mersa-Matrouh. For the season in question a more or less even phosphate distribution is characteristic in the zone of convection intermixing to a depth of 150-200 m below which the phosphate concentration increased slightly and at 1200 m totaled 0.08-0.28 ug-at P/1 (Fig. 33 a & c).

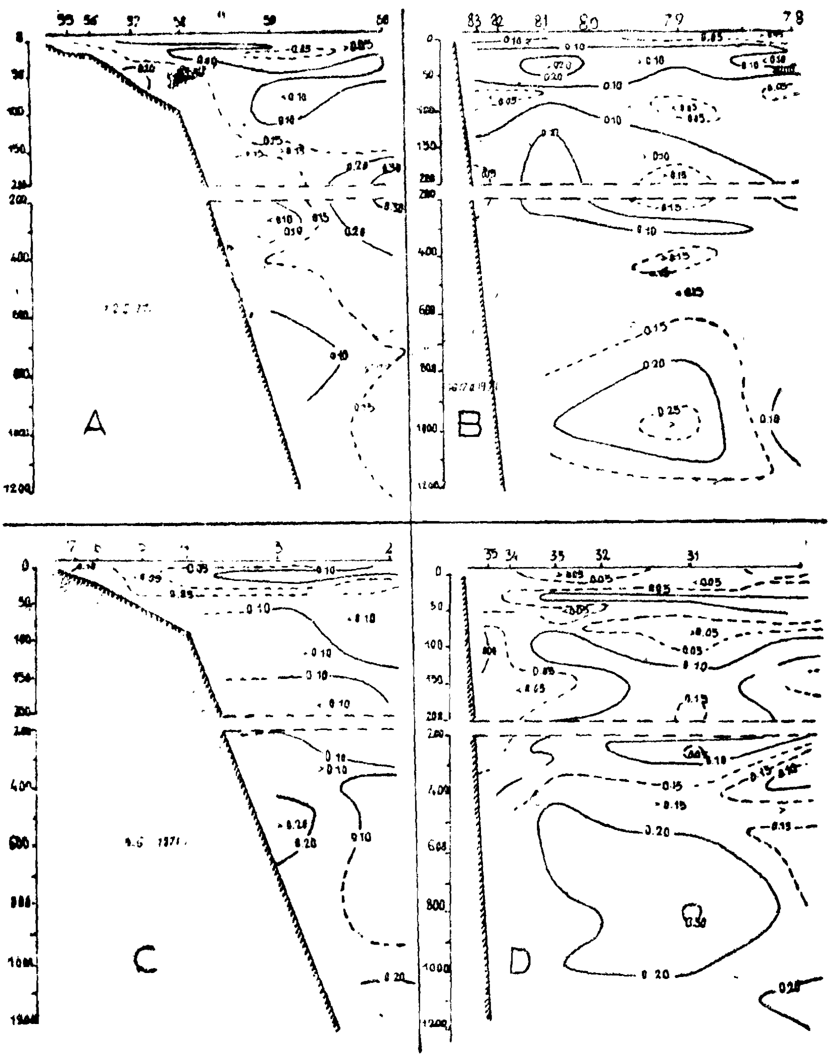


Fig. 33. Phospate distribution, in microgram-atoms P/L, along the sections of Damietta and Mersa Matrouh during the winter (a, b) and the summer (c, d) of 1971.

In spring the values of phosphate content ranged from 0.05 to 0.54 ug-at P/1. In the Bay of Abuki rthe maximum phosphate concentration observed was 0.45 ug-at P/1 at a 5-mile station and 0.27 ug-at P/1 at a 50-mile station. For this season the vertical phosphate distribution is characterized by a lower concentration of phosphates (0.05-0.08 ug-at P/1) in the layer of 0-200, 0-250 m. (depending upon the area). A 20-mile zone (10-40 meters deep) in the area of the Bay of Borullos and the Bay of Abukir was characterized by a higher phosphate content (0.11-0.45 ug-at P/1) down the whole depth. At a dept hof 1200 m. the phosphate values totalled 0.06-0.54 ug-at P/1. Lower phosphate concentration (0.00-013 ug-at P/1) on the surface as compared to other seasons was characteristic for the summer season. The highest phosphate content (0.04-0.13 ug-at P/1) was observed in the area of Damietta, the Cape of Borullos, in the 20-mile zone of the Bay of Abukir and at some stations in the western part of the region. The central part of the waer area investigated was characterized by minimal (0.00-0.02 ug-at P/1 phosphate concentrations.

The westernmost area - the Bay of Sallum - was characterized by a com plete absence of phosphates in the upper 200-meter water column. Th phosphate concentration within 0.05-0.10 ug-at P/1 is ovserved in the lay from 0 to 200 meters in the area from Damietta to the Bay of Mersa-Matro (Fig. 33 c. & d.). Approximately at the depth of thermowedge (30-50 meter the phosphate content increased upto 0.10-0.15 ug-at P/1.

Below 200 meters there was a tendency for a slight nicrease of phosph content with depth throughout the whole region; starting from 500 meter tendency to increase the phosphae content was more pronounced and at level of 1200 meters the phosphate content was 0.10-0.21 ug-at P/1.

Hence, the total level of the phosphate content in the surface layer low. In summer, in a number of aras, pehosphates were non-available at The area from Damietta to the Bay of Abukir was distinguished by a hi phosphate content in all seasons as compared to the remaining part of water area investigated. A pronounced increase in the phosphate conten all seasons was observed only starting from a depth of 400-505 meters.

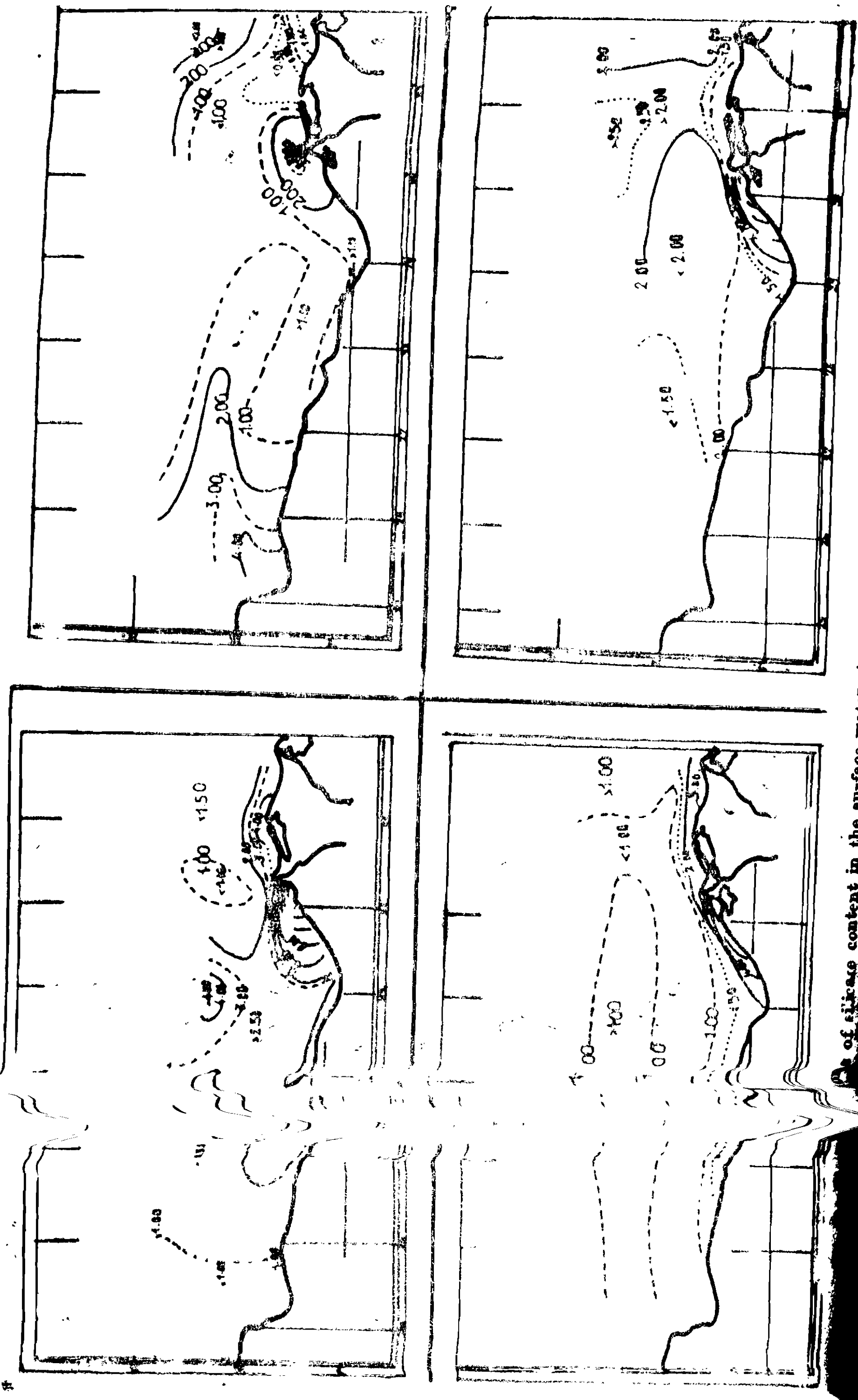
Silicates :

Fig. 34 presents the silicate distribution at the surface in the different seasons of 1970-1971. In autumn their concentration in the whole region varied from 1.28 to 12.28 ug-at Si/1. A highlr silicate content (2.79-12.28 ug-/at Si/1) both at the surface and throughout the whole depth was naticed ın the circumlittoral zone itself in the area of Damietta — the Bay of Abukir. Beyond the limits of this zone in the whol eof the water area horizontal gardients in the silicate distribution are low or insignificant. It is characteristic for autumn to have a small (2.5-6.2 ug-at Si/l) subsurface silicatl maximum at l depth of 10 0meters and an intermediate layer with a lower silicate concentration in the water column 20-50 or 100.200 meters (deplnding on the region).

Seasonal changes in the silicate content took place in the upper 200-m water layer, below which a relative concentration throughout the year and a clearly pronounted regularity of their increase with depth was observed (Fig 35).

In winter, as well as in autumn, a higher silicate concentratoin (3.20-15-86 ug-at Si/1) was characteristic of the 5-mile zone from Damietta to the Bay of Abukir. Farther from the shore, the tendency for thl silicate content to decrease is more pronunced. The vertical silicate distribution under the influencl of convection intermixing down to a depth of 200-250 meters was comparatively uniform (Fig. 35 a,c). The silicate concentration in this column was equal to 1.2-2.0 ug-at Si/1 and the same for the Salloum cross-section being less than 1.0 ug-at Si/1.

In spring the silicate values at the surface varild within the range of 0.09 to 4.78 ug-at Si/1. In the area o fthe Bay of Abukir and the Bay of Salloum the silicate content was equal to 3.54-4.78 ug-at Si/1, whereas in the 20 mile zonl of the Bay of Borullos and the Arab Bay 0.09-0.74 ug-at Si/1. On the whole there was a tendency for the silicate content to decrease from south to north except for the area of Damittla. Here the contentration of silicates varied from 1.43 to 2.53 ug-at Si/1. In the vertical distribution of silicate as compared to winter, the layer of 0.200 meters showed a decrlase in its content especially in the 20-mile zone off Damietta, the Bay of Borullos and thl Ara bBay along the cross-section from the Bay of Mersa-Matrouh, the silicate values were les than 1.00 ug-at Si/1, down to the depth of 100 meters. In the area of the Bay of Salloum a sharp increase in the silicate concentration as comparld with the winter season was observed.



... of silicate content in the surface waters in the south—eastern Mediterranean. (microgram - atom Si/L.)

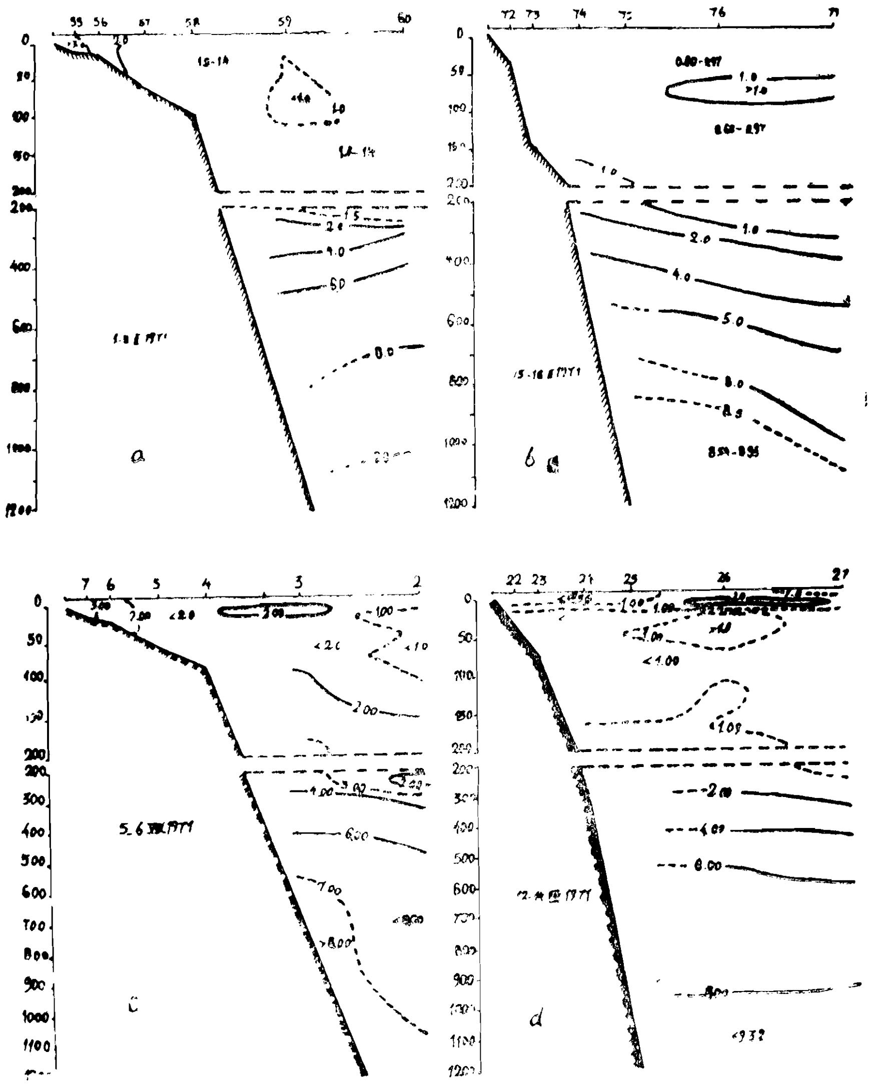


FIG. 35. Silicate distribution along the sections of Damietta and Salloum in the winter (a, b) and summer (c, d) of 1971. (Unit : microgram atom Si/L).

In summer the silicate content at the surface was equal to 0.20-10-54 ug-at Si/1. The silicate content both at the surface and throughout the depth was high (3.09-10.54 ug-at Si/1) in the narrow 5-mile zone from Damietta to the Bay of Abukir. West of Abukir the silicate concentration decreased to 0.79 ug-at Si/1 in the Bay of Salloum. In summer, as well as in spring, a regular decrease of silicate content was observed going farther from the shore. At a depth of 10 meters a subsurface silicate maximum w discovered (0.90-2.42 ug-at Si/1). In the area of the Cape of Borul observation was made of a layer with a lower silicate concentration (less-th 1.00 ug-at Si/), its upper limit being at a depth of 20 meters and the low one being at a depth of 75-100 meters.

In the area of the Bay of Salloum the lower boundary of this layer at the level of 150-200 meters (Fig. 35 c,d).

In the Bay of Abukir there was a layer with a higher silicate cont (more than 1 ug-at Si/1) at the depth of the temperature leap (30 meters).

Thus, the zone from Damietta to the Bay of Abukir differed from remaining investigated water area throughout the year by a higher conc ration of silicate content, the farther from the shore, the lesser the con of silicates.

Seasonal variations in the silicate content took place winthin the co of 0-200 meters and were expressed by the availability of higher conc tions of silicates in the leap layer, in the water sheet with lower silicate centrates (1.00 ug-at Si/1) and in the subsurface silicate maximum at a of 10m. Below 200m there was a relative stability of silicate concent throughout the year with a clearly pronounced regular increase with de

Nitrities :

The distribution of nitrites at the surface in the south-eastern p the Mediterranean Sea in various seasons of 1970-1971 is represent Fig. 36.

In autumn the content of nitrite nitrogen in the surface sea totaled 0.00-0.13 No_2 - N ug-at/1 in the whole sea area under invest The nitrite content decreased going farther from the shore. Only Arab Bay there was a slight increase of nitrites from the shore seaward

In winter the distribution of nitrites at the surface was uniform, its concentration varied from 0.00 to 0.11 ug-at No_2-N/1.

In spring the nitrite content varied from 0.00 to 0.16 ug-at No_2-N The highest concentrations were registered in the Bay of Abukir.

In summer nitrite concentration at the surface was 0.00-0.17 ug-at N

In spring the nitrite content varied from 0.00 to 0.16 ug-at No

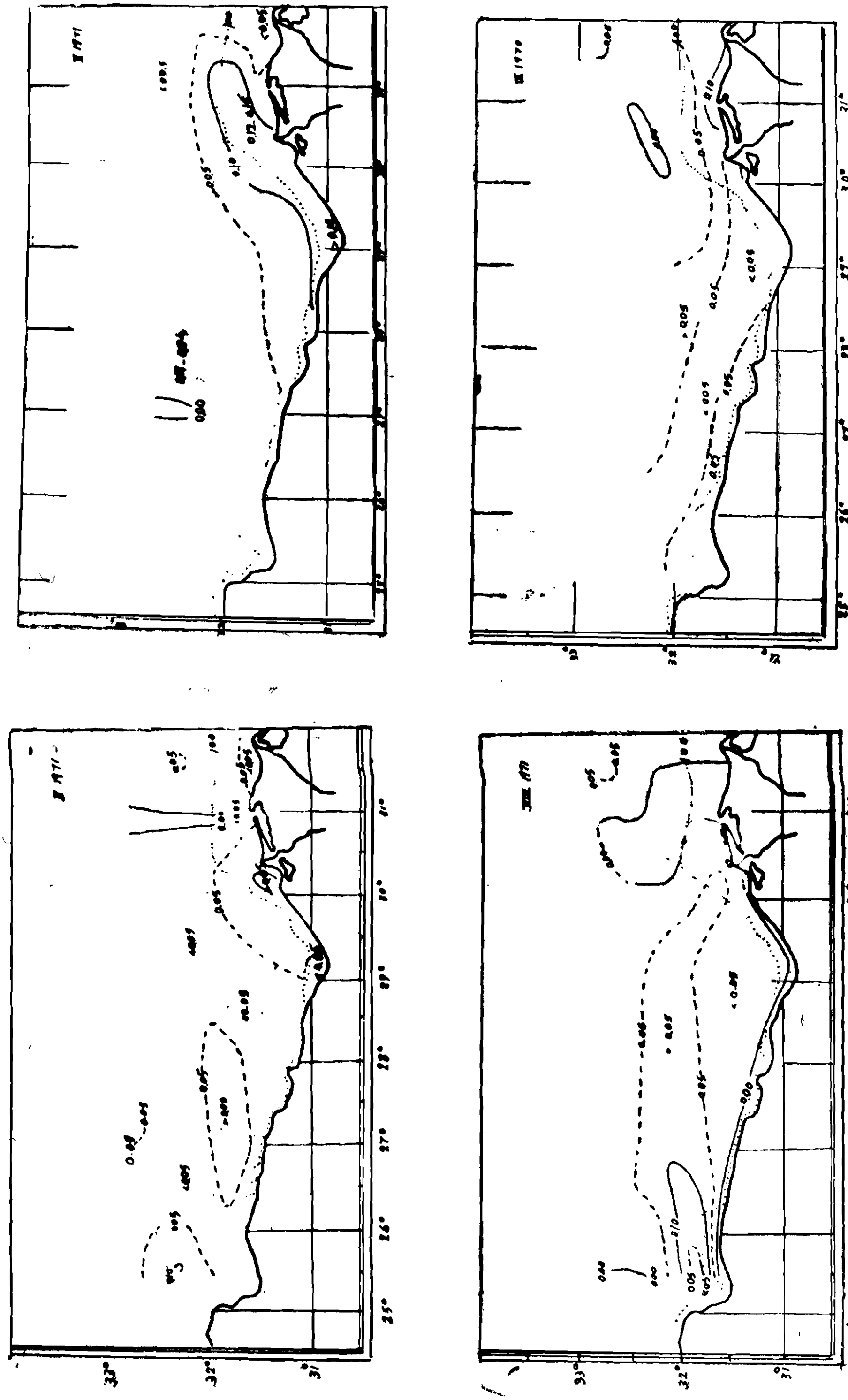


Fig. 36. Surface distribution of nitrite, in μg-at-NO_2-N/l in the south-eastern Mediterranean during the different seasons of the year.

In the region off Damietta and the Bay of Borullos, as well as along the whole shoreline no nitrites were available. A slight tendency to increase their concentration was observed in the direction south-north and east-west in the area from the Bay of Abukir to the Bay of Salloum. In the photosynthetic layer (0-75, 0-100m) there was a decrease in the nitrite concentration with depth from 0.06 to 0.000 ug-at No_2-N/1. However, under the photic layer at a depth of 150-200m, as well as in the temperature leap layer (30-50 m) a maximum of 0.10-0.16 ug-at No_2-n/1 was recorded. Below 150-200 m. its concentration decreased to analytical zero. It seems to be connected with the transition intermediate form of nitrogen, from nitrite to the final form of nitrate.

Nitrates :

The distribution of nitrates at the surface in the south-east part of the Mediterranean Sea in different seasons is presented in Fig. 37.

A characteristic feature of the vertical distribution of nitrates is their extremely low values in the upper 100-m water layer, except for the surface layer in the area between the mouth of Rosetta and Alexandria.

The nitrate content gradually increases with depth and reaches 5 to ug-at No_2-N/1 at levels of 600-800 m.

Oxidation :

This hydrochemical characteristic of sea water was determined at10-3 mile stations in winter, spring and autumn.

In winter the oxidation changed in the surface waters from 0.10 to 0. mg 0_2/1. Its higher values (0.50-0.80 mg 0_2/1) were recorded in the circu littoral 10-mile zone. The farther from the shore, the smaller became t oxidation value, ranging from 0.60 to 0.10 mg 0_2/1.

In spring in the surface water the oxidation was equal to 0.27-0.60 0_2/1. Its lower values (0.27-0.40 mg 0_2/1) as compared to the winter seas were recorded in the littoral zone between Damietta and the Arab B At the diurnal station in the region of the Bay of Borullos the maximu on the surface, (i.e. 0.60 mg 0_2/1) was recorded at 12.00, whereas the minim one - 0.24 mg 0/1 at 18.00. During the day it changed, from 0.24 mg 0 to 0.63 mg O_2/1 in the deep layers at 12.00.

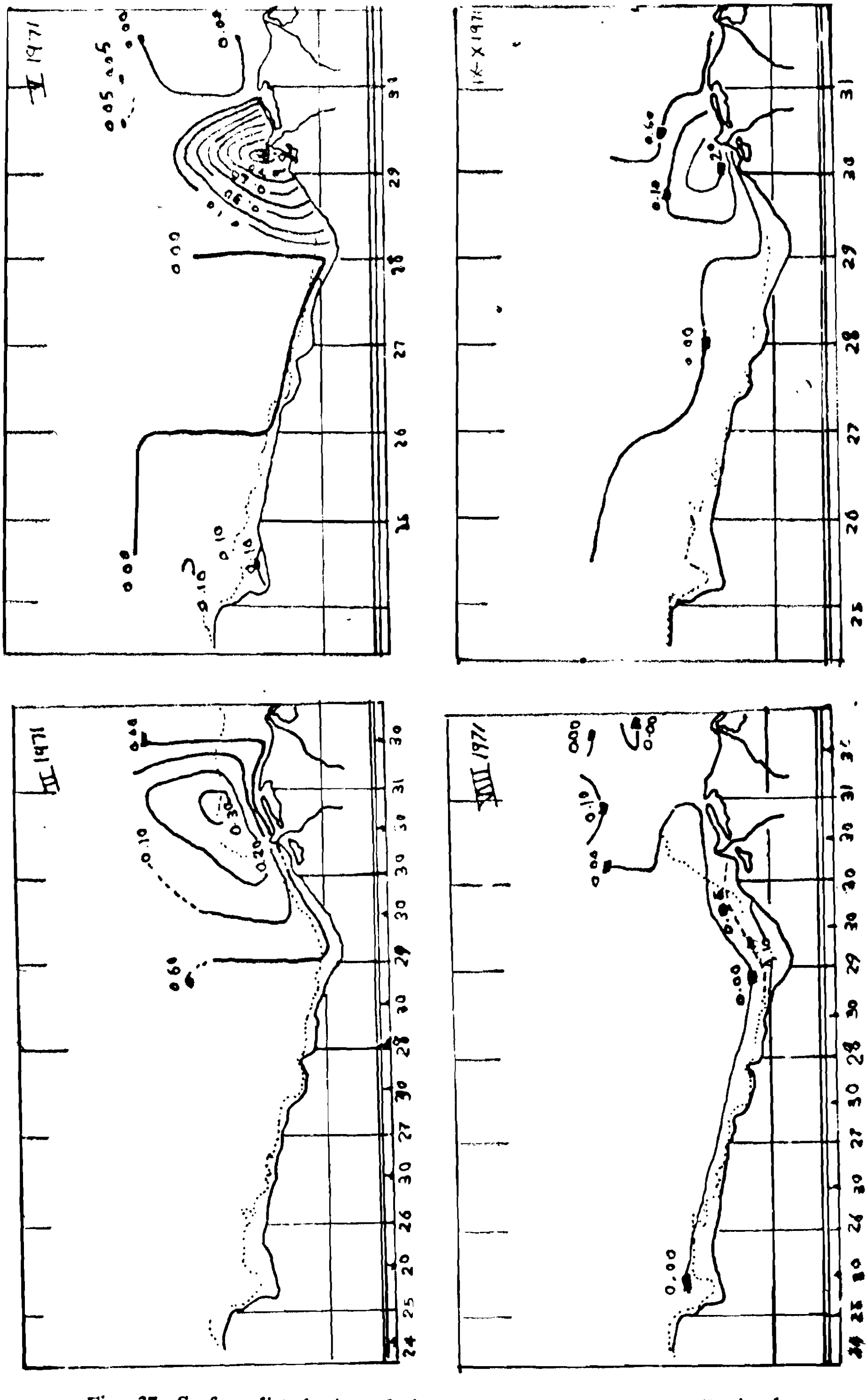


Fig. 37 Surface distribution of nitrate (microgram-at oms NO_3/L) in the South-eastern Mediterranean during the different seasons of the year.

In spring the oxidation values on the surface were less than those in other seasons and amounted to 0.22-0.52 mg O_2/l. The farther from the shore, the higher became the oxidation - up to 0.46-0.52 mg O_2/l.

Throughout the year it was observed that the deeper the lesser the tendency to oxidation. In the circumlittoral zone limited by the isobath 50 meters oxidation values range from 0.24 0.31 mg O_2/l, whereas in the layer of 1000-1260 meters - it varies from 0.11 to 0.-24 mg O_2/l.

Continental Flow :

According to the data of the Ministry of Public works the gross average annual flow of Rosetta and Damietta, the main river branches of the Nile river from 1912 to 1942, amounted to about 62 km³.

In the years after 1956, except 1964, the Nile flow was continuously below this figure (Table 7). This was accounted for by the irrigation drought and partially by climatic factors. The average annual Nile flow from 1956 to 1964 was equal to 43 km³.

In 1965 due to the fact that the Nile was regulated, the flow decreased to 36 km³, whereas in 1966 it amounted only to 3.2 km³, In 1967 the river flow increased to 21.5 km³. In the following years up till now the annual flow of the Nile river has been maintained at a very low level of 4,4 km³ at an average. Thus, a gradual decrease of the Nile flow began actually in the 1950' ies, in the main, on account of the decrease of the Damietta flow, which used to be the main river branch of the Nile.

From 1912 to 1942 the average annual flow of Damietta was almost three times as much as the flow of Rosetta. In the following years a substantial redistribution of the Nile flow took place where its biggest part started to flow seawards through the Rosetta branch. From 1956 to 1965 the annual flow of the Damietta branch was reduced by 28 km³. and was equal in these years only to half the flow of the Rosetta branch. In April 1965 the flow of the Nile waters to the Mediterranean Sea through the Damietta branch was stopped completely. At present only the river branch of Rosetta is functioning, only during the winter season.

Table 7.—MONTHLY NILE DISCHARGE FROM 1956 TO 1972 (in km^3)(1)

Years \ Months	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Gross amount per annum
1956	2.47	0.000	0.00	0.00	0.00	0.03	1.01	10.66	16.18	11.75	10.27	3.36	45.75
1957	3.22	0.66	0.00	0.00	0.00	0.23	0.86	6.90	15.51	5.23	1.03	0.39	34.03
1958	1.11	0.03	0.00	0.00	0.00	0.00	0.00	10.92	14.47	9.91	6.70	1.41	44.55
1959	3.05	0.02	0.00	0.00	0.00	0.00	0.00	7.18	17.79	13.99	5.37	1.96	49.36
1960	3.22	1.02	0.00	0.00	0.00	0.00	0.00	7.18	13.81	8.96	3.75	0.78	8.72
1961	1.92	0.14	0.00	0.00	0.00	0.00	0.00	12.28	19.20	15.88	7.46	1.64	58.52
1962	3.46	0.48	0.06	0.00	0.00	0.00	0.51	4.89	16.55	12.52	4.23	1.33	44.01
1963	3.12	0.50	0.01	0.00	0.00	0.00	1.13	9.96	16.60	7.8[illegible]	2.73	2.09	43.[illegible]4
1964	3.76	1.42	0.31	0.01	0.00	0.00	0.67	12.22	19.29	13.26	8.91	3.87	63.72
1965	5.46	3.31	1.75	1.05	1.31	0.93	0.55	1.29	5.98	6.19	5.08	3.04	35.94(2)
1966	3.19	0.69	0.10	0.04	0.08	0.05	1.26	0.15	1.50	3.86	1.02	1.29	13.24
1967	2.22	0.12	0.05	0.01	0.10	0.00	0.01	0.91	3.33	6.64	4.99	2.31	21.51
1968	2.84	1.45	0.31	0.18	0.10	0.01	0.04	0.02	0.05	0.61	0.66	0.66	5.87
1969	1.74	0.89	0.08	0.01	0.02	0.01	0.02	0.04	0.05	0.16	0.14	0.44	3.60
1970	2.12	0.90	0.06	0.04	0.01	0.05	0.03	0.02	0.04	0.08	0.19	0.48	4.20
1971	2.26	0.48	0.08	0.30	0.05	0.06	0.02	0.04	0.10	0.14	0.17	0.40	4.10
1972	2.41	0.28											

(1) Water discharge was measured near the town of Edfina 30 km from the mouth of Rosetta and near the town of Damietta 20 km from the mouth of this river branch.

(2) Since April 1965, the Damietta discharge has been stopped completely.

In the past the flow of the Rosetta and the Damietta river branche was completely regulated by a system of temporary dams constructed o these river branches. The discharge of fresh waters usually took place fro July or August to January. The maximum flow was recorded in Octob and was equal to 25-30 per cent of the Nile flow per annum.

At present the main flow of Rosetta branch is observed in winter. F two months, i.e. January and February, over 50 per cent of the annu flow enters the sea.

The autumn flood so characteristic for the Nile flow in the past do not take place at present. Thus after the Nile river had been regulated, t flow have been reduced sharply, and its annual distribution have also cha ged considerably. Owing to the reduction of the Nile flow, its share enriching the waters with biogenic substances in the area under study h considerably shrunk.

The river flow reduction is accompanied also by a gradual increase the quantity of drainage water discharged from the cultivated land af irrigation. Due to this fact, the main coastal lagoons of Egypt, i.e. Ed Borullos and Manzala, are at present an additional source of fresh wat In certain months, especially during the summer, their gross discharge exce the Rosetta discharge amount and exerts a noticeable influence on region of adjacent sea areas.

d) Currents :

There are three main factors affecting the water movement in Mediterranean Sea.

1. The force of the horizontal gradient determined by the level differ of the Mediterranean Sea and the Atlantic ocean, this fact accounts the entrance of Atlantic waters into the Mediterranean Sea in the u layer resulting in a stable east current. The latter can be clearly tr along the northern shore-line of Africa, including the shores of Egypt.

2. The force of the horizontal pressure gradient caused by the w density difference in the said basins. This results in discharging the Me ranean waters into the Atlantic ocean in deep layers.

3. The force of tangential tension caused by the wind. The preva of north-westerly winds over the Mediterranean Sea during the greater of the year enchances the constant eastward water movement.

The surface current in the Mediterranean Sea is a cyclonic one d the effect of the Coriolis force.

There is a number of gyres in the Mediterranean Sea, one being located in the south-east part. During the warm season of the year the water movement in the area of this gyre is cyclonic, the bearings of the central part being the meridians of 25-27° E Long. In winter the currents change their direction to the opposite and the speeds increase. The centre of the anticyclonic gyre is moved eastwards to the area of 30° E.Long (Ovchinnikov, 1965 & 1966). Between the shores and the said gyres there is an eastward water movement.

The characteristics of sea currents in the area under study vary greatly with distance from the shore. In the area adjacent to the Delta the currents are mainly caused by the wind and partly by the level gradient which lowers from the shore to the open sea. Constant currents are very weak here. In the area south of isobath 50 a steady permanent current prevails with a speed of 1 knot.

Before the Nile river had been regulated, during the flood, in the area of the Delta there took place a rise of the shore level, which was especially substantial near the mouth of Rosetta. The level leaning resulted in the creation of force of the horizontal presseure gradient, which was directed north and which caused spreading of the Rosetta waters in this direction at speed of 4 to 6 knots (Gorgy, 1966). The farther from the shore, the weaker becomes the force of the horizontal pressure gradient, whereas the constituent directed eastward grows. In the area in which the force of horizontal pressure gradient is equal to the sum of constituents of the wind effect on the water and the Coriolis force the current direction in the surface layer changed to the eastern side whereas the current speed decreased to 0.7 - 1.0.

Near the Damietta mouth the level slope from the shore in the littoral zone is well in accord with the distribution maps of the density conditions (60) and the current velocities calculated on the basis of the said data which are given in the work of Halim (1967).

Near the Damietta mouth the level slope from the shore in the direction of the open sea was much smaller than that in the area of Rosetta. As a result of this Nile water soon after passing from the mouth spread mainly eastwards or south-eastwards where in one week they reach Port Said (Halim, 1960).

At present the Nile waters do not create such a level rise near the shore as in the past. Due to the decrease in the level the surface current near the Nile Delta have sharply droppped. According to data obtained instrumental current measurement undertaken in the area investigated fr board R/V "Ichthyolog" in 1966 and 1971 the total velocity rarely excee 0.5 knots ([1]).

During 1970-1971 in nearly all the Nile mouth area the curr directions were mainly from west to east. A more distinct eastward mo ment was pronounced in summer while in winter it was traced between shore and the 50-75-meter isobath. North of 32° N Lat. the water was observed to be in the western direction.

Thus, after the sharp decrease of the Nile flow the force of the horizo pressure gradient in the formation of the currents in the Nile mouth became considerably lower and accordingly there was a rise in the influ of the tangential wind pressure, the main cause accounting for the w movement on the shelf.

The shelf currents located north of the Nile Delta greatly influence prawn larvae survival in this area. Owing to the effect of the Cori force in the surface layer it has a constituent direction to the south. resulted in conveyance of the prawn larvae and juveniles shorewards, wh the conditions of their existence are more favourable.

(*e*) *Water masses :*

The vertical hydrological structure of the water column of the Medi ranean Sea was considered in a number of works devoted to the inves tion of this basin (Wust, 1959 ; Lacombe and Tchernia, 1960; Gorgy Shaheen, 1964; Moskalenko and Ovchinnickov 1965 ; Gorgy, 1966; Ha et al 1967 ; Morcos, 1967).

In the detailed work by Moskalenko and Ovchinnikov (1965) it is m tioned that there are three water masses in the basin under investigati a lower salinity water mass, a higher salinity water mass and a deep water mass and apart from that, in summer a surface water mass is for characterized by a high temperature and salinity. However, in this w just as is in the others referred to above, the area adjacent to the coast of E is not dealt with. However, the *hydrological structure of the wa*

([1]) The current characteristics in the area of the Egyptian shelf were considered all detail by V.B. Rzhonenisky in the publication "The Oceanographic Characteristic of South East Part of the Mediterranean Sea" (1970). Therefore in this Report these d are not referred to.

in this area is more complicated as compared to the water column of the open part of the Mediterranean Sea, a fact which is mainly determined by the Nile river flow.

In recent years several work was published about the water masses of the south-eastern part of the Mediterranean Sea (Gorgy, 1966, Halim *et al.* 1969, Morcos, 1967). Beside these, it is necessary to point out the work by Halim (1960), Halim *et al* (1967), which is based on the observations undertaken in the area under study in October 1964. The authors showed that in the area adjacent to the Nile Delta within the upper 30-40-meters layer there are two distinctly pronounced water masses : the surface one with a low salinity of the sea water and the water mass of maximum salinity. The depth of the surface water mass is only about several meters while the depth of the second one is 20 to 30 meters. As to its characteristics this water mass corresponds to the surface mass according to the classification by Moskalenko and Ovchinnikov (1965). The quoted work by Halim *et al.* (1967) is based on a small amount of data gathered for one season. Therefore it is deemed feasible on the basis of the observations and material gathered as a result of investigations undertaken in the south-eastern part of the Mediterranean Sea in 1970-1971, except for the area near the mouth of Rosetta and the Bay of Abukir, to throw light on the most important peculiarities of the water column during the cold and the warm seasons of the year.

The TS-curves Fig 38a based on temperature and salinity observations during the summer season of 1971 showed that during this time of the year the following water masses are distinct :

1. A surface water mass located in the layer from 0 to 30-50 m. with a temperature of 22-28°C and a salinity of 38.8-39.6‰.

2. A water mass of lower salinity formed from the Atlantic waters and having such characteristics : T = 17-23°C : S = 38.6-38.8 ‰. The core of this water mass lies in the layer of 50-75 m. With the advance in the eastern direction and due to the intermixing with the upper and the lower layers, the salinity of the water mass in question rises and the depth of the core bottom increases.

3. An intermediate water mass of a higher salinity located at depths from 150 to 400 m (T=15-17°C ; S=38.9-79.0 ‰.).

4. A deep-layer water mass located below the 400-m level. Within this water mass in the layer of 400-1200 m the temperature is equal to 13.6-15.0°C;

the salinity is 38.6-38.8‰. The characteristics of this water mass *is al*[illegible]
unchangeable throughout the year.

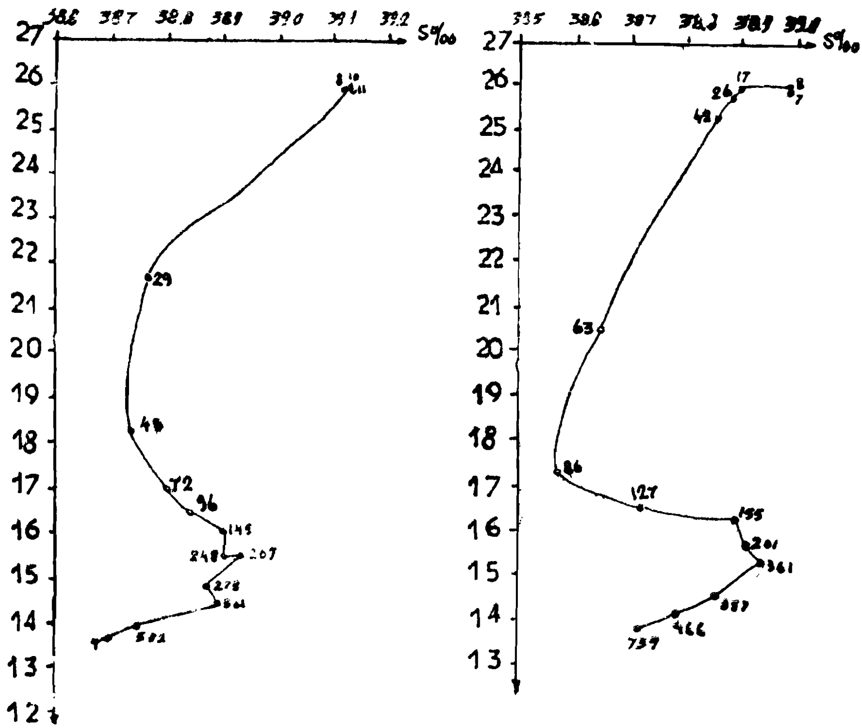


FIG. 38a. TS curves based on temperature and salinity observations in the South-eastern Mediterranean during the summer of 1971.

Moskalenko and Ovchinnikov (1965) pointed out that the intermediat[e] water mass is formed in the northern part of the Levant Sea and partly i[n] the south-east of the Crete basin in winter ; from where it moves in th[e] south-west direction and gradually submerges. The charts of the maximu[m] salinity layer distribution is well in accordance with the data of Wüst (1959[)], Lacombe and Techernia (1960).

In our opinion, in cold winter, for example in 1971 when convecti[on] mixing takes place down to an average depth of 300 m, this water mass [is] formed in the south-east part of the Mediterranean Sea adjacent to the coa[st] *of Egypt.*

Morcos (1967) also does not exclude the possibility of forming an intermediate water layer of higher salinity in the said region.

Let us see the vertical hydrological structure of the south-east part of the Mediterranean Sea during the winter time. Fig. 38b represents TS curves drawn on the basis of our observations during the cold season of 1970-1971. It seems that in winter within the layer in question there are only two water masses ; the upper one and the abyssal one.

At present there are changes in the formation and the distribution of water masses caused by a sharp decrease of the river discharge, which resulted during the summer time in the disappearance of the surface water mass of low salinity whose existence had been pointed out by Halim (1967) before the Nile regulation, whereas the winter time of the year caused the intensity of convection. Consequently, in the south-east part of the Mediterranean Sea within the layer under consideration, down to 1200 m. — during the warm season of the year there are four water masses, and not five as it used to be mentioned before the regulation of the Nile flow. During the winter, however, because of a decrease in the vertical stability, the surface waters submerge very deeply.

Conclusions :

The analysis of oceanographic data enable us to make the following conclusions :

1. The water temperature in the area under study in the layer of 0-75 m is subjected to big seasonal changes (about 8-10°C) which are determined by the annual course of solar radiation. The inter-layer temperature changes in the abyssal layers are small.

2. A special feature of the water temperature distribution in the surface layer is a rise in its values going farther from the shore during autumn and winter while in spring and summer, it decreases in this direction.

3. In autumn, summer and spring of 1970-1971 the water temperature was lower than in the corresponding seasons of 1966.

4. The vertical distribution of salinity in the south-east part of the Mediterranea Sea is very complicated because of the presence of layers with lower and higher values of salinity. The existence of these layers affects greatly the density distribution and mixing of water measses.

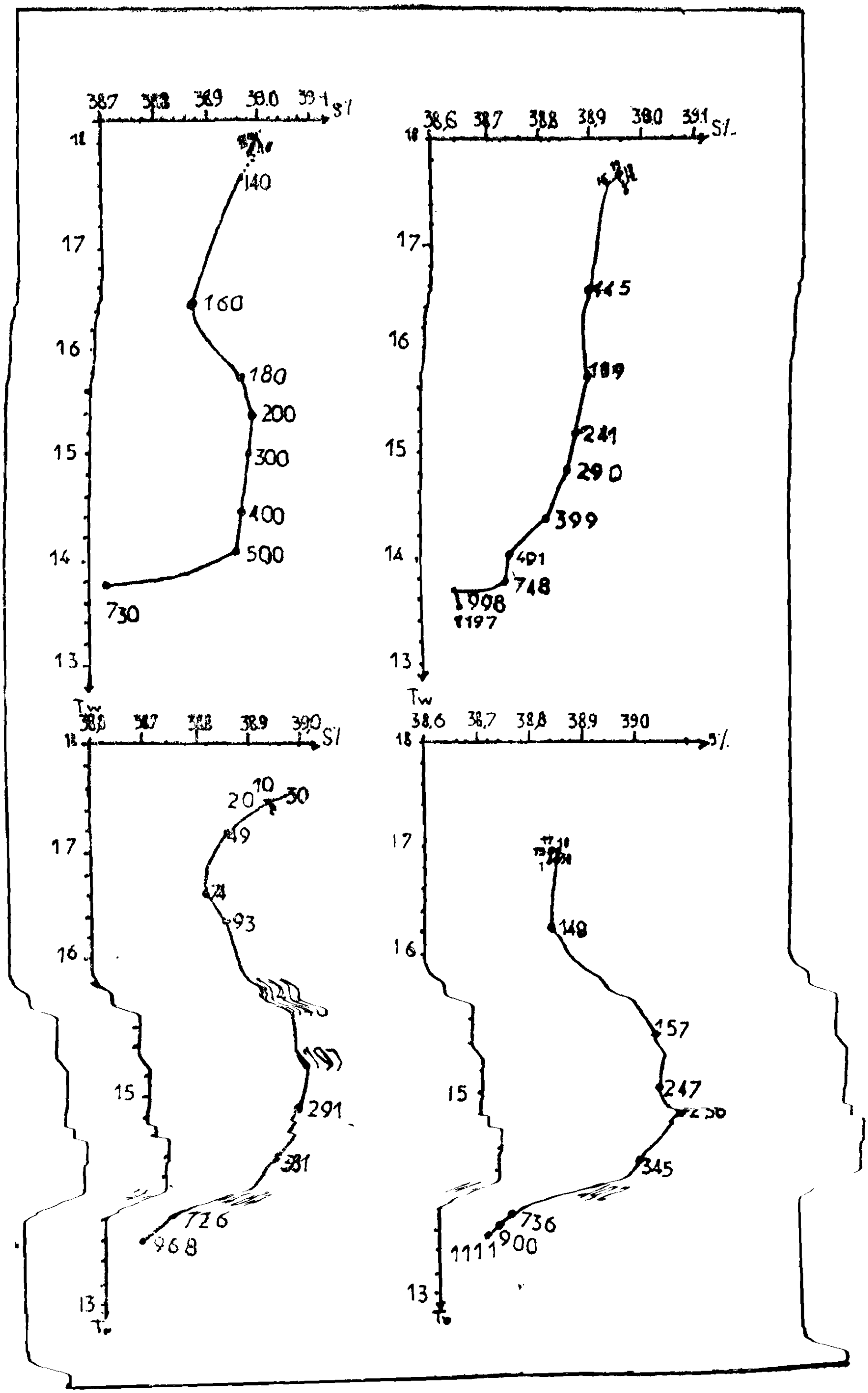


Fig. 33b.—TS Curves, most typical for the winter season.

5. Due to intensive cooling of surface waters during the cold season the convection mixing spreads to a depth of 150-300 m.

6. On the shelf off the Nile Delta, eastern water movement prevails. The speed of currents changes from 10 cm-sec near the coast upto 50 cm/sec in the open sea.

7. During the warm season of the year, in the area under study, four water meases can be distinguished : the surface one characterized by a high temperature and salinity ; a transformed Atlantic one with low salinity, an intermediate water mass with a higher salinity and an abyssal water mass.

In winter there are two water masses, the winter surface water mass and the abyssal water mass.

8. In 1965 and especially in 1968 a sharp reduction of the Nile discharge took place, now being only 4.4 km^3 per annum.

9. The decrease of continental flow caused substantial changes in the physicochemical characteristics distribution as well as in the formation and distribution of water masses in the area located north of the Nile Delta.

10. Waters of the south-east part of the Mediterranean Sea are very well aerated during the year. The content of dissolved oxygen in water on the surface was equal to 4.45-6.35 ml/1 (99-118 per cent), whereas at a depth of 1000 meters 3.59-4.78 ml. (62-83 per cent).

11. The content of Nutrient salts in the waters of the Mediterranean sea is not high. The concentration of phosphates in the surface layer of the south-east part of this basin does not exceed 0.5 µg-at P/1, nitrates — 0.8 g-at No_3/1, silicates — 15 g-at si/1. The content of the majority of Nutrient salts increases negligibly with depth. Nitrates are an exception, where the concentration is 5-6 ug-at No_3/1 at a depth of 400-500 m.

12. Seasonal changes of hydrochemical components are only in the upper 200-m layer.

13. The content of phosphates in winter and spring of 1970-1971 was higher whereas in summer and autumn - lower than in the corresponding seasons of 1966.

14. Due to the sharp decrease of the Nile discharge, the conditions of existence of marine organisms in the area located near the Nile Delta have been determinated to a substantial degree.

IV.—Changes of Oceanographic Conditions in the South-Eastern Mediterreanean Sea Caused by Regulation of Nile Discharge

The Egyptian shelf located between Alexandria and El-Arish has th maximum width of 30-40 miles, north of the Nile Delta. The shelf surfa is flat and sloping with small angles.

The bottom is formed of alluvial quaternary deposits represented main by ooze sediments.

The area in question was considered to be one of the most producti ones in the Mediterranean Sea (Halim, 1967 ; and Halim *et al,* 1969 ; Gor and Shaheen, 1964 ; El-Zarka and Koura, 1965 ; Gorgy, 1966 ; Aleem. 196 The main reason for the high biological productivity of the shelf waters this area was the Nile dischareg. Annually, the Nile waters brou to the sea a great deal of biogenic and organic substances as well mineral particles. This provided a good production of plankton organi and benthos and created favourable conditions for the existence of fish crustaceans. The life cycle of sea organisms in this area depends mai on the river discharge and, in particular, on the seasonal dynamics plankton and pleagic fish migration.

The connection between abiotic factors and marine organisms living the shelf is formed historically throughout a long period of time. There slight fluctuations of the amount of continental flow is inevitably refle on the sea organism multiplication, and their number as it happened 1965.

Before the Nile discharge was controlled in the area under investig there were three distinct zones : a zone of dilution within which a gra transformation of the Nile took place, a zone of intensive mixing of dil and sea waters and a chloistatic zone.

According to Halim (1960), the Nile water spreaded throughout the s eastern part of the Mediterranean Sea and He mentioned that on the b dary line of the diluted and sea waters the physicochmical characteristi water have the following values : salinity - 38.5‰ ; conventional de 26.0-26 ; relative content of dissolved oxygen in water - 105 per cent, phate and silicate concentration, 00.5 µg-at P/1 and 7.5 µg-at respectively.

In 1964 the Nile discharge had been the greatest since 1956. In October 1964 diluted waters occupied a large sea area, whose width north of the mouth of Rosetta was equal to 40-50 miles. One of the authors of this report, Bybik, took part in the cruise of R/V "Ichthyolog" in 1964 and saw himself the boundary line of the maximum spread of the transformed Nile waters.

Fig. 39 (a) shows the salinity distribution of sea water, in 1964 and Fig. 41a, shows the water percentage saturation with oxygen on the shelf in October 1964 (data of R/V "Ichtyolog"). It is Obvious that all the three mentioned zones are clearly identified by the distribution of these characteristics especially by the sea water transparency. The latter, north of Rosetta on the boundary line dividing diluted and sea waters changed throughout 300-500 meters from 10 m to 35-40 m.

In 1956 the Nile discharge was reduced approximately twice, whereas in 1966- almost five times was as compared with the volume of discharge in 1964. Since 1968 the average annual Nile discharge is equal only to 1/10 of the average discharge for the period from 1956 to 1964.

The oceanographic observations undertaken in this region in 1966 showed that the zone of dilution as compared to 1964 is greatly reduced.

The intermixing of fresh water with sea water took place neare shore. In the remaining water area of the river mouth the salinity in the surface layer in the autumn of 1966 proved to be higher than in the same period of 1964 by 2-4‰ on the average. Almost all the area under study, except for the narrow circumlittoral zone, in 1966 was covered by sea water with a salinity over 38.5‰ (Fig. 40). Only in February 1966 the zone of dilution was distinctly identified in the eastern part of the area. In February it covered a big area east of the Cape of Borullos. However, the width of this area did not exceed 10 miles.

In the remaining seasons of 1966, except for October, the river discharge did not cause any substantial dilution of the circumlittoral zone of the sea.

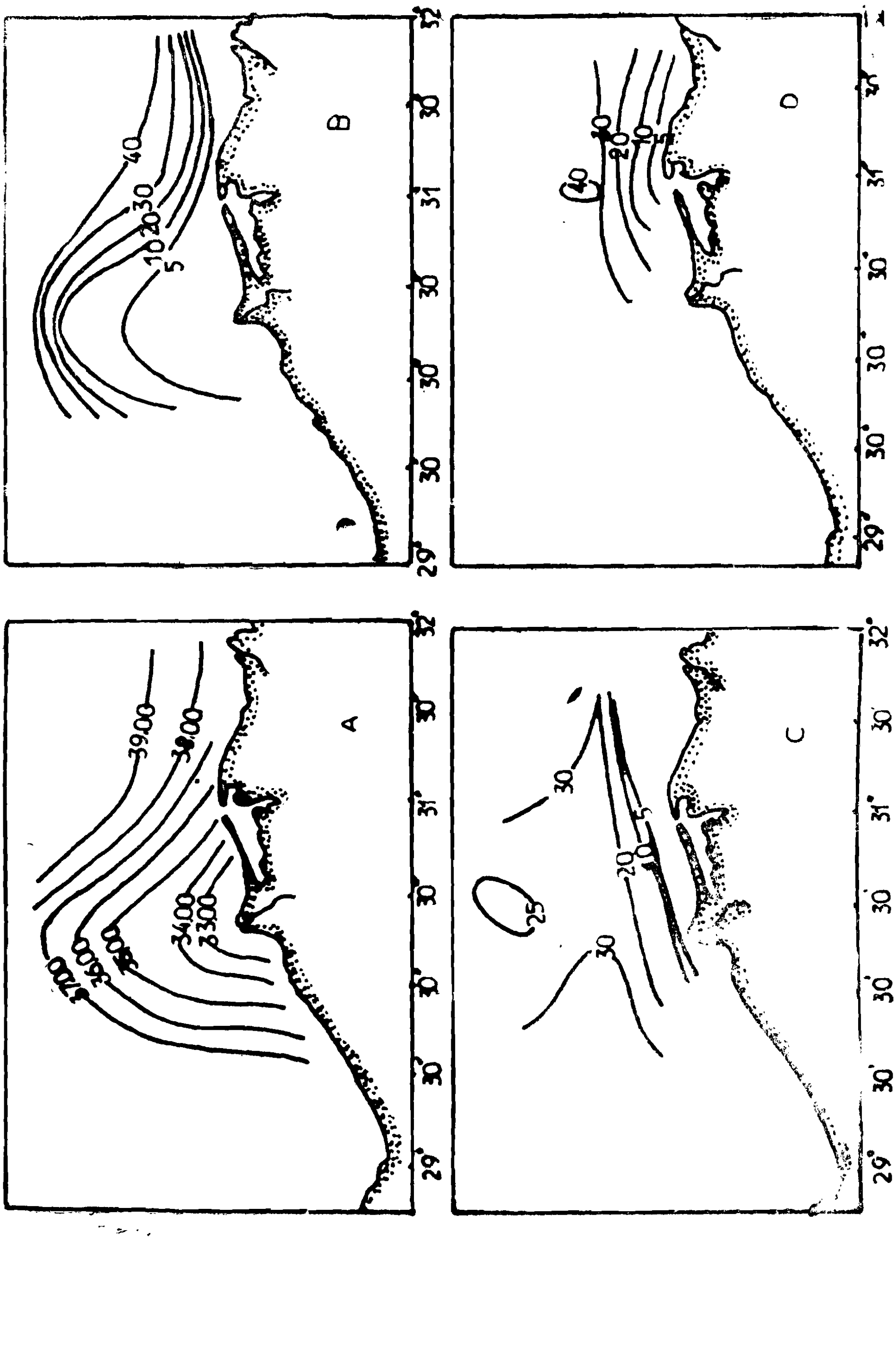


FIG. 39. Distribution of surface salinity for October, 1934 (a) ; distribution of sea water transparency for October, 1934 (b), August, 1933 (c), [illegible] 1971 (d).

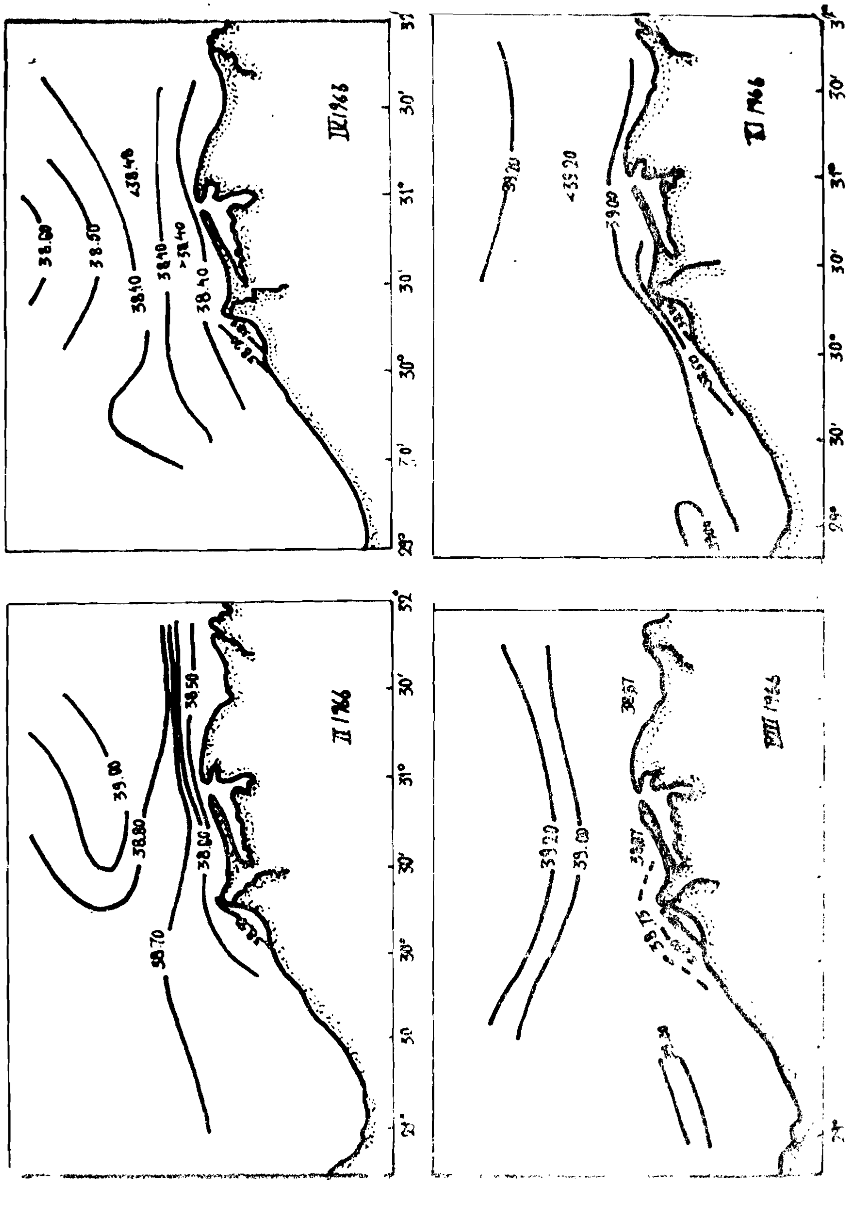


FIG. 40. Distribution of surface salinity in February, April, August and November of 1966.

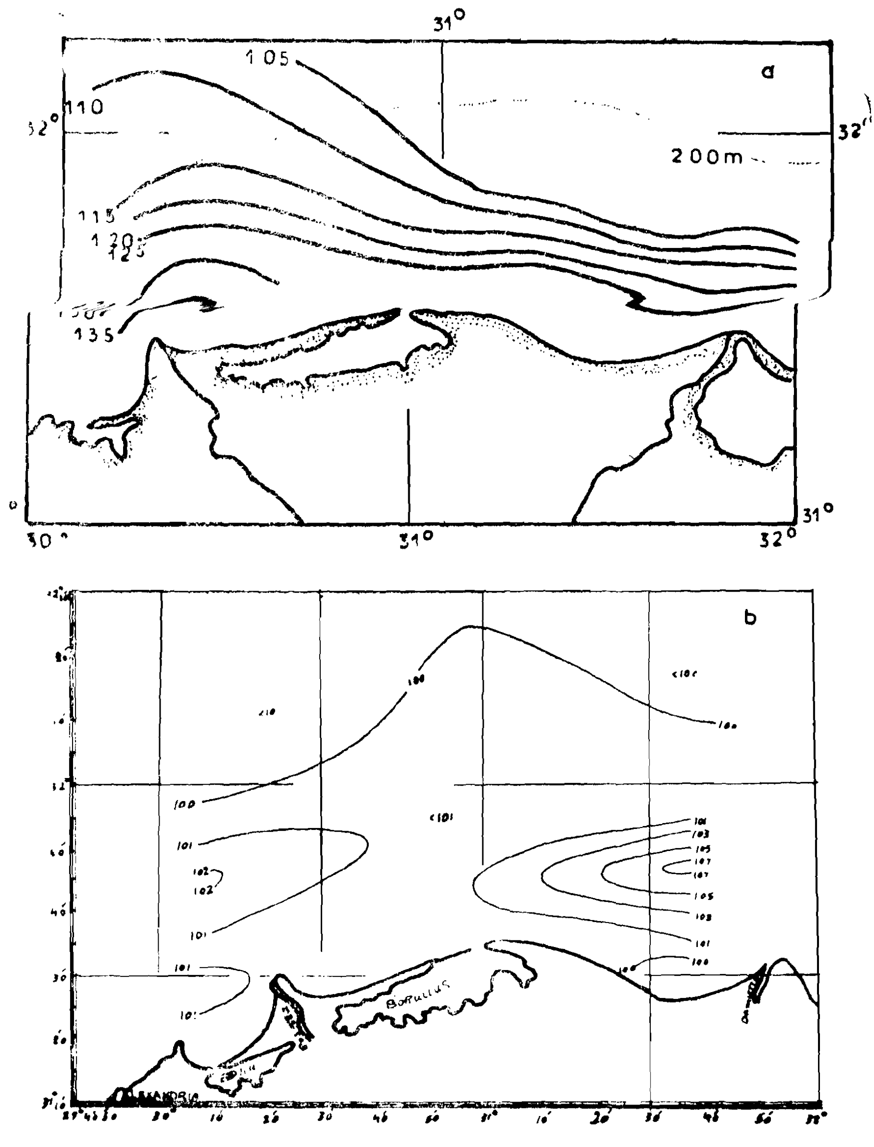


FIG. 41. Percentage Saturation of oxygen in sea water in October, 1964 (a) and September, 1970, (b).

In the following years, salinity variations determined by the continental flow took place mainly in areas located near the mouth of Rosetta and the coastal lakes - Edku, Borullos and Manzala. In 1970-1971, as it was in 1966, the maximum spread of the lower salinity waters in the region in question was observed in winter. Thus, in February 1971 the dilution zone ocupied a wide area between Alexandria and the Bay of Borullos. In the Bay of Abukir which is under the influence of the discharge from lake Edku and partly Rosetta mouth the boundary line between the sea water and the diluted water was at a distance of 12-15 miles from the coast. The minimum salinity on the surface in this area was 34.6‰ (Fig. 22). During the summer of 1971, similar to the corresponding season of 1966, diluted waters covered a comparatively small area between Alexandria and the mouth of Rosetta (Fig. 25). In September 1970 due to a very small discharge, this zone was practially non-existent (Fig. 22).

The river dicharge reduction caused not only a sharp shrinkage of the dilution zone in the region under study but substantial changes also took place in the seasonal distribution of salinity of the surface layer owing to the interyear redistribution of the river discharge. Before the Nile river had been controlled, about 80 per cent of its discharge took place during the flood period. In accordance with this the maximum spread of diluted waters and the minimum salinity on the surface were observed in autumn, usually in October.

With the start of control of the Nile river the annual distribution of the discharge changed in principle. Now the largest values are obsreved in winter, the most noticeable dilutoin and the minimum values of salinity in the circumlittoral zone - in February, whereas beyond its limits - in spring, i.e. April.

The change of the interyear distribution of the Nile discharge upset the normal cycle of prawn breeding and first of all - peneid - whose spawning was in autumn before the Nile control started.

In 1964 the difference between the maximum and the minimum values of salinity in the area located at a distance of 10-15 miles from the Nile delta was over 4.0‰. In 1966 and 1970-1971 the seasonal changes of salinity in the surface layer did not exceed 0.6‰ and were similar to those in the open areas of the south-eastern part of the Mediterranean Sea. This fact besides a very sharp shrinkage of the dilution zone and a significant rise of salinity may explain the existence of sea organisms, especially, prawn juveniles.

The salinity increase had already resulted in the migration of certain fishes to the south-eastern part of the sea from other areas of this basin (see Chapear VII). Oren (1970), referring to the opinion of G .Torson, stated that in future this may account for a migration of the Red Sea species to the area under investigation.

However, we do not know yet, how the salinity increase and its seasonal variations will influence those local spceies of marine organisms which spend part of their life cycle in diluted waters.

The Nile discharge decrease also had a great influence on the transparency of the sea water. Fig. 39 b, c, & d shows the distribution of this characteristic in the area under study in October 1964, August 1966 and September 1970.

The water transparency on the shelf seems to undergo great changes. This was caused mainly by two factors ; a sharp decrease in the solid discharge of the Nile river and the number of phytoplankton especially in the circumlittoral zone, after 1966.

Before the Nile river was controlled, about 57 million tons of suspended solid particles had entered the Mediterranean Sea annualy according to data by Shukri (1950).

Large amounts of suspended solid material were discharged during the flood. During that period 1 m of river water contained an average 4 kgs of solid material. The distribution of transparency within the Nile mouth area was a good index of propagation of the Nile turbid waters in the sea.

The solid and organic discharge of the Nile is the main source of sediments of silt and organic origin in the area under investigation. According to data by Mohamed (1967)[1] there are several areas with a higher content of silt and organic material, on the shelf north of the mouths of Rosetta and Damietta and the area between them. The location of these areas is first of all correlated with the spread of the Nile waters. In particular the area with a higher content of silt and organic material on the bottom, located in the western part of the area, coincides distinctly with the position of the zone of mixing of diluted and sea water during the years of normal discharge. In this zone there was an active settling of fine silt particles, containing organic material as a result of coagulation of these particles in the course of mixing of the waters of different origin and a sharp decrease of the current speed.

(1) The data refered to are based on 58 sediment samples eollected by R/V "Ichth. iolog" in 1966.

The highest amount of oragnic material is observed in the sediment with a high content of silt since the settling rate of organic and silt particles coincides. Accordingly, the place of deposition of these two most important sediment characteristics on the shelf almost do not differ.

Since 1966 the amount of sediment discharge of the Nile has started to decrease sharply. It was determined not only by the decrease of the river water volume entering the sea but also by a substantial decrease of suspended solid particles contained in it.

The construction of hydrotechnical structures on the Nile river and its branches brings about an active sediment accumulation in artifical ponds. According to Oren (1970), over half the yearly solid discharge of the Nile settles down in Lake Nasser.

Consequently the concentration of the suspended solid particles in the Nile water has greatly reduced. We consider that at present the sea receives less than 10 per cent of the volume of silt matrial which entered it before the Nile control. (*)

Such a sharp reduction of the solid material discharge has already resulted in an increase of the sea water transparency by 15-20 m (as compared to 1964) and adversely affected the formation and dynamics of sediment and shores near the Delta and north of it.

It may be inferred that the living conditions of crustaceans on the Egyptian shelf have substantially deteriorated to the lack of transport of silt material. The most significant changes must have taken place in the sea areas there where during the years of the largest dischargr there was a zone of mixing diluted and sea waters. As pointed out above, in such waters there was an intensive settling of silt particles rich in organic matter.

Due to these changes a drop in the population of parwns of Penaeus species living at depths of 20 to 50 meters was most significant.

The living conditions of shrimps in the cricumlittoral zone have changed less perceptibly. Suspended and organic materials entering the sea from Rosetta and the coastal lakes at present are not transported far away from the coast as it used to be but settle at smaller depths (Chapt. III, Section "Currents"). Therefore, the population of "*Metapenaeus stebbingi*" prawns living near the Delta, have reduced much less than the populotion of peneid.

(*) Regarding the reduction of organic material transport there are different opinions. However, since ther are no relative data available now, it is impossible to discuss the matter at present.

The highest amount of oragnic material is observed in the sediment with a high content of silt since the settling rate of organic and silt particles coincides. Accordingly, the place of deposition of these two most important sediment characteristics on the shelf almost do not differ.

Since 1966 the amount of sediment discharge of the Nile has started to decrease sharply. It was determined not only by the decrease of the river water volume entering the sea but also bv a substantial decrease of suspended solid particles contained in it.

The construction of hydrotechnical structures on the Nile river and
The construction of hydrotechnical structures on the Nile river and
its branches brings about an active sediment accumulation in artificial ponds. According to Oren (1970), over half the yearly solid discharge of the Nile settles down in Lake Nasser.

Consequently the concentration of the suspended solid particles in the Nile water has greatly reduced. We consider that at present the sea receives less than 10 per cent of the volume of silt matrial which entered it before the Nile control. (*)

Such a sharp reduction of the solid material discharge has already resulted in an increase of the sea water transparency by 15-20 m (as compared to 1964) and adversely affected the formation and dynamics of sediment and shores near the Delta and north of it.

It may be inferred that the living conditions of crustaceans on the Egyptian shelf have substantially deteriorated to the lack of transport of silt material. The most significant changes must have taken place in the sea areas there where during the years of the largest dischargr there was a zone of mixing diluted and sea waters. As pointed out above, in such waters there was an intensive settling of silt particles rich in organic matter.

Due to these changes a drop in the population of parwns of Penaeus species living at depths of 20 to 50 meters was most significant.

The living conditions of shrimps in the cricumlittoral zone have changed less perceptibly. Suspended and organic materials entering the sea from
Rosetta and the
Rosetta and the coastal lakes at present are not transported far away from
... lakes at present are not transported far away from
the coast as it used to be but settle at smaller depths (Chap. [illegible] "Currents"). Therefore, the population of "*Metapenaeus stebbingi*" prawns living near the Delta, have reduced much less than the populotion of peneid.

(*) Regarding the reduction of organic material transport there are different opinions. However, since ther are no relative data available now, it is impossible to discuss the matter at present.

Fig. 41a represents the percentage saturation of oxygen in the surface waters in the area under study in October 1964 and September 1970.

The distribution of this feature as presented in Fig. 1 after Halim, *et al*, (1967) can be considered typical for the autumn season before the discharge control.

The oxygen distribution represented by Fig. 2 in the work of Halim *et al.*, (1967) is characteristic of this area after a sharp drop of the Nile discharge which made a great influence in the oceanographic regime of the whole south-eastern part of the Mediterranean Sea.

In 1964 oxygen saturation was calculated from Foxs, Tables, while in 1970-1971 by tables after Green and Carritt (1967). In spite of the somewhat different results due to changes in circumstnaces it is clear that in 1964 the production of oxygen by phytoplankton was much more effective than in 1970. In October, 1964 the oversaturation of water with oxygen in the 10-20 mile circumlittoral zone amounts to 135-125 per cent. In the zone of inensive mixing of diluted and sea waters, susbtantial horizontal oxygen gradients, with oxygen saturation ranging from 125 to 105 per cent, was noticed.

In September 1970 the oxygen saturation in the area under study did not exceed 102 per cent, and only one station showed 107 per cent. The oxygen content in the surface waters of the circumlittoral zone and in the open sea area under study almost did not differ.

The vertical distribution of water saturation with oxygen in the two compared years was also very different, especially near coast. In 1964 the dissolved oxygen content in the circumlittoral zone percebtibly reduced with depth (upto 60-80 per cent at the levels of 20-30 m). A great positive stability in the layer of 0-10 m during the flood period prevented the mixing of surface and near-bottom waters. At present the vertical oxygen distribution in the area adjacent to the Delta changes only to a negligible degree, where at a number of stations the percentage increases with depth.

Thus, the decreased river discharge caused not only changes in the distribution of salinity and transparency of the sea water on the shelf but also affected greatly the degree of its saturation with oxygen.

Fig. 42 shows seasonal variations of various hydrochemical characteristics in the surface waters in the circumlittoral zone in 1966 and 1970-1971. It is obvious that the percentage of oxygen saturation in the said years did not vary to a subsatntial degree.

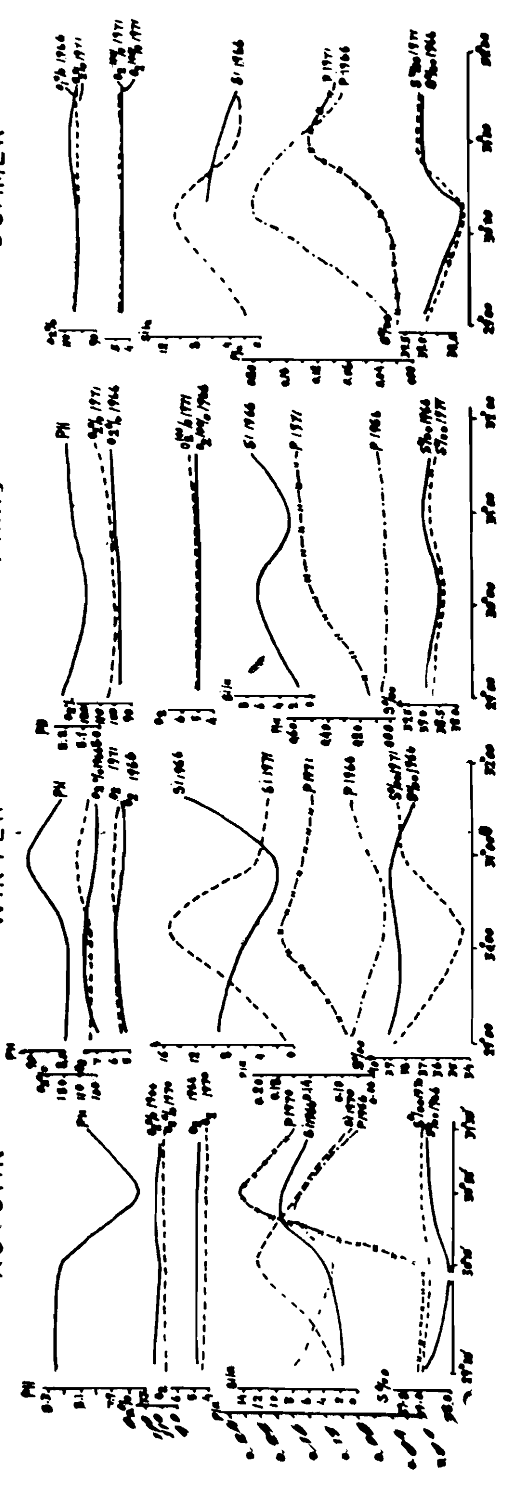


FIG. 42. The pH, oxygen, phosphate, (in µ g-at P/l) Silicate (in µ g-at Si/L), and salinity at the surface in the coastal waters between the Arab Bay and Dametta during the different seasons of 1966 and 1970-1971.

In 1970-1971 the relative content of oxygen was lower in autumn, higher in winter and spring, and almost equal in summer as compared to similar seasons in 1966. However, neither in 1966 nor in 1970-1971 within the area under study there was no such high oversaturation with oxygen as it used to be in 1964 and the preceeding years.

A sharp reduction of oxygen production by phytoplankton is indicative of the fact that the algae numbers in the south-eastern part of the Mediterranean sea have substantially decreased lately.

In 1966 the Nile discharge was equal only to 13.2 km^3. Supposing that the nutrient discharge had been reduced proportionately with the river water in 1966, in such a case the sea would have received 2.5 x 10^3 ton of phosphates and 125 x 10^3 of silicates, i.e. about 5 times less than that in 1964.

Actually, the concentration of biogenic salts in the Nile waters was reduced substantially after the Nile had been controlled. According to data of the Institute of Oceanography and Fisheries, Alexandria, the content of phosphates in the river water in general equal on an average of [illegible] ug-at P/1, silicates — about 30 ug-at Si/1 and nitrites — 4 ug-at 0_2/1 (1).

Even if the data given by Halim (1960) on the concentration of nutrient elements before the Nile control are somewhat higher, there is no doubt that after the construction of the Aswan High Dam the hydrochemical composition substantially changed. This reduction of the content of nutritive salts was caused first of all by their intensive consumption in the river itself, especially in Lake Nasser. The latter accordingly will gradually turn into a highly productive pond with great possibilities for artificial fish breeding (Aleem, 1969).

In connection with the change of the quantitative content of the Nile waters, the Nile biogenic discharge is reduced to a much greater degree in proportion to the reduction of the fresh water discharge. Therefore the actual phosphate discharge into the Mediterranean sea in 1966 was equal to only 280 tons but not 2.5 $\times$ 10^3 tons as was calculated by us supposing that the concentration of this element in the river water did not change after the discharge control. As to silicates this difference exceeds 100 thousand tons.

---

(1) These figures are only averages since the content of biogenic substances in the Nile waters varies according to the season. Samples for hydrochemical analysis were collected at 10 km. from Rosetta mouth. Since April 1965 the Damietta discharge has stopped.

In 1971 the Nile discharge was equal to 4.1 km^3. With this volume of water, according to our estimation, up to 90-100 tons of phosphates and about 3.5 thousand tons of silicates were discharged into the sea.

These estimates are most approximate. Nevertheless they enable us to determine the influence of the sharp discharge on the chemical base condition of the area under study. At present, the annual discharge of phosphates into the sea is 80 times less and that of silicates is about 100 times less than during the years of normal discharge.

However, the actual nutrient base in the south-eastern part of the Mediterranean Sea has deteriorated to a greater degree due to the reduction of the content of fine silt particles in the river waters,. The latter, as pointed out above, having borne a large quantity of nutritive salts on their surface. This process played an important part in the enrichment of sea water with phosphates and nitrates.

The Nile discharge reduction has mostly affected the chemical base condition of the 10-15-mile circumlittoral zone of the sea.

According to Halim (1960), the phosphate content near the mouth of Damietta, - at a distance of 3-6 km from the coast, - in August, 1957 and 1959 varied from 1.5 to 2.1 ug-at P/1. In October, during the phytoplankton bloom the concentration of this element dropped to 0.38-1.1 ug-at P/1. The silicate content varied from 220 ug-at Si/1 in August to 35–36 ug-at Si/1 in October (Halim, 1960). Prominent concentrations of nutrient materials during the flood period were recorded to take place on the shelf adjacent to the mouth of Rosetta (Gorgy. 1966).

With the establishment of the Nile control the phosphate content on the surface is equal to an average of 0.05-0.15 ug-at P/1. Only near the coast in the areas under the influence of waters discharged from the coastal lakes and Rosetta mouth, sometimes the phosphate and nitrate concentrations are observed to be increasing up to 0.2-0.5 ug-at P/1 and 0.5-0.8 ug-at NO_3-N/1 accordingly. The highest content of nutrient materials in 1970-1971 was observed in the Bay of Abukir (see Chapt.III of this Report).

Beyond the limits of the zone in question the Nile waters, even during the years of big discharge, influenced much less the hydrochemical regime of the open sea area under investigation as compared to the circumlittoral zone. Therefore the discharge drop deteriorated the nutrient base of the area located north of the 50-meter isobath to a lesser degree than that near the Delta. Thus, in October 1964 the content of phosphates beyond the limit of the turbid Nile water spreading was equal to 0.13-0.21 ug-at P/1 (within the zone of mixing the river and sea waters - 0.3 ug-at P/1), according to the data by R/V "Ichthyolog". In November 1966 and September-October 1970 the concentration of this element in the surface layer of this area did not exceed 0.10 ug-at P/1 (in the littoral zone - 0.15-0.20 ug-at P/1, in 1966 and 1970 respectively). However, while assessing the chemical base in 1964 it is necessary to keep in mind an increasingly high level of phytoplankton development. Therefore the consumption of nutritive salts was very high so as to affect a substantial drop of their concentrations in the sea water during the autumn season of 1964.

Thus, after the Nile had been controlled, the biogenic base of the south-eastern part of the Mediterranean Sea sharply deteriorated. This was the main reason for a reduction of the primary productivity of the area under study.

All investigators who dealt with the primary production of the Mediterranean Sea noted that the number of phytoplankton on the Egyptian shelf was exceptionally high for this basin (Halim, 1960; Gorgy, 1966; Halim *et al.*, 1967 ; Aleem 1969).

There was a distinct connection between the distribution, the number and seasonal dynamics of algae in the area under study and the Nile discharge, The highest concentrations of phytoplankton were recorded near the Delta in autumn during the flood, with numbers about several hundred thousand cells per litre.

On the basis of observations undertaken near the Damietta mouth at the end of the 50ies Halim (1960) showed the influence of the river discharge on the development of phytoplankton. This data allow to compare the number of algae in the sea water before and after the intensive dilution of the circumlittoral zone. At the beginning of August (before the Nile waters enterd the sea) the surface layer 5-6 km north of the Damietta mouth totaled 60-70 thousand cells per litre at an average (1). In four days after the river waters discharge into the sea the cell numbers increased up to 1.2 million and three weeks later they reached 2.5 million cells/1.

During the following period as the content of nutritive salts decreased because of their increasing consumption, the number of algae decreased, being less than at the end of August or the beginning of September.

Halim et al. (1967) also worked on the distriubtion of phytoplankton on the whole water shelf in October 1964. The biggest concentrations of

(1) The interyear distribution of the Damietta discharge is referred to in the chapter : "The Continental Discharge".

algae were observed north of the mouth of Rosetta, the area being 25-30 miles wide and the phytpolankton concentration varying from 500 thousand to 1 million cells/1.

After the control of the Nile discharge the phytoplankton numbers in the area under investigation substantially reduced. In 1966 the maximum algae content in the layer of 0-10 m of the circumlittoral zone did not exceed 180 thousand cells per litre and was observed in January.

In November 1966 the phytoplankton numbers totaled in the same layer only 40 thousand cells/1. In the remaining seasons of the year in question it did not exceed 10-11 thousand cells/1 (Savich, 1970).

According to the data by Salah, (1971) the phytoplankton numbers on the shelf located north of the Nile delta in 1970-1971 was substantially less than in 1966.

The development of plankton was increasingly affected not only by the reduction of the river discharge but also by a change of its monthly distribution. In accordance with this there was a change of the seasonal dynamics of phytoplankton. An intensive bloom of plankton previously observed in autumn is, at present, practically not recorded. The seasonal changes of phytoplankton numbers just as well as the salinity variations reduced on the greater part of the shelf after the Nile discharge control had been affected. The latter, in addition to that, caused substantial changes in the distribution of algae in the area of study. During the years of the normal discharge, especially during the flood period, the numbers of phytoplankton were less going farther away from the coast in the direction of the open sea. In 1966 this regularity was upset. In particular in August and November 1966 the areas rich in phytoplankton were located not only near the Delta but also above the deep-sea sections of the shelf.

The changes set forth above which took place in the content of phytoplankton after the discharge control resulted in a sharp deterioration of the nutritive base of pelagic fishes in the south-east part of the Mediterranean Sea.

El-Zarka and Koura (1965) determined a relation between sardine catches and intra-year distribution of the river discharge before its control. The relationship between the catch and the discharge is indirect as the discharge provides the development of phytoplnakton ; the main food for sardine.

A mass entrance of sardines into the circumlittoral zone of the sea was recorded during the flood. The biggest catches of sardines were recorded a month after the maximum discharge (the coefficient of correlation 0.895).

In 1962 the maximum average monthly discharge of the Ni... ber, and the biggest sardine catch took place in October. F... from September through November 1962 - the river disc... per cent of the annual figure. Within this period about 9... annual sardine catch was produced on the shelf.

The discharge reduction and consequently, the deterio... conditions affected greatly the reproduction of sardines an... the long run, on their population, which during the last... a low level (Aleem 1969 ; Pavlovskaya and Budnichenko... 1972).

Along with the discharge drop the main reason fo... of the living conditions of marine organisms on the shelf, t... which partly compensate for the said deterioration becom... In particular rocord is made of a nutrient and organic... from the coastal lakes. Diluted waters entering... lakes of Edku, Borullos and Manzala contain a large a... susbtances. According to data of the Laboratory of Hy... Alexandria Institute of Oceanography and Fisheries, the... tration in the water of Lake Edku amounts to an ave... μ g-at P/1, silicates 150-220 μ g-at Si/1 and Nitrates 1... The waters of Lake Manzala contain 0.9 μ g-at P/... and 6 μ g-at NO_3/1.

The discharge from these lakes play a significant r... of the hydrochemical regime of the Bay of Abukir an... of the Egyptian shelf. The central part of the Delta is... of a discharge from Lake Borullos. In 1966 the influ... and organic discharge from the lakes was almost imperc...

In 1971 this influence was traced more distinctly. ... trations of biogenic subtances in the surface waters in... in areas adjacent to the above mentioned lakes ; in ... Abukir and in August in the vicinity of Lake Borullos (... influence of the river discharge on the nutrient base... May and August may be practically exluded.

At present the coastal lakes are actually small ri... receiving drainage water discharge from irrigation fields. ... waters grows the role of the lake water discharge in... chemical base of the coast area will be gradually enha...

A substantial rise in salinity which took place i...
... study after 1965, determined an increa...
the area under study after 1965, determined an increa...

stability decrease in the upper 10-m layer. This created mor favourable conditions for vertical water mixing, whose propagation depth increased during the last years. To some degree this enhanced the arrival of nutrient substances from deep layers to the surface ones by means of convection. However, in our opinion this process is not in a position to compensate for a deterioration of the chemiacl base of biological productivity caused by a sharp discharge reduction. The deep waters of the Mediteranean Sea are poor in biogenic salts, except for nitrates. The content of phosphates, silicates and especially nitrites in the area under study increases with depth only to a small degree.

The average phosphate concentrations at the level of 300-400 which is the lower limit of a possible penetration of winter convection - totals only 0.10-00.15 μg-at PO_4-P/1, nitrites - 0.05 μ g-at NO_2-N/1, and it is only the content of nitrites in the deep see layers that is relatively high. At the levels of 400-600 m it contained about 5 μ g-at NO_3-N/l. At the surface the quantity of nitrates rarely exceeds 0.01 g-at NO_3-N/1.

The enhancement of quantitative exchange of nutrient substances between deep and surface layers of the sea may result in an increase of nitrite content in the zone of photosynthesis. However, there is no sign of any possible incraese of phosphates, silicates and nitrites. Apart from that, it is very important that convection mixing is a transient process and stops with the advent of spring water heating. Therefore the storage of biogenic substances during the warm season is soon depleted.

A depth increase of convection mixing cannot substantially improve the condition of the chemical base in the future. Therefore, we cannot agree with the opinion of Oren (1970) that the winter convection "will involve big resources of nutrient elements of deep-sea waters and make the eastern part of the Mediterranean Sea a highly productive basin", an opinion which has no base.

Nevertheless, the role of convection mixing together with other factors mentioned above exerts now a far greater influence on the formation of the nutrient base than before the discharge control implementation. An increasing role of these factors is clearly seen when comparing hydrochemical conditions in the area under investigation in 1970-1971 and in 1966. Fig. 42 shows a seasonal variation of the sea water hydrochemical characteristics in the surface waters in the years 1966 & 1970-71 in the area adjacent to the Nile Delta. Fig. 43 shows the monthly change of the average phosphate content at different levels in the same years. It is seen that the concentration of this element as well as silicates in the surface layer almost in the whole region under study in 1970-1971 was higher in winter and lower in summer as compared with the corresponding season of 1966. In 1971 the river discharge equalled less than 1/3 of the discharge value in 1966. In accordance with this, its role in enriching the sea water with nutrient salts substantially diminished. Nevertheless during the first half of 1971 the chemical base of the area under study was on a much higher level than in 1966. This is explained by the enhancement of convection mixing during the winter season of 1971, by the water influx increase from the coastal lakes as well as by a much smaller consumption of nutrient elements by phytoplankton as compared with the winter-spring season of 1966. According to Salah (1971) the algae amount in February and May, 1971 was lower than in the same months of 1966.

The low content of phosphates and silicates during the summer season of 1971 as compared to the corresponding season of 1966 was caused by several reasons.

Firstly, by a small continental discharge where from June to August, 1971 the Nile discharge amounted only to 1/10 of the discharge figure for the same period of 1966. Therefore, the chemical base replenishment on account of the 1971 summer discharge was very weak, and the phytoplankton number in August 1971 proved to be very low in the area under investigation.

In 1966 the main factor of the chemical base formation of the area in question was the Nile discharge as before, its small volume providing only a low level of the nutrient base and the biological productivity. However, the seasonal distribution of the nutrient substance content in the sea water and the dynamics of phytoplankton numbers as a whole agreed with the intra-year discharge distribution .

In 1970-1971 the role of the Nile in enriching the waters of the south eastern part of the Mediterranean Sea sharply diminished and the supply of biogenic substances on account of winter convection and the lakes discharge increased as compared with 1966. The enhancement of the role of these factors enable us to suppose that in the near future the chemical base of nutrient productivity of the sea area under study will somewhat improve. It can also be supposed that the sea discharge will increase after Lake Nasser is finally filled. This will provide an additonal supply of nutrient salts to the coastal area of the sea located north of the Nile Delta. However, it is difficult now to maintain that the supposed improvement of living conditions of marine organisms will result in an increase of biological productivity on the shelf. In order to check up the said inferences regarding the improvement of the sea chemical base it is necessary to analyze the role of each of the factors examined above, after the river discharge and the hydrological regime of the area in equestion are firmly stabilized.

V—EXPLORATORY AND FISHERY INVESTIGATIONS

During the expedition the whole area of study was covered by exploratory and fishery investigations, which provided information regarding the fishery significance of the areas covered and determined the nature of the material collected.

TRAWLING OPERATIONS

Traling survey was carried out during the following time-limits.

Autumn season — from 8.9.70 till 27.9.70.

Winter season — from 17.1.71 till 28.1.71.

Spring season — from 19.4.71 till 17.5.71.

Summer season — from 23.8.71 till 8.9.71.

The diagram of exploratory work within those seasons is shown in Figures 44-47. Sonic sounding gear survey preceded the trawling.

Within the autumn season it was carried out in the egions of Damietta, Borullos, Rosetta & Abukir. These regions are characterized by a wide shelf, which reaches 25-35 miles in width and smooth gentle bottom covered with sandy and muddy sediments from 10 to 100 meter depth contour. Beyond the limits of 100 m. depth contour a sharp drop in depth begins. Sonic sounding gear and trawling survey showed that ground at depths of 100 metres are almost unsuitable for work with bottom trawl because of the rough bottom and reef formations. Only a small area with depths of up to 400 m. located to the North of Alexandria, allowed for bottom trawling. That area of about 600 km² is limited from the East with 100 m. depth contour, and from the West with coordinates :

Longitude = 31° 38′ O N Latitude = 29° 51′ O E
Longitude = 31° 25′ O N Latitude = 29° 46′ O E

Nine experimental trawlings were carried out in the area of study.

From the 6th till the 15th of October, 1970 exploratory work was executed in the area of Salloum Bay. The exploration was carried out with hydro-acoustic equipment at equally positioned tracks every 5-7 miles. For that period an area of about 2600 km² was surveyed. The diagram of exploratory work in the Salloum Bay is shown on Fig. 48. As a result of sonic sounding gear survey it was clear that the above area was not suitable for trawling. During that period no concentrations of fish were found.

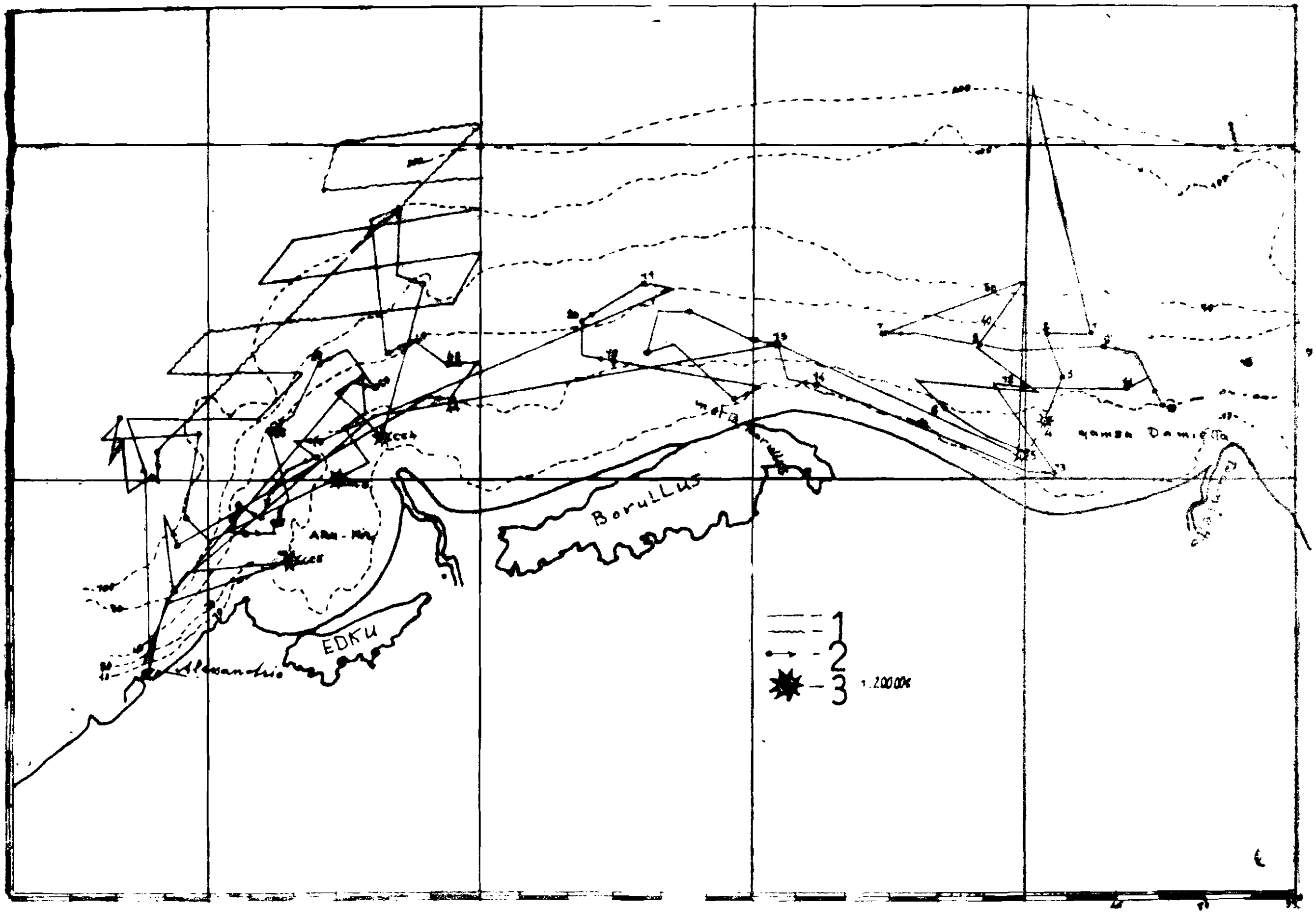


FIG. 44. Map showing exploratory fishing operations of Ichthyology during the period from September 8 to 27, 1970.

Legend ;

1. Search patterns (i.e. exploratory tracks), the straight line shows the grounds suitable for trawling, the zigzag line marks the bottom unsuitable for trawling ; 2. Bottom trawling ; 3. Light attraction stations.

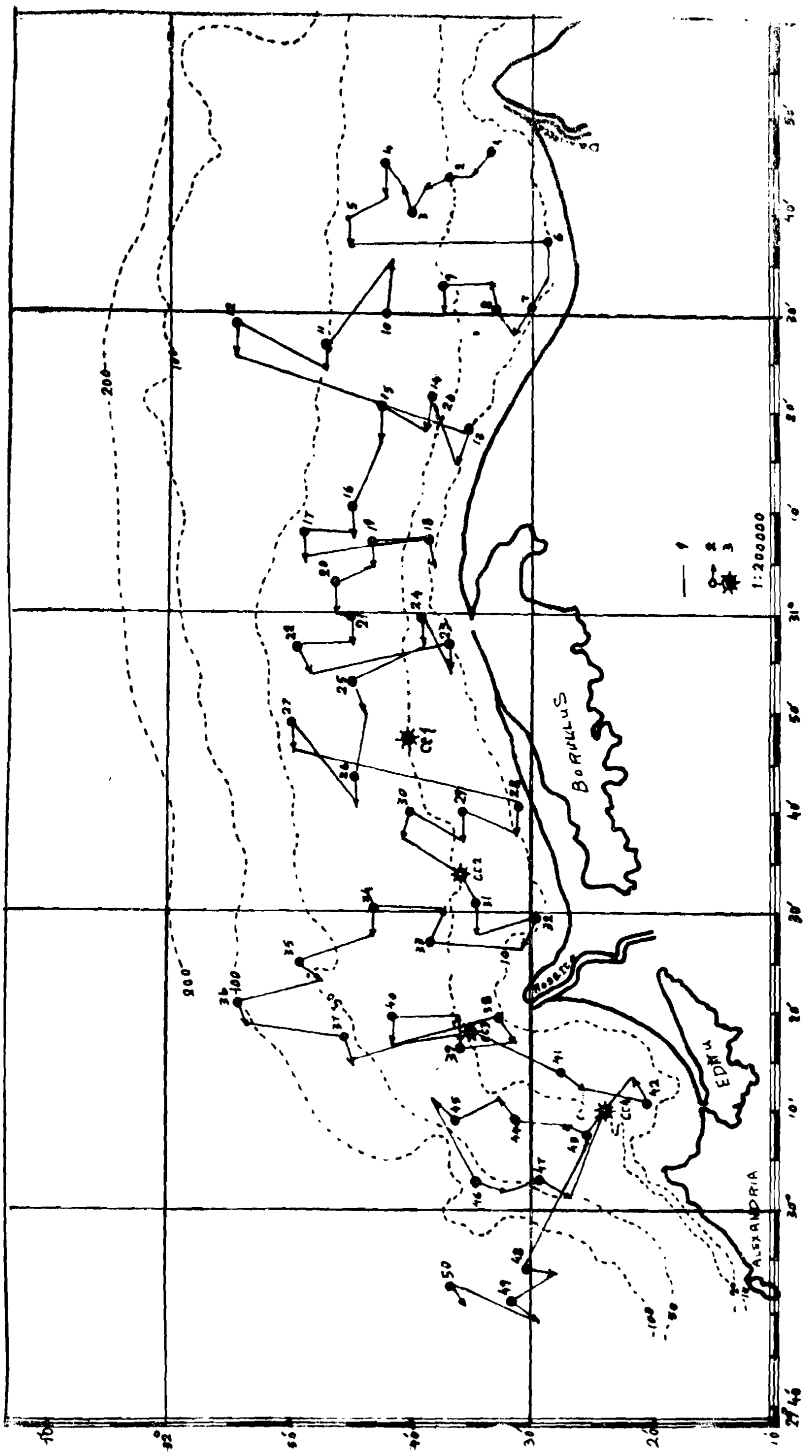


FIG. 45. Schematic map showing exploratory fishing operations of Ichthyolog during the period from 17 to 28 January 1971.
Legend : Same as in Fig. 44.

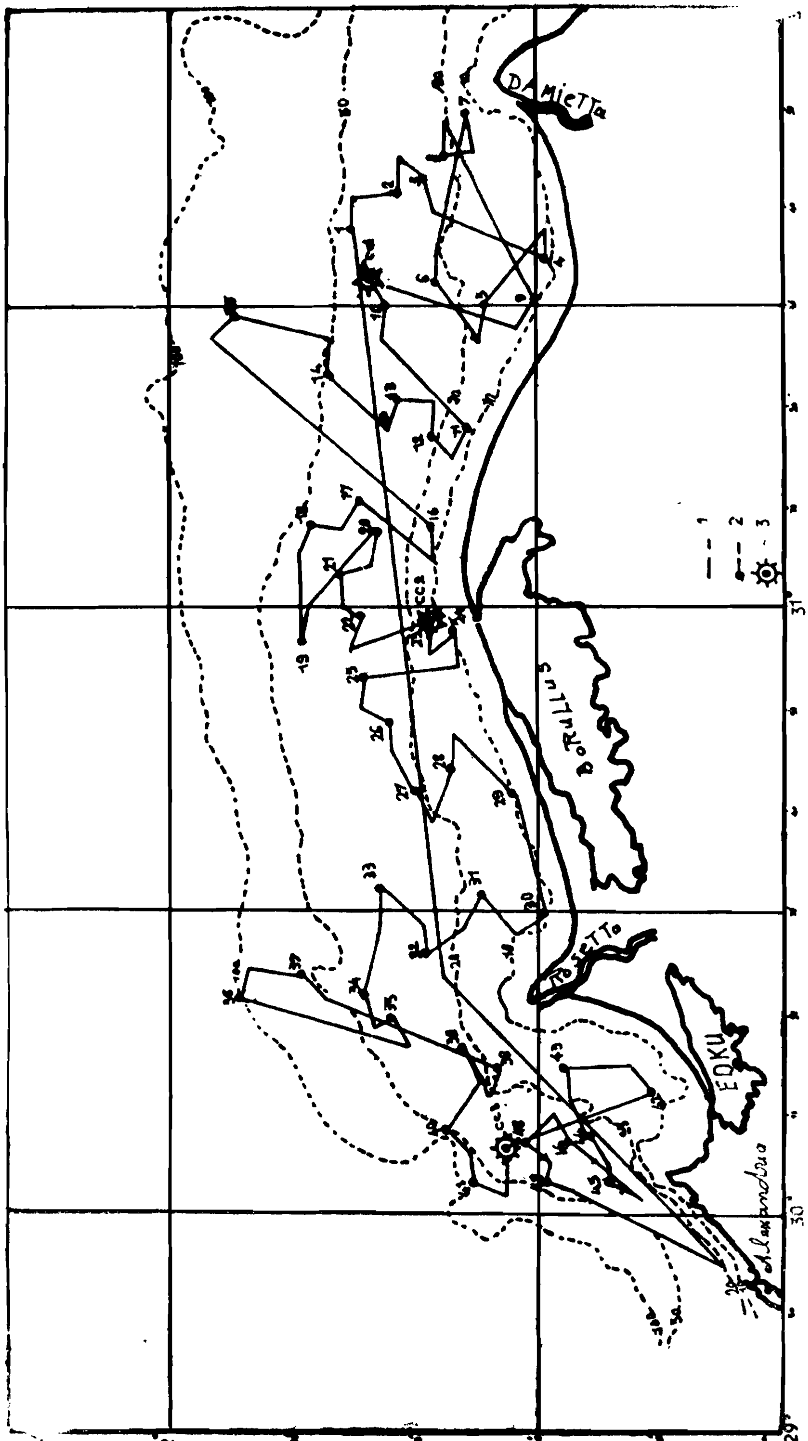


FIG. 46. Map Showing exploratory fishing operations of Ichthyolog during the period from April 19, 1971, to May 17, 1971.
Legend : Same as in Fig. 44.

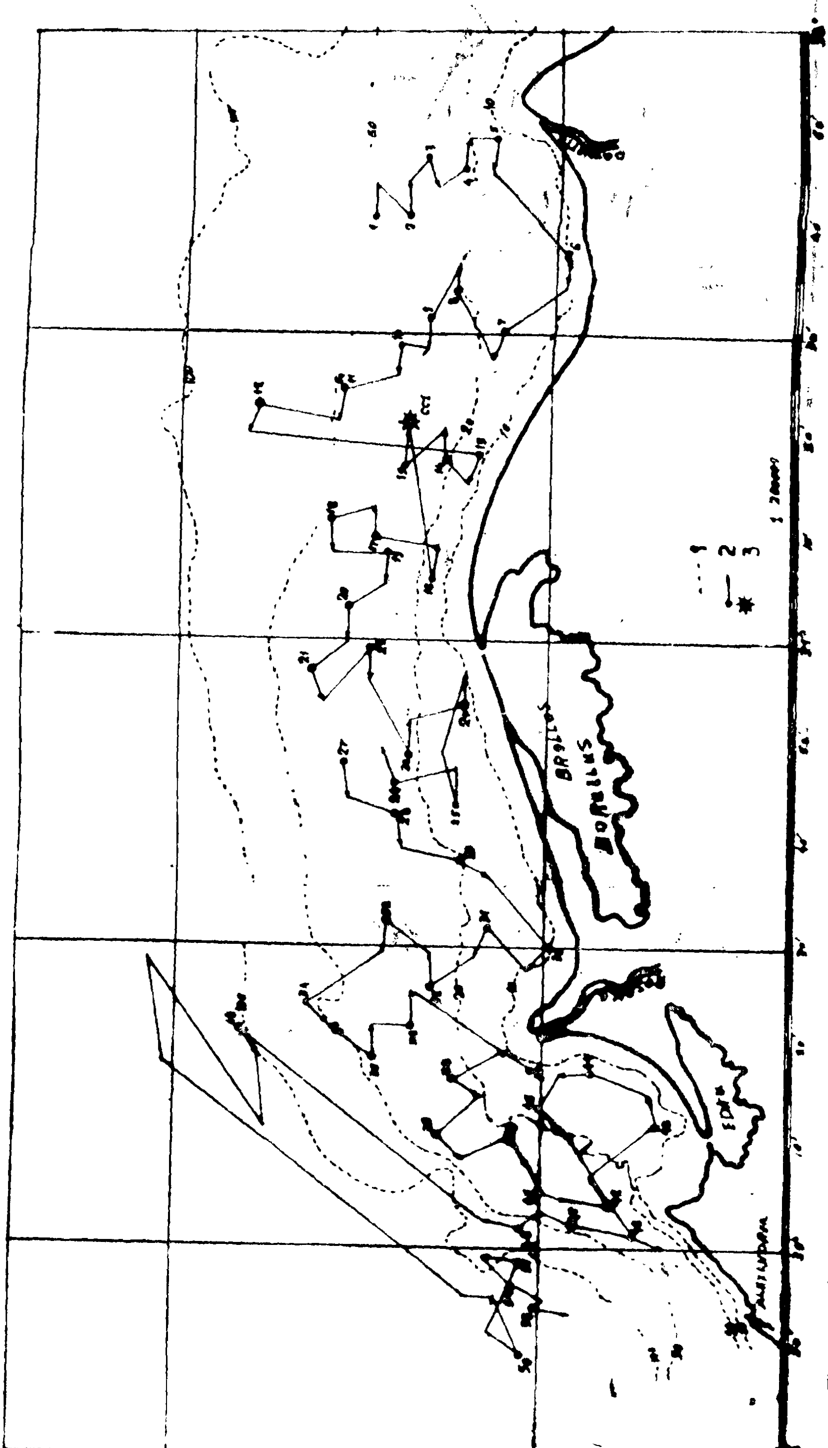


Fig. 47. Map showing exploratory fishing operations of Icithyolog during the period from Auguts 23, 1971, to September 8, 1971. Legend : same as in Fig. 44.

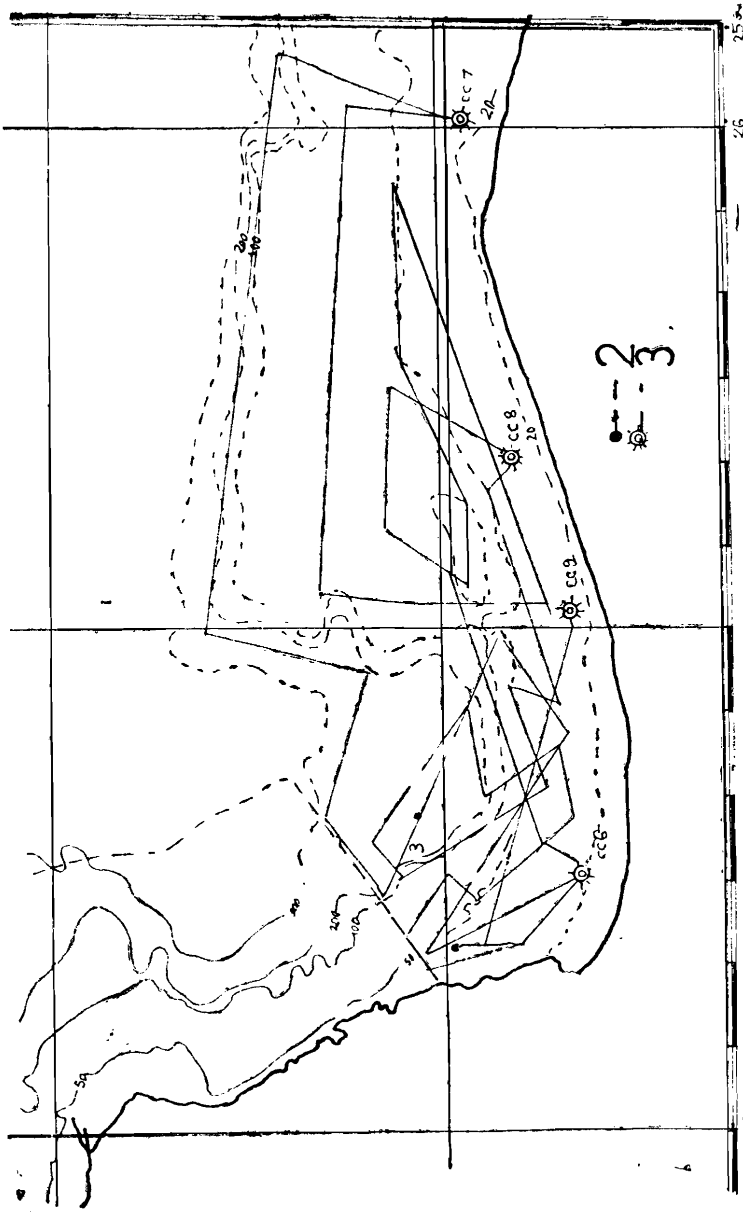


FIG. 48. Map Showing exploratory traips of the Ichthyolog in the Salloum Bay during the period from October 6 to 15, 1970. Legend : Same as in Fig. 44.

At the request of the Egyptian side a thorough sonic sounding gear survey of the Kenayes Bay and Arab Bay was carried out from the 3rd till the 8th of March, 1971. The diagrams of these surveys are given in Fig. 49. Hydroacoustic survey showed that the above areas are not suitable for trawling because of the rough bottom. Experimental trawling carried out in that area happened to be an emergency one.

General results of the expedition's trawling operations during the seasons are given in Appendix 1, 2, 3, & 4.

During Autumn, from the hydroacoustic equipment records, no fish concentrations were noticed. Fourty seven one-hour trawling carried out resulted in 433 kg of fish and 17 kg of shrimp caught. A portion of the catch consisted of non-commercial fish. The commercial fish (*Mullidae* and *Synodontidae*) occured in the catch. An average catch per hour of trawling gave 9.2 kg of fish and 0.4 kg of shrimp ; maximum catch was 32.6 kg of fish and 4.5 kg of shrimp. Distribution of catches during the Autumn season is given in Table 8.

Table 8.—Distribution of Catches in Autumn, 1970.

Catch (kg)	Under 1	1–5	5–10	10–20	Over 20
No. of trawling operations . .	5	11	12	15	4

Distribution of trawlings and catches during autumn period according to depth is given in Table 9.

Table 9 clearly indicates that the bulk of fish was caught at a depth of 10—30 meters. Maximum catches per 1 hour of trawling were at depths of 20—50 meters, and for shrimps at a depth of 10—40 meters.

Analysis of catches per region as given in Table 10 and represented in Fig. 50 (I) indicates that the bulk of shrimp was caught in the region of Borullos, and fish in the region of Rosetta. However, the difference in the catches of fish was determined mainly by the catch of non-commercial fishes at a depth over 50 meters and the catch of commercial fishes was almost the same everywhere and ceoncentrated at a depth of 50 m.

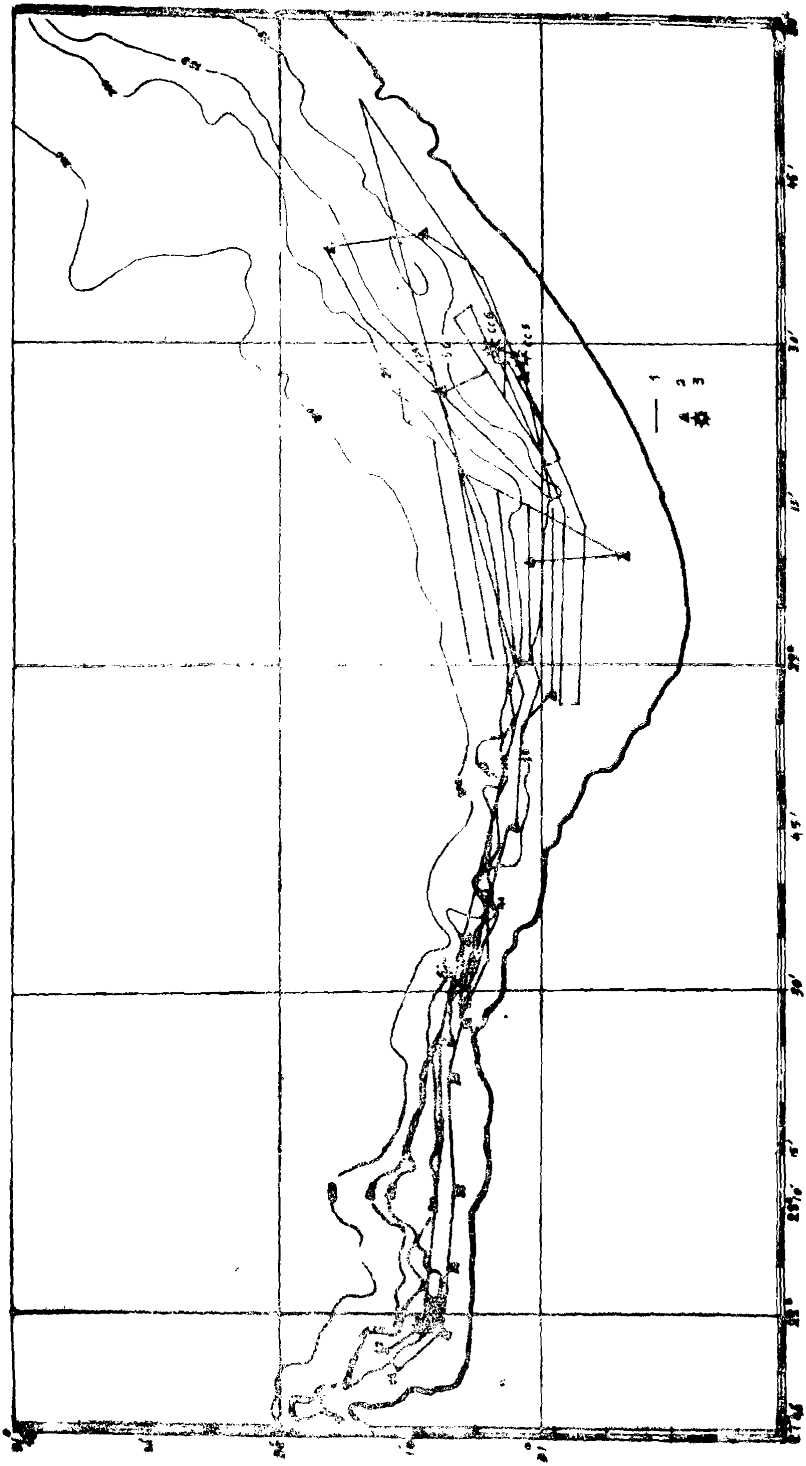


FIG. 49. Map showing the survey cruises of Ichthyolog in the Kerayes Bay and Arab Bay during the period from May 3 to 8, 1971. Legned: same as in Fig. 44. Bottom sampling stations are shown by triangles.

Table 9.—Distribution of Trawling operatiens and Catches with Depth in September, 1970.

Depth (m)	10	20-30	30-40	40-50	Over 50
No. of trawling	13	14	6	5	9
Total catch (kg) of which :	100.5	177.0	81.5	69.6	50.3
Shrimp (kg)	6.5	5.3	3.7	0.8	0.5
Catch per 1 hour of trawling (kg) of which :	7.7	12.6	13.5	13.8	5.6
Shrimp (kg)	0.5	4.9	0.6	0.2	0.1

During winter no concentrations of commercial fish were found. Only 209.5 kg of fish and 15.5 kg of shrimp were caught per 50 trawlings. Considerable portion of the catches consisted of non-commercial fishes. From commercial fishes there were *Synodontidae, Mullidae* and *Serranidae.* Average catch per 1 hour of trawling comprised 4.2 kg of fish and 0.3 kg of shrimp. Maximum catch was equal to 22.8 kg of fish and 2.4 kg of shrimp. All the trawlings lasted for 1 hour. Table 11 shows the distribution of catches within the winter season.

Distribution of catches per region was rather equal, although the larger quantity of commercial fish and shrimp was noticed in the region of Abukir. The biggest catches of fish per 1 hour of trawling were at depths of 10 m to 40 m, and for shrimp within the range of 20—40 m.

In spring sonic sounding gear survey was carried out during the whole trip parallel with trawling and oceanographic work. During the period of surveying there were no records of commercial concentration of fish on the gear tape, except for a few sporadic records of *S. pilchardus* shoals having no commercial importance (Fig. 51). The records on the gear tape were done with 4—5 fold amplification.

Table 10.—CATCHES (KG) AND THEIR COMPOSITION AT VARIOUS DEPTHS IN 1970–1971.

Month	(Depth m) Species / Regions	10–25 m			26–50 m			51–100 m			101–200 and over		
		Shrimp	Non-commercial fish	Commercial fish	Shrimp	Non-commercial fish	Commercial fish	Shrimp	Non-commercial fish	Commercial fish	Shrimp	Non-commercial fish	Commercial fish
I-September	Damietta	0.2	3.0	1.8	0.2	3.6	5.0						
	Borullos	1.1	2.3	2.6	0.8	2.0	5.6						
	Rosetta	0.2	2.0	3.3	0.1	0.9	8.4		0.4	17.4			
	Abukir		3.9	1.6	0.1	4.3	4.8		0.5	7.0			
II-January	Damietta	0.2	1.8	3.9	0.6	0.5	6.0			0.2			
	Borullos	0.4	0.7	5.1	0.1	0.2	4.0						
	Rosetta		0.4	5.2	0.7	1.0	3.4	0.1		3.9		1.0	1.0
	Abukir	0.2	2.1	2.5	0.3	0.4	1.1	1.9	0.3	1.6			
III-April-May	Damietta	1.0	0.4	1.1	0.3	0.6	2.0	0.2	2.4	1.7			
	Borullos	1.1	0.3	0.9	0.4	0.5	1.8						
	Rosetta	0.1	1.2	1.3	2.1	1.0	2.6		0.1	0.5	0.1		0.1
	Abukir	0.1	0.2	1.0	1.6	0.5	2.4	1.6	1.1	0.3			
IV-August-September	Damietta	0.4	1.4	2.2	0.4	5.3			1.5				
	Borullos	0.2	2.8	4.0	1.0	5.0							
	Rosetta	0.9	7.4	4.8	1.3	6.0		1.1	6.2			0.2	
	Abukir	0.2	1.2	1.5	0.5	3.8	4.1	1.6	0.5	4.8			0.4

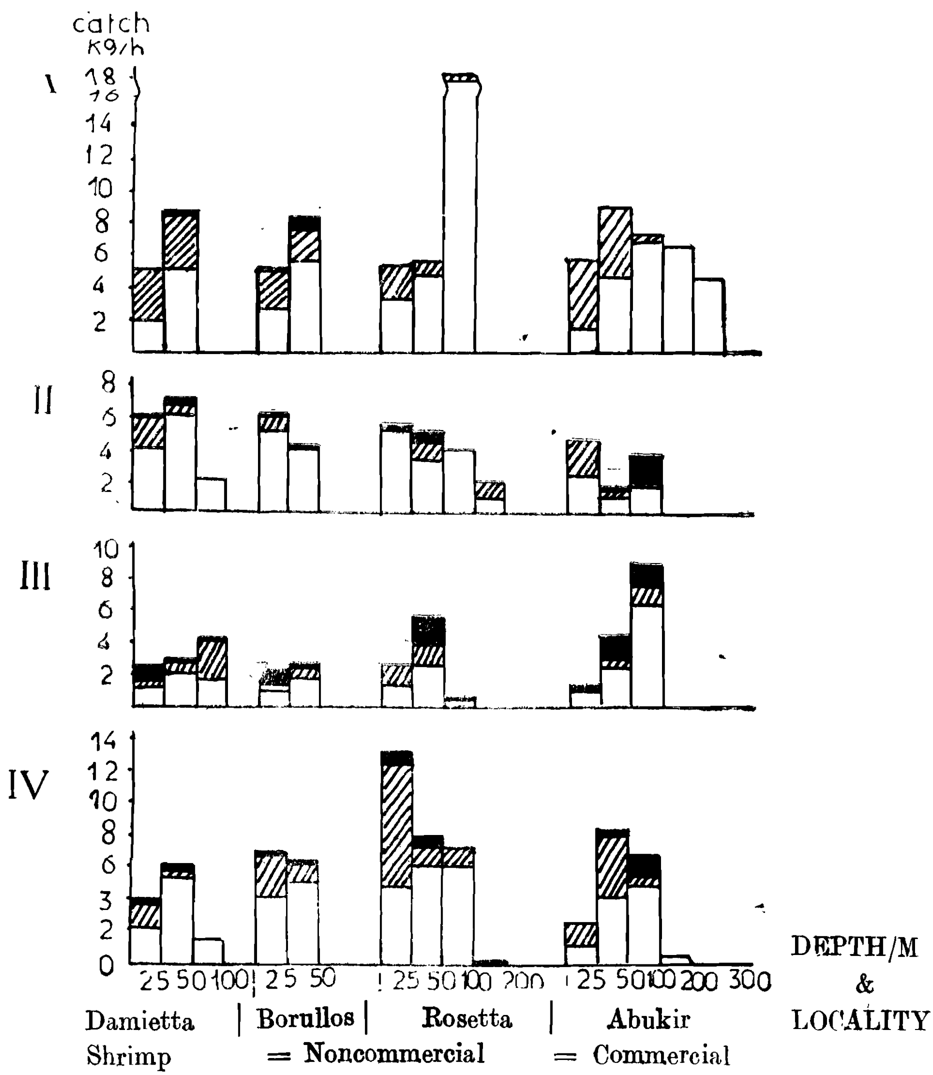


FIG. 50.—Catches (in kg) of fish and shrimp from Iohthyolog fishing surveys in Abu Kir–Damietta region during September, 1970 (I), January, 1971 (II), April—May, 1971 (III), and August—September, 1971 (IV).

Due to the fact that at depths over 50 m the shrimp got into the catch in single samples, the trawling operations were carried out mostly within the range of depths from 10 to 50 m. The distribution of catches with depth within this period is shown in Table 13 and represented on Fig. 50 (III). All-in-all 131.0 kg of fish and 45.5 kg of shrimp were caught per 53 trawlings. Average catch per 1-hour trawling comprised 5.8 kg of fish and 0.9 kg of shrimp. The maximum catch comprised 7.4 kg of fish and 5.2 kg of shrimp.

In the spring season the catch of shrimp was most significant, particularly in the regions of Abukir and Rosetta. At the same time the catch of commercial fishes (*Sparidae* and *Synodontidae*) were not big. The biggest catches were noted in the region of Damietta.

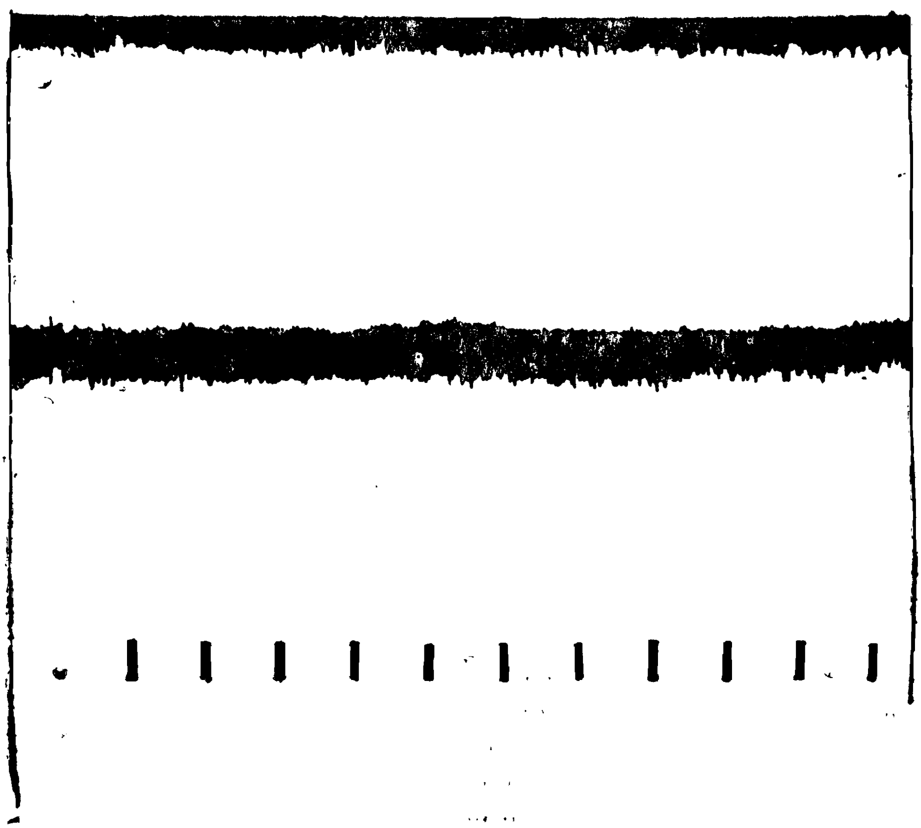


FIG. 51. Recorded echoes of a shoal of sardine in the region of Borullos (haul No. 20,21.1.1971).

Table 11.—Distribution of Catches in Winter 1971

Catch (kg)	Under 1	1-5	5-10	10-20	Over 20
No. of trawlings	10	21	15	3	1

Table 12.—Distribution of Trawlings and Catches with Depth in January 1971.

Depths (m)	10-20	20-30	30-40	40-50	Over 50
No. of trawlings	17	10	6	8	9
Total catch (kg)	76.5	51.0	49.0	31.7	17.8
of which:					
Shrimp (kg)	2.9	4.0	3.2	2.2	3.2
Catch per 1-hour trawling (kg)	4.5	5.1	8.3	4.0	2.0
of which:					
Shrimp (kg)	0.2	0.4	0.5	0.3	0.4

The data given in Table 14 indicate that catches of shrimp per one-hour trawling were in the range of 10-40 m, and fish from 10-40 m. Summer catches were rather bigger than the spring ones. The region of Rosetta was most remarkable. That region provided the biggest quantity of the *commercial fishes (Fig 50-IV; Table 10).*

Table 15 gives comparative data on catches by the expeditions of R/V "Ichthiology" in 1965-1966 and 1970-1971 in the regions of Damietta, Borullos, Rosetta and Abukir. One can see from the table that average catches of fish per one-hour trawlings decreased by 15 per cent, and of shrimps by 11 per cent. It is indicative that both 1965-66 and 1970-71 expeditions failed to get a commercial catch, therefore the ship did not operate in the commercial regime.

Table 13.—Distribution of Trawling Operations and Catches with Depth in April-May 1971.

Depth (m)	10–20	20–30	30–40	40–50	Over 50
No. of trawlings	21	12	8	7	5
Total catch (kg)	58.8	27.0	38.1	32.3	20.8
of which : shrimp (kg)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Catch per 1-hour trawlings (kg)	2.8	2.2	4.7	4.6	4.2
of which : shrimp (kg)	0.8	0.8	0.6	1.6	0.4

Table 14.—Distribution of Trawling Operations and Catches with Depths in August-September, 1971.

Depth (m)	10–20	20–30	30–40	40–50	50–70	over 70
No. of Trawling operations	16	12	10	6	3	6
Total catch (kg)	94.0	75.5	93.9	34.3	21.1	4.2
of which : shrimp (kg)	6.7	6.3	7.9	0.4	—	—
Catch per 1-hour Trawling (kg)	5.9	6.2	9.4	5.7	7.0	0.7
of which : shrimp (kg)	0.4	0.5	0.8	0.1	—	—

In the autumn season nine light stations were installed. Within the above season, judging by the data of the acoustic equipment, the fish did not show commercial concentrations and were rather poorly concentrated around the underwater sources of light. With the purpose of determining the variety of fish it was caught with cone net, which allowed to determine
the variety of fish it was caught with cone net, which allowed to determine
that mainly *S. pilchardus* were attracted to the light.

Table 13.—DISTRIBUTION OF TRAWLIAG OPERATIONS AND CATCHES WITH DEPTH IN APRIL-MAY 1971.

Depth (m)	10-20	20-30	30-40	40-50	Over 50
No. of trawlings	21	12	8	7	5
Total catch (kg)	58.8	27.0	38.1	32.3	20.8
of which : shrimp (kg)	18.1	9.6	5.1	11.0	2.2
Catch per 1-hour					
trawlings (kg)	2.8	2.2	4.7	4.6	4.2
of which : shrimp (kg)	0.8	0.8	0.6	1.6	0.4

Table 14.—DISTRIBUTION OF TRAWLING OPERATIONS AND CATCHES WITH DEPTHS IN AUGUST-SEPTEMBER, 1971.

Depth (m)	10-20	20-30	30-40	40-50	50-70	over 70
No. of Trawling operations	16	12	10	6	3	6
Total catch (kg)	94.0	75.5	93.9	34.3	21.1	4.2
of which : shrimp (kg)	6.7	6.3	7.9	0.4	—	—
Catch per 1-hour						
Trawling (kg)	5.9	6.2	9.4	5.7	7.0	0.7
of which : shrimp (kg)	0.4	0.5	0.8	0.1	—	—

In the autumn season nine light stations were installed. Within the above season, judging by the data of the acoustic equipment, the fish did not show commercial concentrations and were rather poorly concentrated around the underwater sources of light. With the purpose of determining the variety of fish it was caught with cone net, which allowed to determine that mainly *S. pilchardus* were attracted to the light.

Table 15.—CATCH DATA OF "ICHTHYOLOG" EXPEDITIONS IN 1965-1966 AND 1970-1971

Ser. No.	Time of work	No. of trawling operatioas	Total catch (kg)		Average catch per 1-hour tarwling (kg)		Maximum catch per 1-hour trawling (kg)	
			Fish	Shrimps	Fish	Shrimps	Fish	Shrimps
	Autumn Season :							
1.	September, 1966	4	58.0	0.3	14.5	—	40.9	—
2.	8.9.70-27.9.70	47	433.0	17.0	9.0	0.4	32.6	4.5
3.	Ratio in per cent (*)				63		81	
	Winter Season							
1.	22.12 65-25.1.66	59	324.3	57.2	6.9	1.2	67.5	6.0
2.	17 1.71-28.1.71	50	209.2	15.5	4.2	0.3	22.8	2 4
3.	Ratio in per cent				61	25	34	40
	Spring Season							
1.	2 &3 1.66-3.5 66	89	349.6	194.4	4.0	2.2	57.8	16.0
2.	19.4.71-17.5.71	53	131.0	45.9	5.8	0.9	7.4	5.2
3.	Ratio in per cent				145	41	13	32
	Summer Season :							
1.	18.8.66-28.8.66	42	335.2	102.0	8 0	2.4	30.0	9.4
2.	23.8.71-8.9.71	53	299.1	24.5	5.6	0.5	23.5	3.2
3.	Ratio in per cent				70	21	78	34
	Average ratio in per cent				85	29	52	35

The winter season did not give positive results. The sonic sounding gear records on the tape registering the approach of fish to the light were either exceedingly weak or they were not present at all at every station.

For the spring season the stations were installed in the regions of Damietta, Borullos, Arab Bay and Kenayes Bay. During moonless nights the tape of the sonic sounding gear in the Arab Bay recorded the attraction of the *S. pilchardus* to the light (Record of the XAL-400 sonic sounding gear tape with amplifying 1-2) but while using the board catcher the catch was insignificant (Fig. 52). The fish in the area of light was very active, made sporadic movement, sometimes leaving the source of light, sometimes approaching it. On switching off the CU-83 lamps of white colour, recorded fish on the gear tape dissappeared immediately. It was noticed visually that while switching on the deck mechanisms for lifting the lower support with loads, the fish got frightened and left the area of fishing.

During the summer sonic sounding gear survey, there were no essential concentrations of fish noticed. All-inall 53 trawlings gave 299.1 kg of fish and 24.5 kg of shrimp. Average catch per 1-hour trawling comprised 5.6 kg of fish and 0.5 kg of shrimp. Maximum catch was equal to 23.5 kg of fish and 3.2 kg of shrimp. A considerable portion of catches consisted of non-commercial fishes. *Mullidae* were numerous among the commercial fishes.

For the summer period the light stations were installed in the regions of Damietta, Salloum and Marsa-Matruh (Fig. 53). During operation in the regions of Damietta and Marsa-Matrouh there were no noticeable concentrations of fish around the light. At the middle of September the acoustic equipment registered the approach of fish to the light, but its complete fishing failed (25 kg of *S. pilchardus* were caught with the board catcher).

Light stations were installed both in the shelf zone over depths of up to 50 m and behind the shelf limits over the depth drops from 100 m to 1000 m. Fish were attracted to the light in the shelf zone, but at depths over 50 m it didn't. General information on the results of the light stations is given in Appendix 5.

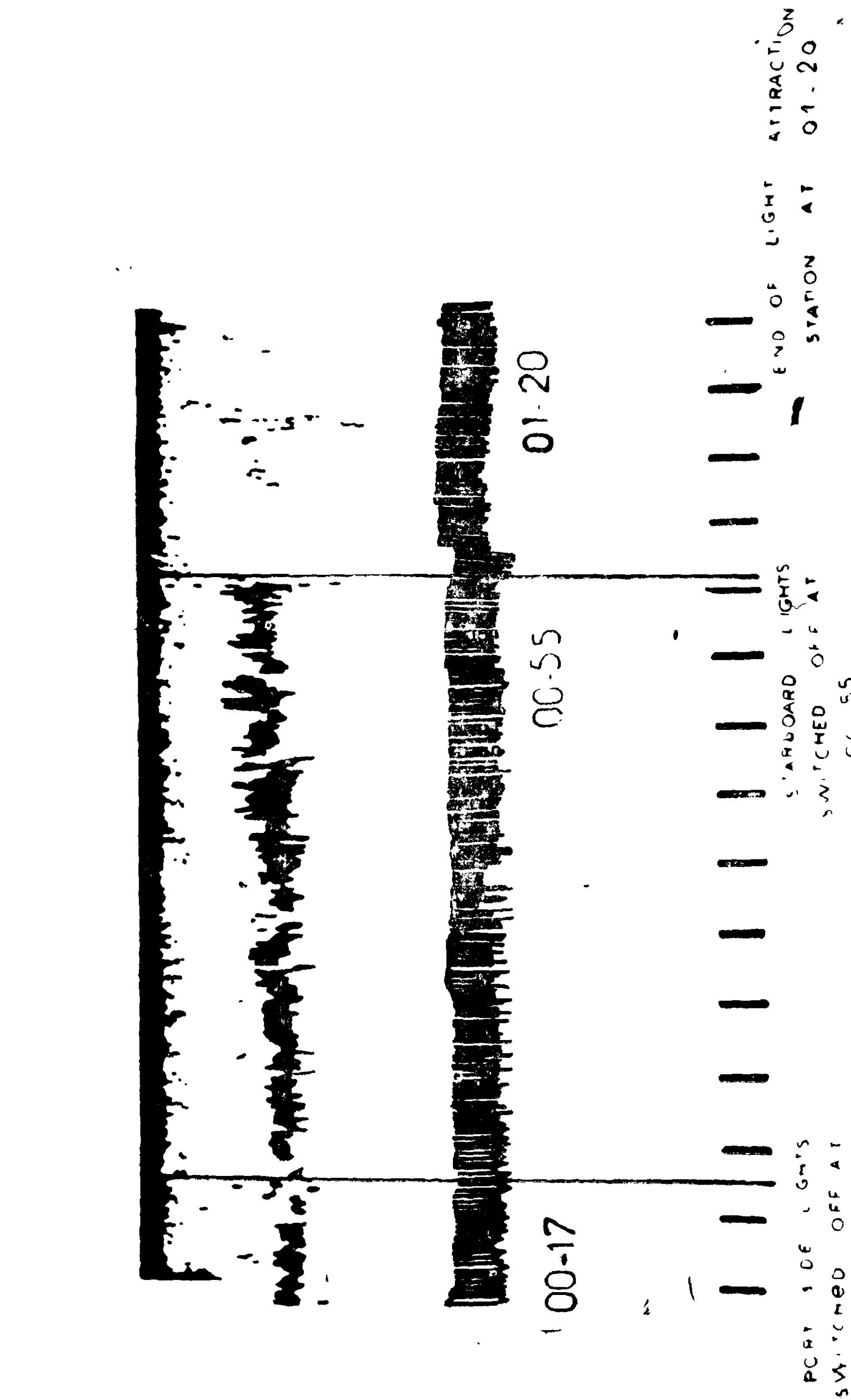


Fig. 52. Echogram of a shoal of sardine from the Arab Bay, light attraction station No. 5, 6-5- 1971.

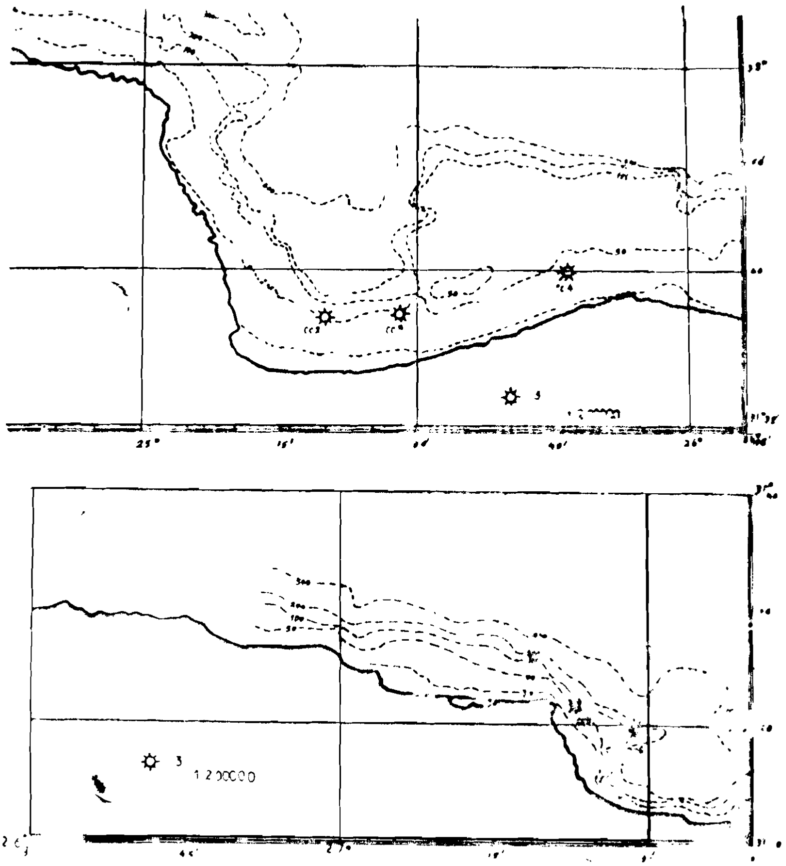


FIG. 53. Chart of exploratory fishing surveys of Ichthyolog in Bays of Salloum and Mersa Matrouh, from 17 to 19 September, 1971.

Conclusions :

1. All fishing gear provided for by the programme operated well.

2. Sonic sounding gear survey and control structure showed that from all the regions surveyed in the south-eastern part of the Mediterranean Sea along the coasts of Egypt only Damietta, Borullos, Rosetta and Abukir are suitable for bottom trawling at depths of 10-100 m.

3. Regions of Salloum, Mersa-Matrouh and the Arab Bay are not suitable for bottom trawling because of the roughness of the bottom and reef formations.

4. During the trawling survey in the exploration area the catches were insignificant and comprised on the average 6.2 kg of fish and 0.5 kg of shrimp per one hour of trawling.

5. Attraction of *S. pilchardus* to the light was observed in the Arab Bay in May and in the Salloum Bay in September over depths of 40-50 m.

VI—SHRIMP

The study of the biology of the shrimp along the Mediterranean coast of Egypt began quite recently due to their increased commercial importance. The work by El-Zarka and Koura, (1965), deals with the species composition and the shrimp quantitative distribution off the Nile mouths from the above point of view. Their investigation is based on some data of the early 60-s when the shrimp fishery was at its peak. These data characterize the shrimp population during its flourishing period. Long intensive fisheries and the changes in the ambient caused by the regulation of the Nile flow resulted in considerable changes in the shrimp population which predetermined a necessity to study their biology. With this purpose in 1965-1966 a first Mediterranean expedition of the Azcher Niro was carried out which gave some idea on the biology of mass shrimp species inhabiting the shelf zone of the Nile Delta and allowed to reveal certain alterations in their conditions which affected the fishing level.

Repeated annual studies carried out in 1970-1971 give a possibility to determine the character of transformations in the shrimp population which are taking place in newly formed conditions of the ambient and to define the specific features of the present fisheries.

The data of the seasonal trawling surveys described above in the chapter "Search and Fisheries" Fig. 44-47) were used as initial data for characterizing the conditions of the shrimp population along the Mediterranean coast of Egypt in 1970-1971. They cover the shelf zone from Abukir Bay to the Damietta Cape. Within the depth range from 10 m isobath passing along the shore to 400 m isobath located on the continental slope. The basic information was collected in the zone of 10-50 m inhabited by the greatest shrimp population. The volume of information corresponds to the catch yield of 203 trawlings where 3637 specimens were measured and 2418 specimens were analyzed.

TAXONOMY

Species composition of the shrimp population on the Mediterranean shelf of Egypt

In the catches made in the shelf zone near the Nile mouth we have found shrimps of the following three families : Penaeidae, Pandalidae and Crangonidae.

Family Pandalidae was represented by the species of *Plesionika longirostis* and the family Penacidae by seven species :

Penaeus japonicus Bate

Penaeus semisuleatus de Haan

Penaeus trisulcatus Leach

Metapenacus monoceros Fabricius

Metapenaeus stebbingi Nobili

Parapenaeus longirostris (Lucas)

Trachypenaeus curvirostris (Stimpson)

Solenocera indica Nataray.

In general, the composition of paeneids of the southeastern part of the Mediterranean Sea was known before. However, the species of *Trachypenaeus curvirostris* was known as *Parapenaeus* sp., and for the first time it was determined by the authors of this report. The species of *Solenocera indica* had not been found in the region of our investigations before. In spring of 1971 the members of the expedition caught 4 females at 23 depth in Abukir region at the station having the following coordinates : latitude 31°35 '8" North and longitude 30°16 '2" East.

The composition of the penaeids in the region under investigation is not homogenous in its origin. Only two species, i.e. *P. Kerathurus* and *P. longirostris* can be considered as truly local species (endemic) (Heldt, 1938 ; Holthius and Gottlieb, 1956).

After inanguration of the Suez channel in 1872 the shrimp fauna of the Mediterranean Sea was enriched by the species of *P. semisulcatus*, *P. japonicus and M. stebbingi* (Al-Kholy and El Hawary, 1970). As to the other species (*M. monoceros, T. curvirostris, S. indica*), a clear idea on the ways of their penetration to the Mediterranean Sea is lacking, but as they are typical inhabitants of the Indian and Pacific oceans they also should be considered incomers (Heldt, 1938 ; Kubo, 1949).

The general poverty in composition of the penaeids in the area under investigation in comparison with any other tropical zone, suggests development of some species.

According to the information of 1966 the percentage of the above shrimp species in the investigated area is very different as they have different ecological behaviour. It has been found that there are several permanent zones where certain species prevail. The zone limits change somewhat tdue to sesonal migration.

In order to reveal the seasonal changes which ocurred in the species percentages in 1970-1971 the data of the surveys carried out in April and January which characterized two opposite seasons : spring-summer and autumn-winter, were studied.

According to the predominance of certain species the following four zones were determined in April (Fig. 54 & Table 16) :

First zone - *M. stebbingi*

Second zone - *P. longirostris*

Third zone - mixed

Fourth zone - *T. curvirostris.*

The first zone extends along the entire shelf occupying the least of the investigated depths, i.e. up to 20 m. The main species here was *M. stebbingi* (42 per cent - 82 per cent). In respect of the accompanying species importance this area can be subdivided into several sub-zones. Two subzones with great content of *T. curvirostris* are found in Abukir Bay and Lake Borullos (32.4 per cent 47 per cent respectively) ; several sub-zones with considerable content of *T. curvirostris* (24 per cent) and *M. monoceros* (20.6 percent) in the region of Damietta.

In the second zone which covers all the deep-water part of Abukir Bay and partially the Rosetta region occupying depths over 30-50 m, the prevailing species was *P. longirostris* ,85.9 per cent).

The third zone extended between lake Borollos and the Damietta mouth of the Nile, occupying deeper portion of the shelf in respect of the first zone. Here the shrimp composition was very diversified, all main species (i.e. *M. monoceros, M. stebbingi, T. curvirostris*) and representatives of *Penacus* had approximacely equal importance.

Table 16.—PERCENTAGE OF VARIOUS SHRIMP SPECIES IN APRIL, 1971.

Region	Zone & Subzone	Shrimp Species composition, (per cent)							Total %
		P. japonic.	P. trisulc.	P. semisulc.	M. mono	M. stebbingi	P. longir	P. curv.	
Abukir-Rosetta (up to 20 m)	1	1.0	2.0	—	12.1	81.9	3.0	—	100
Abukir (up to 20m)	1-1st	0.9	0.6	0.3	13.1	42.2	32.4	10.5	100
Borullos (up to 20m)	1-2nd	2.4	1.5	—	5.6	43.5	—	47	100
Damietta (up to 20m)	1-3rd	3.3	1.9	0.4	20.6	49.8	—	24.0	100
Abukir-Rosetta (over 20m)	II	0.4	0.3	0.1	1.0	4.1	85.9	8.2	100
Rosetta-Borullos (over 20 m)	IV	2.0	0.4	0.1	0.4	0.7	1.8	94.6	100
Borullos-Damietta	III	14.2	3.4	1.4	37.5	22.0	1.0	20.5	100

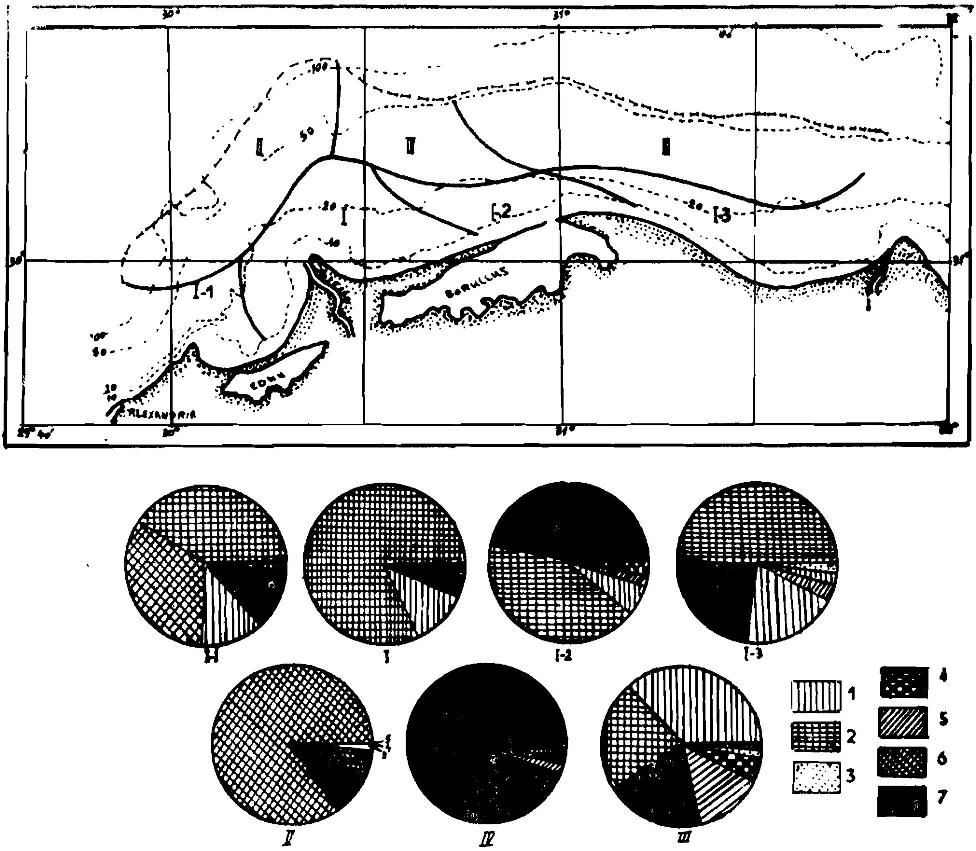


FIG. 54. Zonation of various shrimp species in April, 1971.

The diagrams show the different proportions in which these species occur in the corresponding zones.

Legend :

1.—*M. monoceros* ;
2.—*M. stebbingi* ;
3.—*P. semisulcatus* ;
4.—*P. trisulcatus* ·
5.—*P. japonicus* ;
6.—*P. longirostris* ;
7.—*P. curvirostris*.

The fourth zone was located between the Rosetta and Damietta regions and was represented completely by *T. curvirostris* (49.6 per cent) though, as in the second zone, all species were present.

In January, the importance of zone species changed radically. According to the prevailing species only three zones can be detrmined (Fig. 55, & Table 17) :

First zone — *M. monoceros*

Second zone — *P. Longirostris*

Third zone — *T. curvirostris*

The first zone lies in the shallow and the middle parts of Abukir Bay and off the region of Rosetta mouth. In the western part of this zone, besides *M. monoceros, M. stebbingi* accounted for more than a quarter (28.5 per cent) while in the eastern portion only *M. monoceros* was prevailing (92.5 per cent).

The second zone, as usual, was located in the deep off-shore portions of Abukir Bay and Rosetta region. The percentage of *P. longirostris* did not change in comparison with spring accounting for 84 per cent. It was accompanied by *T. curvirostris* (14.6 per cent).

The third zone occupied the whole middle and eastern parts of the investigated shelf. In the middle portion, i.e. in the Borollos lake region *T. curvirostris* accounted for 90.2 per cent. In the eastern part two sub-zones, i.e. deep and shallow, can be identified. In the first, the present species were *M. monoceros* (22.4 per cent) and penaeids (15.8 per cent) ; in the second sub-zone, penaeids (94.7 per cent) and *M. stebbingi* (25.9 per cent).

Thus, during winter of 1970-1971 at the depth up to 20m in the western part of the investigated area (Abukir and Rosetta region *M. monoceros* was prevailing and to the east, *T. curvirostris*. During spring of 1971 the predominance of *M. stebbingi* increased sharply at small depth, while to the east predominance of *T. curvirostris* remained. The shrimp composition on the western slope of the shelf at a depth over 50 m remained invariable with the permanent prevalence of *P. longirostris*.

In the eastern part of the investigated shelf at a depth of 20-50 m. the representatives of the *Penaeus* species retained their comparatively great importance.

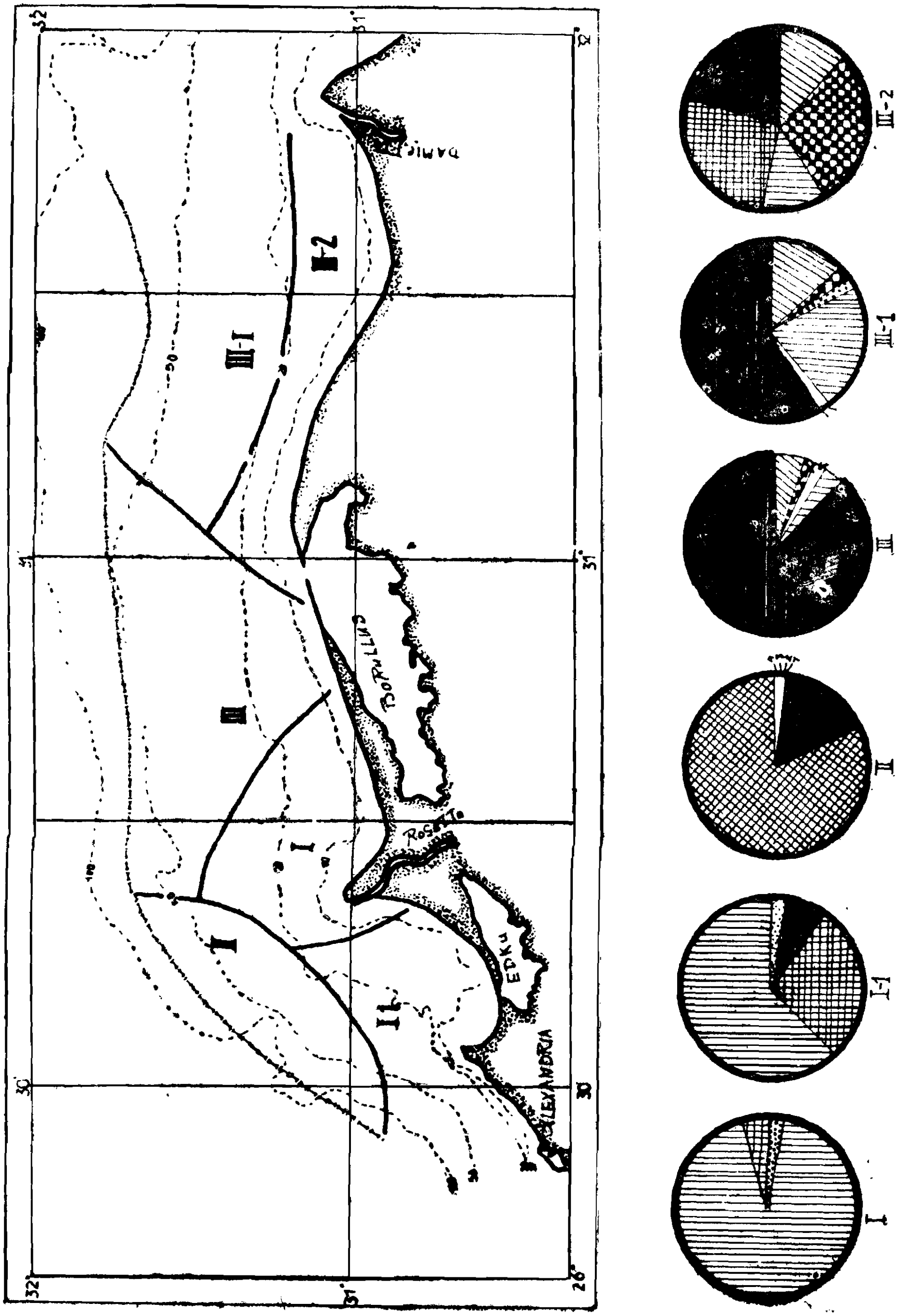


FIG. 55.—Location of the zones wherein the shrimp species occurred in different proportions in January, 1971, Legend : same as in Fig. 54.

Table 17.—PERCENTAGE OF DIFFERENT SHRIMP SPECIES IN JANUARY 1971.

Region	Zone & Subzone	Shrimp Species composition, (per cent)							Total %
		P. japon.	P. trisulc.	P. semis.	M. monoc.	M. stebbingi	P. longir	T. curv.	
Rosetta	I	—	—	2.5	92.5	5.0	—	—	100
Abukir	I-Ist	—	—	1.8	62.5	28.5	—	7.1	100
Abukir-Rosetta (over 20 m)	II	—	0.1	0.4	0.8	0.1	84.0	14.6	100
Borullos	III	4.8	1.9	0.5	2.4	0.2	—	90.2	100
Damietta (over 20 m)	III-Ist	12.7	1.8	1.3	22 4	0.7	0.2	60.9	100
Damietta (up to 20 m)	III-2nd	11.1	29.6	—	11.1	25.9	—	22.3	100

Therefore, the shrimp composition in the west is more homogenous (at every season a certain species iis apparently prevailing) and labile seasonwise (a complete substitution of one prevailing species by another takes place), while in the east the shrimp composition is more diversified and does not change sharply with change of the season.

On the whole, the species percentage composition in 1970-1971 was characterized by stable predominance of *M. Stebbingi* in the coastal areas, by greater concentration of *T. curvirostris* in the east (the Borullos and Damietta regions by invariable prevalence of *P. longirostris* on the western slope of the shelf and by extremely low importance of large *penaeids* (*P. semisulcatus, P. japonicus* and *P. trisulcatus*).

In Comparison with the data of 1966 (Drobysheva, 1970), it was shown *that location of the zones, on the whole, remained the same while considerable* changes in the species percentgae composition took place. If before the mass species was *M. monoceros* (40.5 per cent), in 1971 it accounted only for 9.3 per cent of the total quantity. The role of *M. stebbingi* increased greatly, its zone being extended considerably towards the zone of *M. monoceros*. The importance of *P. trisulcatus* dropped off sharply while the role of *P. japonicus* increased somewhat. The importance of small non-food species *P. longirostris* and *T. curvirostris* increased considerably.

BIONOMICS

Distribution and biological Characteristics of the main shrimp species of the family Penacidae :

Mass accumulations of the shrimp-penaids in the World Ocean are located in the shelf zones near the mouths of big rivers (in the Mexican, Guinean and Persian Gulfs, along the coastline of Hindustan and Northern Australia, etc), which carry out a lot of suspended and organic matter forming the littoral zone, of silty and silt-sandy soils. The shrimps are related to this type of soil both trophically and ecologically since they ensure abundant food and serve as a safe shelter.

From the above point of view the shelf area near the Nile mouths is rather a favourable place for inhabitation of the shrimp family-Penacidae. According to Mohamed (1967) wide zones of fine clayey sand (20 m) bordered by a band of silty sand and sandy silt (20-80 m) are found in the area off the Nile branches-Rosetta and Damietta-to a depth upto 20 m. Between the Nile branches in the Borullos area there is an extensive zone of shelly sand which covers even deeper parts of the shelf and is substituted in the area of continenal slope by silty bryozoan sand and gravel sand.

According to Aleem (1969), the width of the zone of silt and silty sand in the first half of the 60-s was 45 km. The expedition of 1970-1971 confirmed this width. However, it cannot be considered invariable under the conditions of the river flow regulation.

Acccording to Oren (1970), the construction of the Aswan Barrages in 1902, resulted in the disappearance of 2 km land in the Rosetta and Damietta regions. If usually the Nile carried out to the sea 140 million tons of silt and mud (4 kg/m^3), nowadays the Aswan Dam retains $10^8 m^3$ of suspended particles annually. Practically this stopped sedimentation and even caused the disintegration of the "Shrimp" ground (Aleem, 1969 & Oren, 1970).

Besides the trophical and ecological aspects the connection of the penaeids with the littoral zones ensures the conditions required for their reproduction because the post-larval instars and the brood of many species of this family inhabit littoral fresh-water reservoirs. Availablity of the sea-water and fresh water phases in the life cycle of the penaeids predetermines their age migrations and their seasonal accumulation. The periods, massiveness and location of annual accumulations depend on the specific conditions of the year which to a great extent predetermines good population and therefore the commercial importance of the shrimp.

The information collected during this expedition allows to form an opinion only about the mature portion of the shrimp population. The methodology used gives an idea about the shrimp quantitative distribution and allows to evaluate some aspects of the biological cycle.

(*a*) *Penaeus japonicus* :

In 1970-1971, representatives of this species were found in the entire investigated area of the shelf, giving 50 specimens per trawling hour. Its average catch yields were similar in all seasons not exceeding 0.300 kg, and only in August of 1971 reaching 0.805 kg in the Abukir region at a depth of 25-50 m (Appendix 6a, & Fig. 56a).

During all seasons the basic mass of specimens of this species was caught at a depth of 20-40 m. As it can be seen from Fig. 57, *P. japonicus* specimens were found near the very shore only in April of 1971, while in other seasons they inhabited at a depth over 10 m. Their distribution shows a certain connection with the Lake Borullos outlet, as some specimens were always found in shallow places near this area.

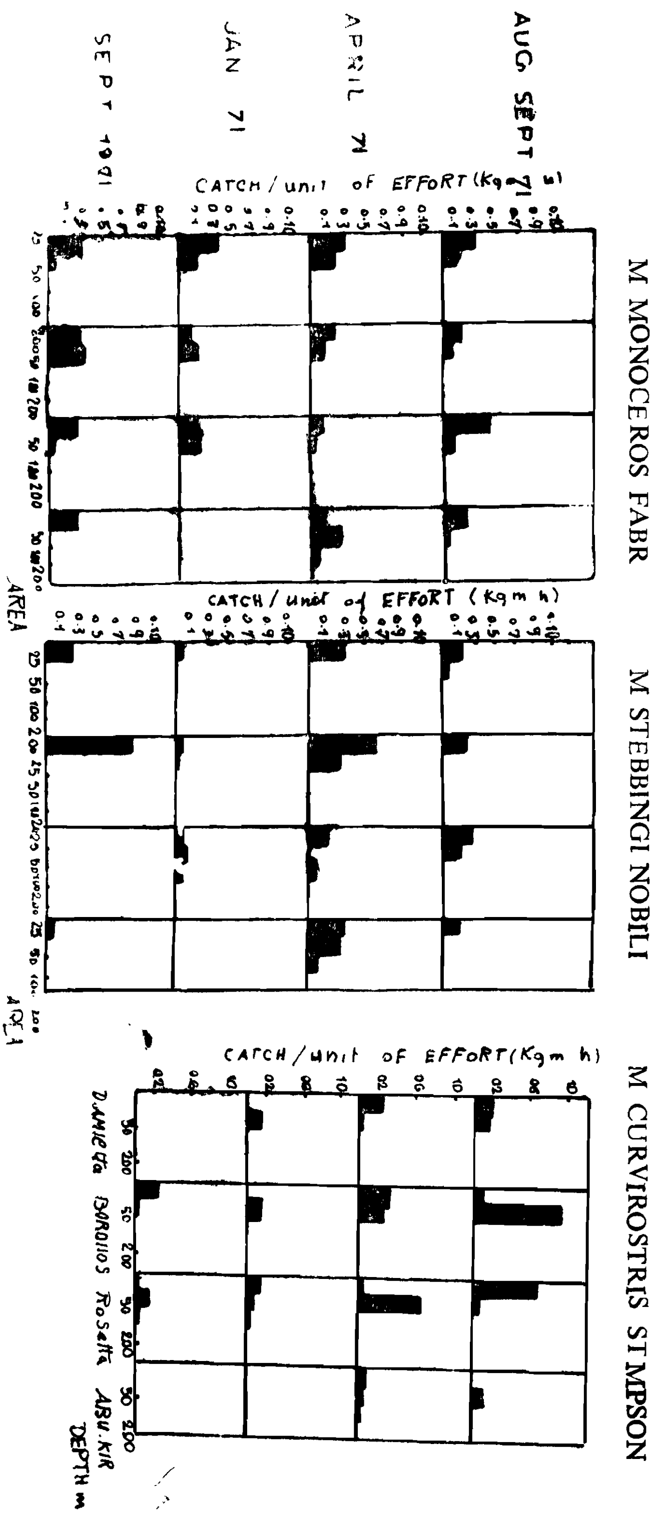
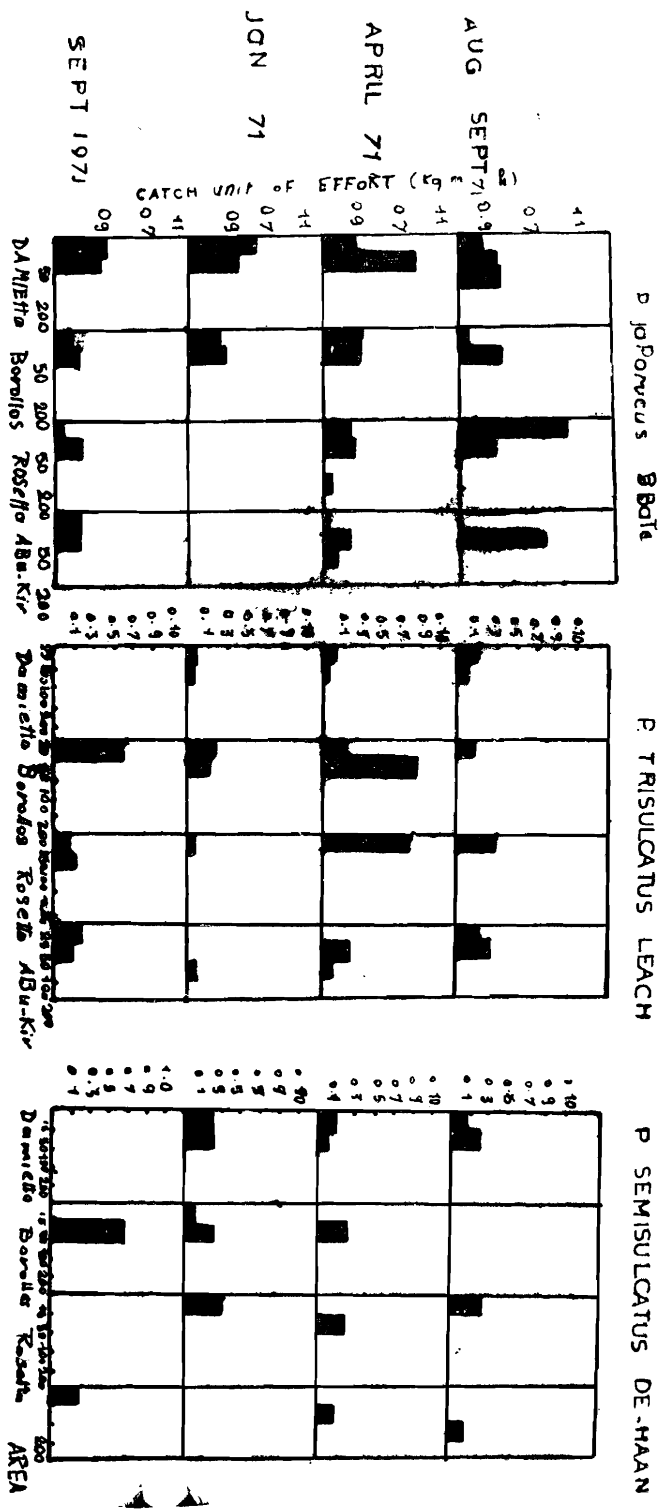


Fig. 56. Average catches of shrimp by species, in kg per hour of trawling, during



the Ichthyolog seasonal cruises in the Mediterranean waters off the coast of Egypt.

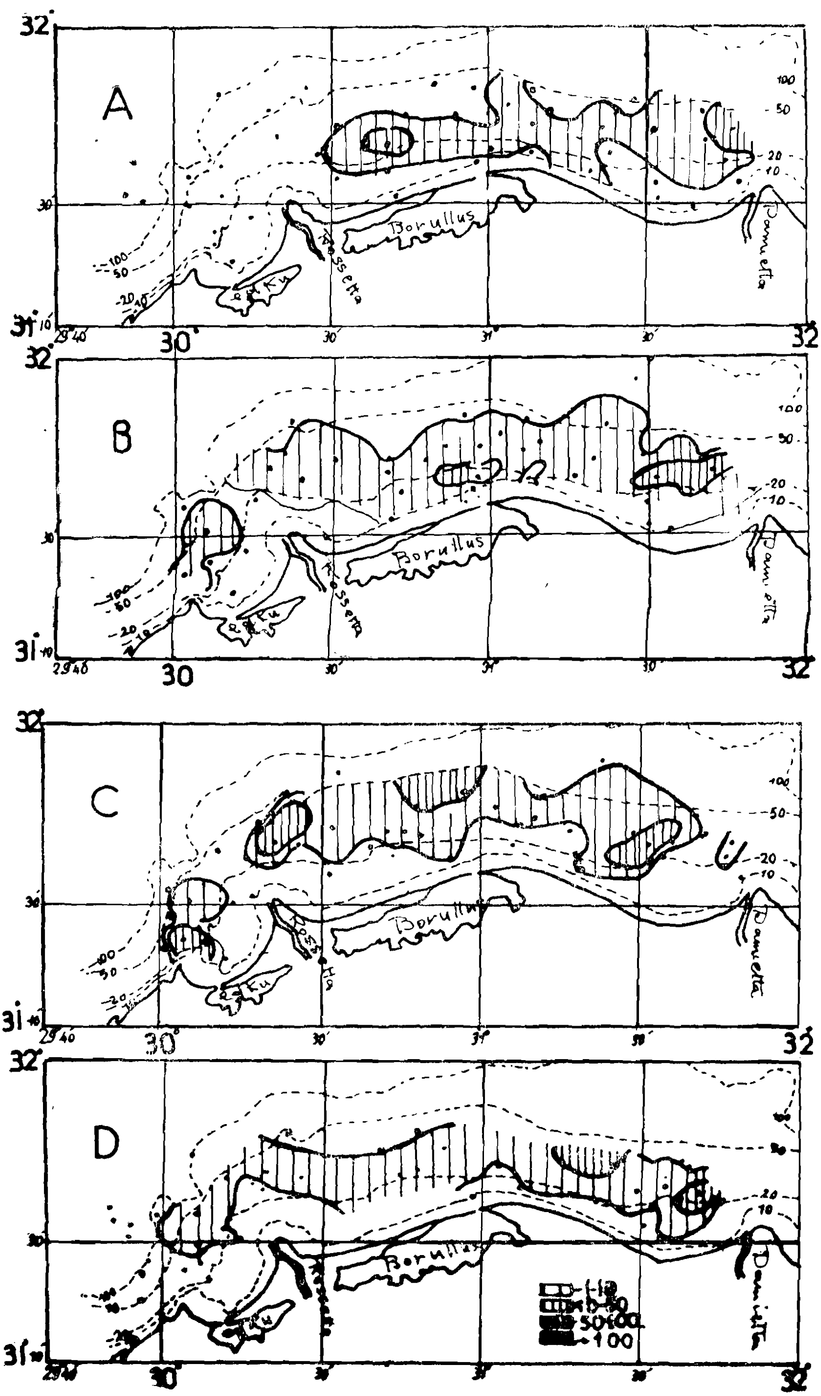


FIG. 57.—Distribution of *P. japonicus* during January (a), April (b), August (c) of 1971, and in September, 1970 (d), expressed as the number of shrimp caught per hour of trawling: 1–10 ; 10–50 ; 50–100 ; above 100.

In summer, autumn and winter, the size series of *P. japonicus* was represented by compact groups of large matured specimens, 120-230 mm long (Fig. 58 & Appendix 8a). The modal groups of males and females differed in about 20-30 mm. In all seasons the average size of males was 155-160 mm. and that of females — 190-195 mm. Only in April the size series was extended very much due to appearance of young specimens of size-95-120 mm. Alteration in the size composition corresponded to a change of the reproductive correlation and maturity (Table 19 & Fig. 59). During the autumn-winter season (September 1970 and January 1971) males were prevailing (63 per cent and 64 per cent of the total number), while during the spring-summer period (April and August 1971) females were predominating (58 per cent and 59 per cent). The maximum maturity was observed in April when 81 per cent of females had 4th and 5th phases.

(*b*) *P. trisulcatus :*

The number of specimens of this species caught in 1970-1971 was extremely small ; only in the spring-summer period not more than 10 specimens were caught per trawling hour. Accordingly, the yield of *P. trisalcatus* did not exceed 0.100 kg per trawling hour in all season (Appendix 6 "b", Fig. 56 b). Only in September and April some trawlings gave yields of 0.6 and 0.6 kg respectively. It is interesting to state that these catches were given in the Borullos region. The greatest number of specimens was caught at a depth of 10-40 m, i.e. nearer to the shore than *P. japonicus* (Table 18).

In the trawls only large matured specimens were present (Appendix 7 "b" & Fig. 60). They were represented by compact groups, the difference between males and females being 20-30 mm. During winter and spring the modal group of males was of the size 120-160 mm. and that of females 140-170 mm. In autumn the length of males increased somewhat reaching 140-160 mm., while that of females increased considerably reaching 170-210 mm. Thus, replenishment of the mature part of the population begins in winter reaching the maximum sizes by autumn.

The maturity of females increases by April. Presence of numerous females in the 5*th* (spawning-run) and the 2nd (post-spawning phases) during summer indicates long summer spawning. Due to the long spawning the sex correlation does not change sharply during the year and is characterized by constant prevalence of males (Table 19).

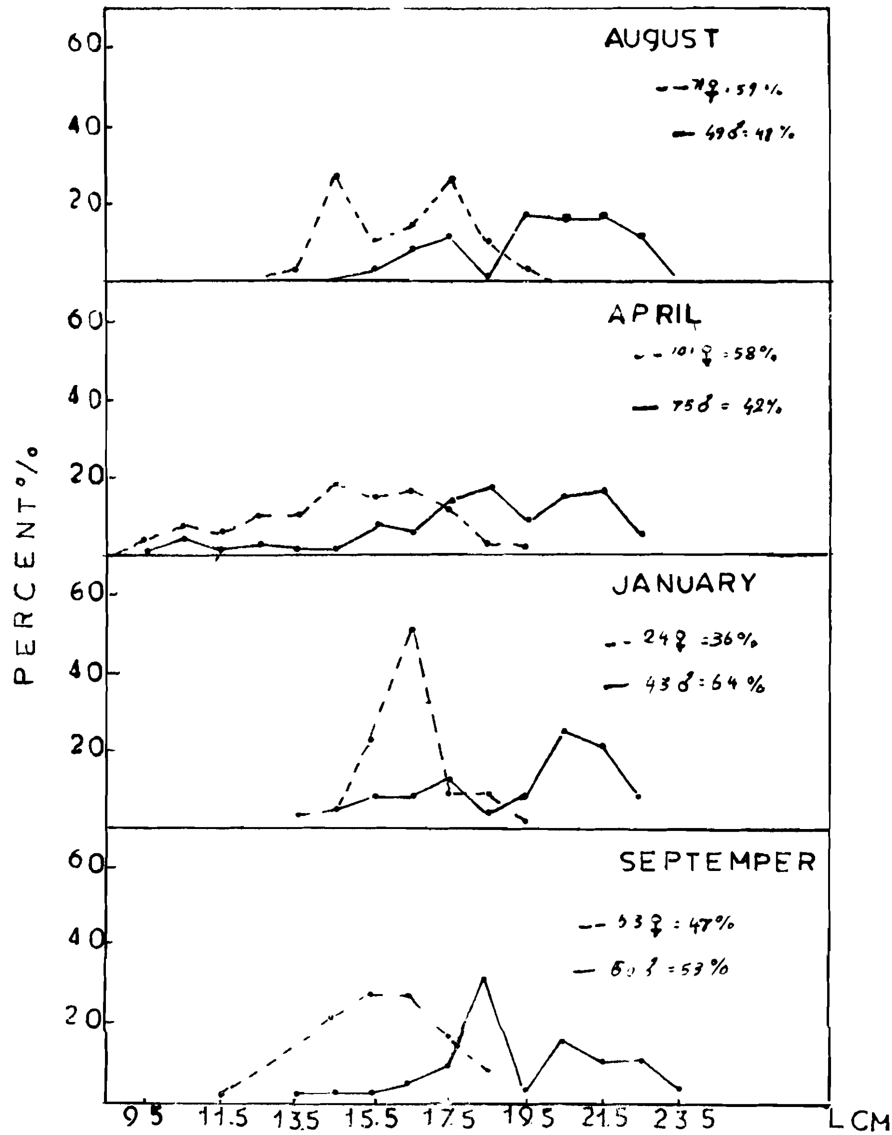


FIG. 58.—Size composition of *P. japonicus* in January (a), April (b), August (c) of 1971, and in September, 1970 (d) on the Egyptian Mediterranean shelf.

TABLE 18.—Seasonal distribution of various shrimp species at different depths in 1971 (in montns)

Depth (m)	10–20				21–30				31–40				41–50				51–60				61–70				Total, %			
Species / Month	January	April	August	September	January	April	August	September	January	April	August	September	January	April	August	September	January	April	August	September	January	April	August	September	January	April	August	Spetember
Penaeus Japonicus	1.9	19.1	2.0	1.4	28.4	49 3	14.4	56.4	64.7	20.4	56.0	21.1	8.6	5.4	7.6	21.1	—	6.8	—	—	—	—	—	—	10)	10)	10)	100
Penaeus. Trisulcatus	14.2	23.8	59.8	33.6	20.0	30.9	7.6		28.6	29.9	33.2	12 9	8.6	3.6	—	22.6	—	H,9	—	—	28.6	—	—	—	100	10)		00
Penaeus Semisulcatus	16.6	13.4	21.8	—	55.6	22 2	19.4	11.8	27.8	33.3	—	88 2	—	20.0	—	—	—	—	29.4	—	—	—	29.4	—	10)	10)	10)	
Meta penaeus monoceros	43.5	32.0	52.9	38.7	27.4	26.5	38 3	14.8	19.0	12.4	7.9	43.4	8.3	7.2	0.9	3.1	1.8	20.0	—	—	—	1.9	—	—	10)	10)	100	100
Metapenaeus Stebbıngi	22.6	59.9	65.3	78.9	15.1	13.1	28.8	18 3	62.3	8.6		2.9	—	13.3	—	—	—	—	—	—	—	5.1	—	—	100	10)	10)	100
Parapenaeus. longirostiris	3.2	18.5	2.4	46.9	38.6	29.6	75.4	2	35.3	43 1	22.2	12.7	21.6	8.1		13.2	1.2	0.7	—	—	—	—	—	—	9)	10)	10)	100
Trachypenaeus curvirostris		0.2 —	—	—	0.3	0.6	—	6.2	0.1	20 0	0.03	1.6	11.1	53.6	—	—	— 53.4			—	35.1	43.6	9997	—	100 200			100

Table 19.—SEX CORRELATION OF DIFFERENT SHRIMP SPECIES ON THE MEDITERRANEAN SHELF OF EGYPT

Season	Species													
	P. Japonic.		P. trisulc.		P. semis.		M. monoc.		M. stebbingi		T. curvir.		P. longir.	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
September 1970	63	47	65	35	21	79	68	32	71	29	57.5	42.5	6.4	93.6
January 1971	64	36	64	36	71	29	71	29	33	67	44.6	55.4	36.4	63 6
April 1971	42	58	65	35	62	38	48	52	10	90	45.3	54.7	35.1	61.9
August 1971	41	59	54	46	55	45	58	42	64	54	73.4	26.6	33.3	66.7
Number of specimens. . .	257	215	56	103	29	30	1020	972	1523	1039	2501	2363	1751	3804

(*c*) *P. semisulcatus*

According to the information of 1966 the main area, where this species inhabits, is located eastward of the Damietta branch Drobysheva, 1970). In 1970-1971 to the west of this area only single specimens of this species are found never forming accumulations. The maximum catch yield of this species which was obtained in September 1970 in Abukir region at a depth of 52-50 m (Appendix 6 "c") did not exceed 0.5 kg per trawling hour.

The information obtained is so insignificant (the average yield was 0.200 kg) that it is impossible to draw any conclusion about a definite zone within the investigated part of the shelf (Abukir-Damietta) where this species prefers to live (Fig. 56 "c"). However, it can be stated that during all seasons the specimens of *P. semisulcatus* were found only at a depth up to 50 preferring the range of 20-40 m, where over 50 per cent it was concentrated at all times.

During the year only big specimens (females averaging 175-225 mm, males 170-190 mm) were found in the trawl catches (Appendix 7 "c"). During all seasons of the year (except for September) females prevailed accounting for 71 per cent of the total quantity in January of 1971, 62 per cent — in April and 55 per cent — in August. In September their percentage was very small, 21 per cent (Table 18). During the year the maturity of females of *P. semisulcatus* was at a high level ; about half of their quantity was in pre-spawning phases all the year round (4th or 5th phase of maturity, Fig. 59).

Comparing the spawing seasons, the time of mass accumulation and the growth of the three species described above, one can observe apparent similarity of their life cycles which is characterized by the fact that their phases are extended in time very much. Beginning from April the off-shore accumulations begin to be replenished by young specimens which gradually, going off the shore, mature in the sea and join spawn groups. As a result of this the spawning takes place during the whole summer. This fact was also found to be true for the species inhabiting the Red Sea (Al-Kholy and El-Hawary, 1970). The long spawning period results in low concentration of off-shore accumulations.

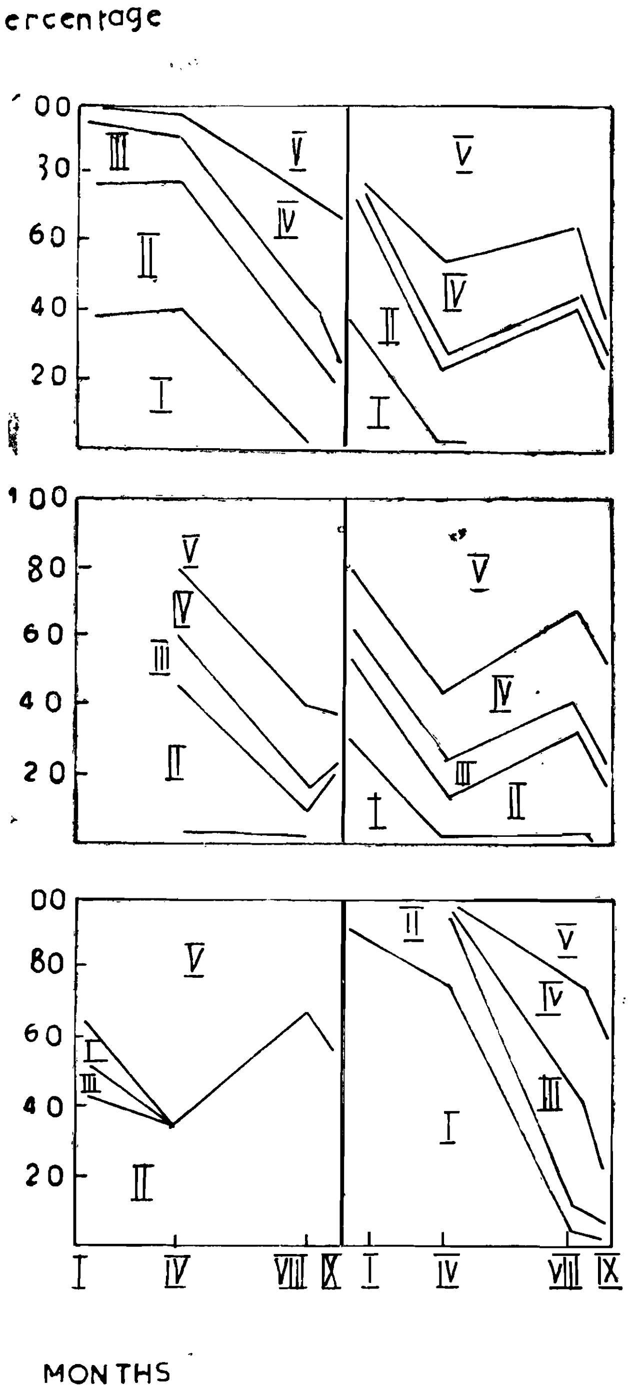


Fig. 59. Maturity of the female shrimps during 1971 on the Mediterranean shelf of Egypt.
Left : *M. monoceros* ; *M. stebbingi* : *P. semisulcatus* :
Right : *P. trisulcatus*, *P. japonicus*, *T. curvirostris*.

(*d*) *M. monoceros* :

The number of *M. monoceros* in 1970-1971 was considerably higher than that of *P. semisulcatus*. During all seasons one trawling hour produced, in the average, 50-100 specimens. In Spetember, in Borullos region a small accumulation area was found yielding up to 200 specimens. However, smaller sizes of this species (See explanation below) predetermined small yields : only in September the average yield reached 0.564 kg, in all other seasons they were at a level of 0.2-0.3 kg (Appendix 6 d & Fig. 61 d).

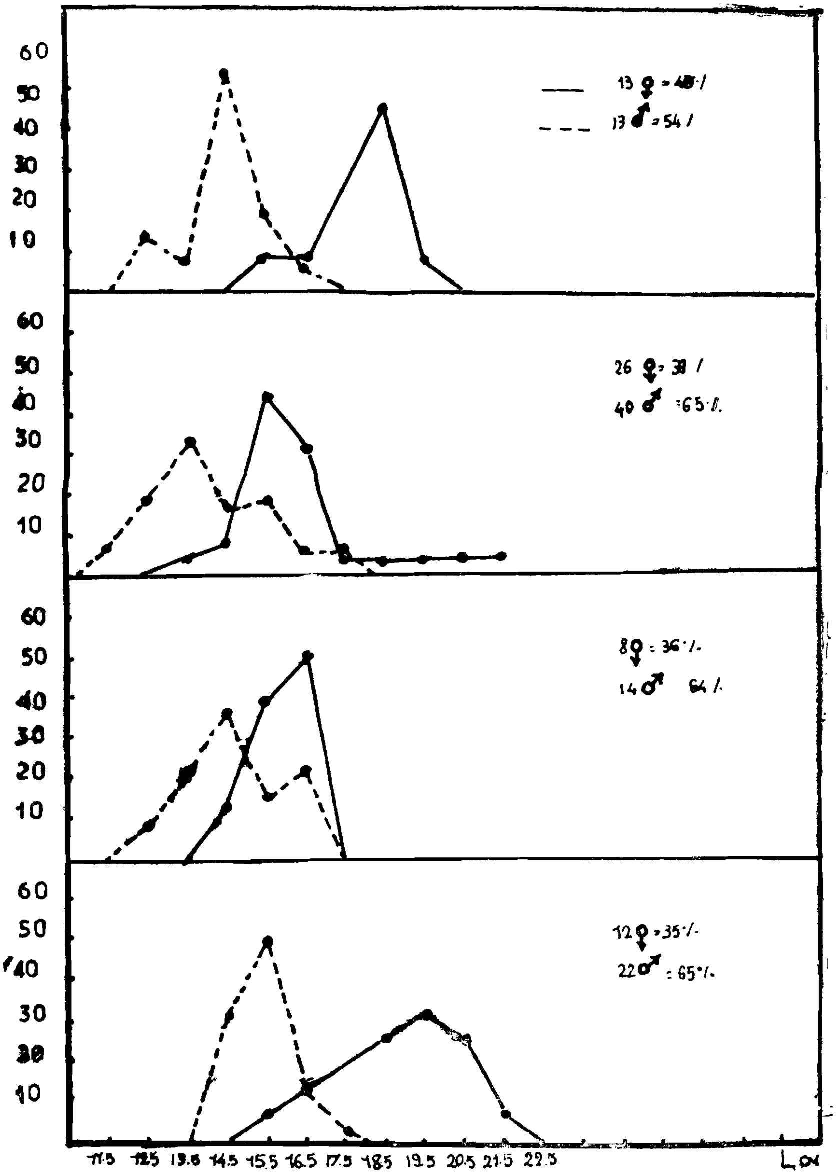


FIG. 60. Size composition of *P. trisulcatus* during 1971 on the Mediterranean shelf of Egypt.

Distribution of *M. monoceros* in the investigated part of the shelf (Abukir-Dammietta) was quite uniform during all seasons, its concentration being somewhat higher in the eastern areas (Fig. 61).

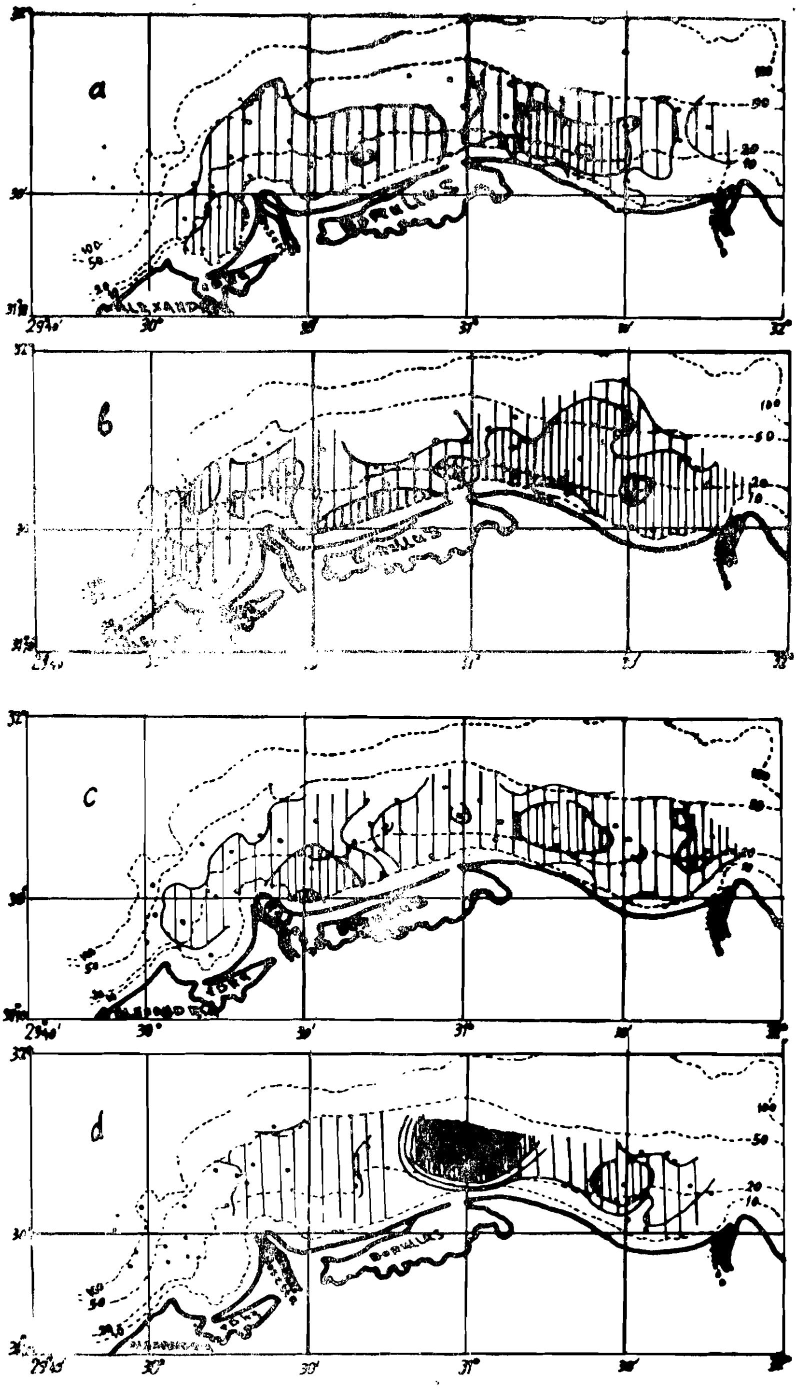


FIG. 61.—Geographical distribution of *M. monoceros* in January (a), April (b), August (c) of 1971, and in September, 1970 (d). Legend : same as in Fig. 57.

The main mass of this shrimp species was found at a depth of 10-50 m (Table 18) all the year round. In January some specimens of this species moved into the open sea due to which 62.3 per cent of caught specimens was found at a depth of 30-40 m.

This size series of *M. monoceros* was represented by one-peak group for all months, with the exception of January (Appndix 7 d, Fig. 62 d). In January of 1971 the average sizes were minimal, being 114 mm for females and 105 mm for males.

Presence in winter of small specimens and the two-peak curve of the size series (which is particularly marked for females) suggests that the mature part of the *M. monoceros* population is replenished in winter. In spring of 1971 the size series remained invariable. By autumn of 1970 and 1971 the length of specimens increased somewhat. The average size of males being 112-113 mm and that of females-132 mm. The maximum autumn size of *M. monoceros* corresponded to the maximum maturity of females : in August and September the number of females in the 4th and 5th phases reached its maximum while females in the 1st phase were practically absent (Fig. 59).

Thus, the main spawning time of this species took place in early spring which ensured winter replenishment of the population. During spawning and in winter the sex correlation was characterized by prevalence of males (Table 18).

The spawning of this species is more intensive and shorter than that of the penaeaids. This predetermines rapid and steady reproduction. The time period between the appearance of young specimens (winter) and the spawning (autumn) is quite long which suggests that the growth and maturity take place mainly in the open sea. As a result of this, accumulations of this species are stable all the year round having the maximum concentrations in autumn.

(*ε*) *M. stebbingi.*

In 1970 the number of *M. stebbingi* changed seasonally very much (Appendix 6e, Fig. 56e). It was minimal in January : the trawls caught single specimens amounting to not more than 0.05 kg per trawling hour and averaging 0.024 kg. In April the number of this species increased : in most of the area occupied by them a catch yield amounted to 100 specimens and over per trawling hour (Fig. 63). This ensured an average yield equal to 0.289 kg per trawling hour. In some cases it reached 0.600 kg (April 1971, Borullos region, depth of 10-25 m). During autumn months of both

The main mass of this shrimp species was found at a depth of 10-50 m (Table 18) all the year round. In January some specimens of this species moved into the open sea due to which 62.3 per cent of caught specimens was found at a depth of 30-40 m.

This size series of *M. monoceros* was represented by one-peak group for all months, with the exception of January (Appndix 7 d, Fig. 62 d). In January of 1971 the average sizes were minimal, being 114 mm for females and 105 mm for males.

Presence in winter of small specimens and the two-peak curve of the size series (which is particularly marked for females) suggests that the mature part of the *M. monoceros* population is replenished in winter. In spring of 1971 the size series remained invariable. By autumn of 1970 and 1971 the length of specimens increased somewhat. The average size of males being 112-113 mm and that of females-132 mm. The maximum autumn size of *M. monoceros* corresponded to the maximum maturity of females : in August and September the number of females in the 4th and 5th phases reached its maximum while females in the 1st phase were practically absent (Fig. 59).

Thus, the main spawning time of this species took place in early spring which ensured winter replenishment of the population. During spawning and in winter the sex correlation was characterized by prevalence of males (Table 18).

The spawning of this species is more intensive and shorter than that of the penaeaids. This predetermines rapid and steady reproduction. The time period between the appearance of young specimens (winter) and the spawning (autumn) is quite long which suggests that the growth and maturity take place mainly in the open sea. As a result of this, accumulations of this species are stable all the year round having the maximum concentrations in autumn.

(ε) *M. stebbingi.*

In 1970 the number of *M. stebbingi* changed seasonally very much (Appendix 6e, Fig. 56e). It was minimal in January : the trawls caught single specimens amounting to not more than 0.05 kg per trawling hour and averaging 0.024 kg. In April the number of this species increased : in most of the area occupied by them a catch yield amounted to 100 specimens and over per trawling hour (Fig. 63). This ensured an average yield equal to 0.289 kg per trawling hour. In some cases it reached 0.600 kg (April 1971, Borullos region, depth of 10-25 m). During autumn months of both

1970 and 1971 the density of accumulations dropped to 50 specimens per trawling hour. However, in the narrow coastal area, small "patches" were found which produced more than 100 specimens per trawling hour. Such a "patch" was found in September of 1970 at the Borullos Lake water outlet. It was also observed in August of 1971. During this season the average catch yields in the whole water body were within the range of 0.333-0.127kg.

Location of *M. stebbingi* accumulation was very characteristic in all seasons : 60-80 per cent of the total mass was concentrated in the shallow zone having a depth up to 20 m (Fig. 63). Only in January when the *M. stebbingi* population was extremely small and dispersed at a depth of up to 50 m.

During the investigation period the distribution and yields of *M. stebbingi* were comparatively uniform in all region however, the largest accumulations were found at the minimal depth in Borullos region.

During spring and autumn, the sizes of the mature *M. stebbingi* did not differ : the average length of females was 100-105 mm, that of males 79-83 mm (Fig. 64, & Appendix 7 "e"). In winter (when their population was minimal) bigger specimens were found, some females reaching 120 mm and some males-90 mm. During this season the maturity of females was maximal (Fig. 59) and they constituted the basic mass (Table 18). Judging from the size composition, maturity of the females and their distribution (off-shore migration) it can be said that the spawning of this species took place in winter. Insignificant changes in the size of mature specimens in the off-shore accumulations and sharp seasonal variations of their population suggests that the sea phase of the *M. stebbingi* life cycle is not long. It seems that for the most of them it is limited by spring months. As no specimens of the 1st maturity phase were not practically found in the open sea one can suppose that maturity of the specimens occurs during their long stay near the shore while increase in the population during spring testifies clearly marked seasonal migrations. As a result of this the sea accumulations of this species are short but massive.

(f) T. curvirostris :

In 1970-1971 it was the most numerous species on a level with *M. stebbingi* and *P. longirostris*. In spring and autumn of 1971 its population ensured catch yields up to 200 specimens per trawling hour and in winter of 1971-not less than 50 specimens. Accordingly, the seasonal yield variations of *T. curvirostris* were within the limits of 0.075-0.252 kg (Appendix 6 f & Fig. 56 f).

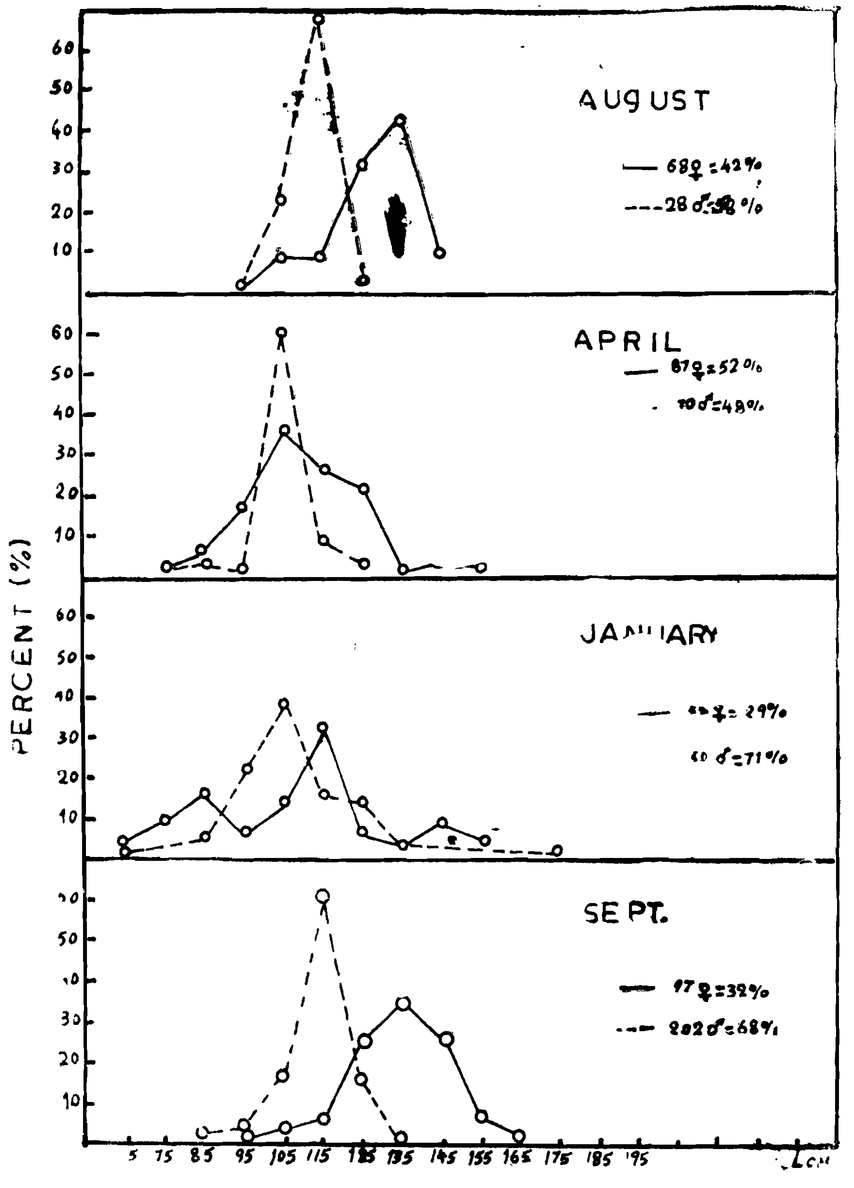


FIG. 62. Size composition of *M. monoceros* in January (a), April (b), August (c) of 1971, and in September, 1970 (d), on the Mediterranean shelf of Egypt.

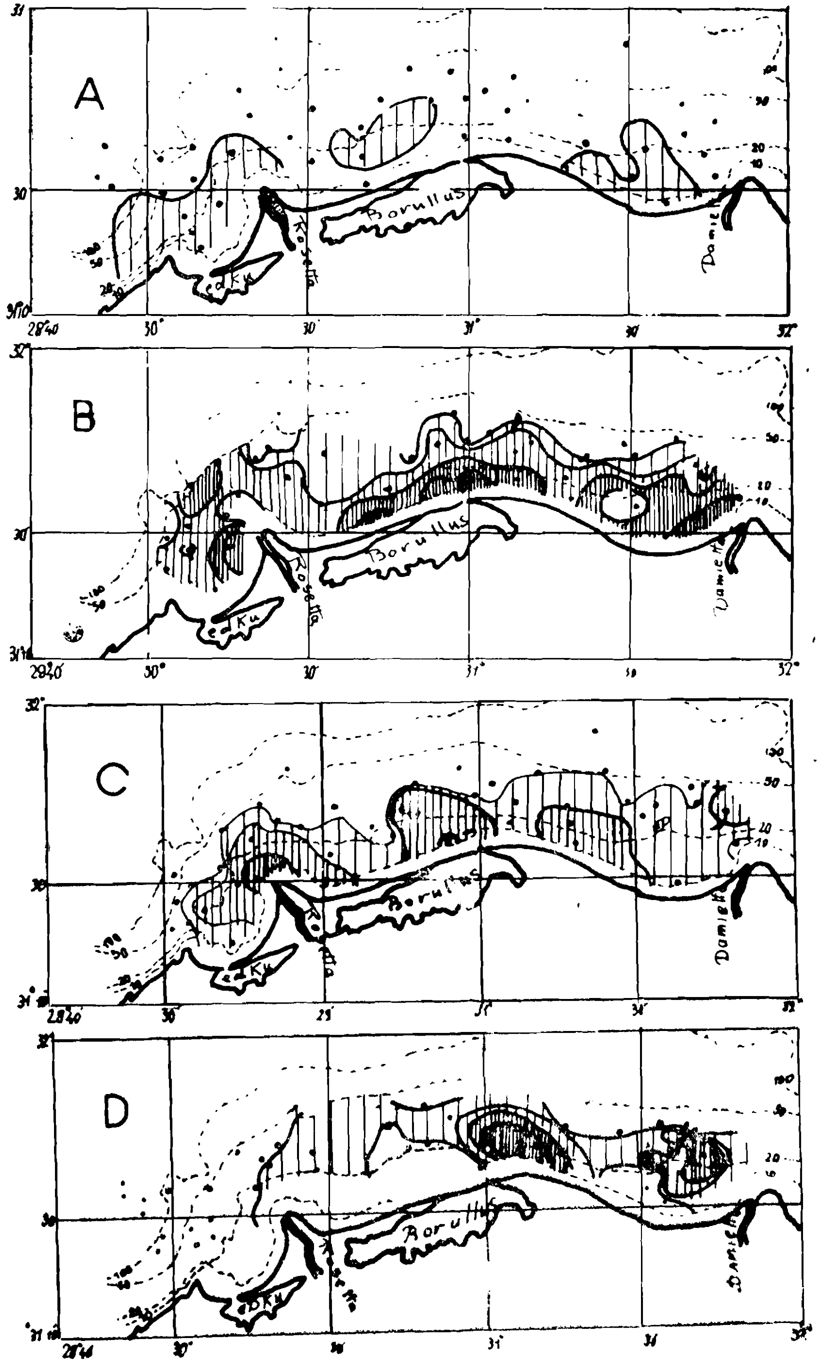


FIG. 63. Geographical distribution of *M. stebbingi* in January (a), April (b), August (c) of 1971, and in September, (d). 1970.

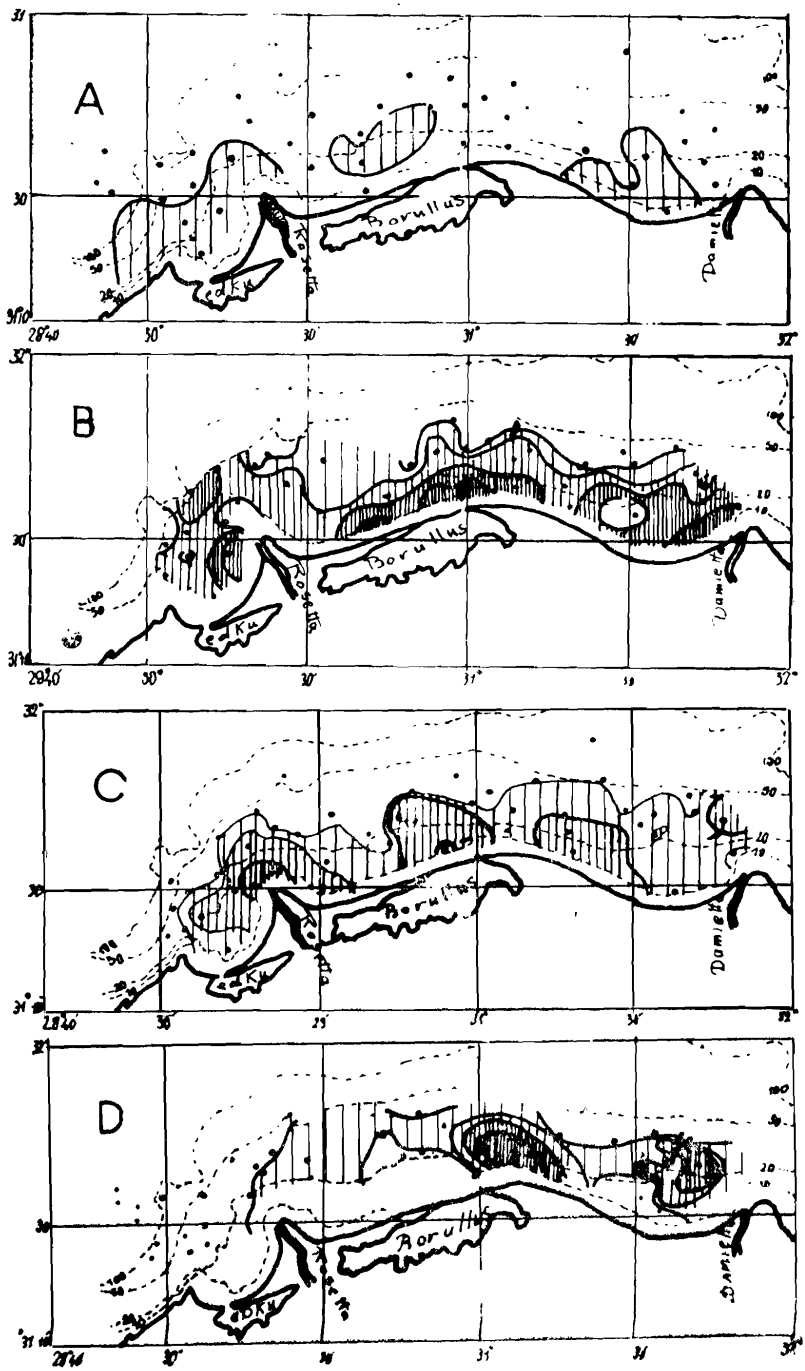


Fig. 63. Geographical distribution of *M. stebbingi* in January (a), April (b), August (c) of 1971, and in September, (d). 1970.

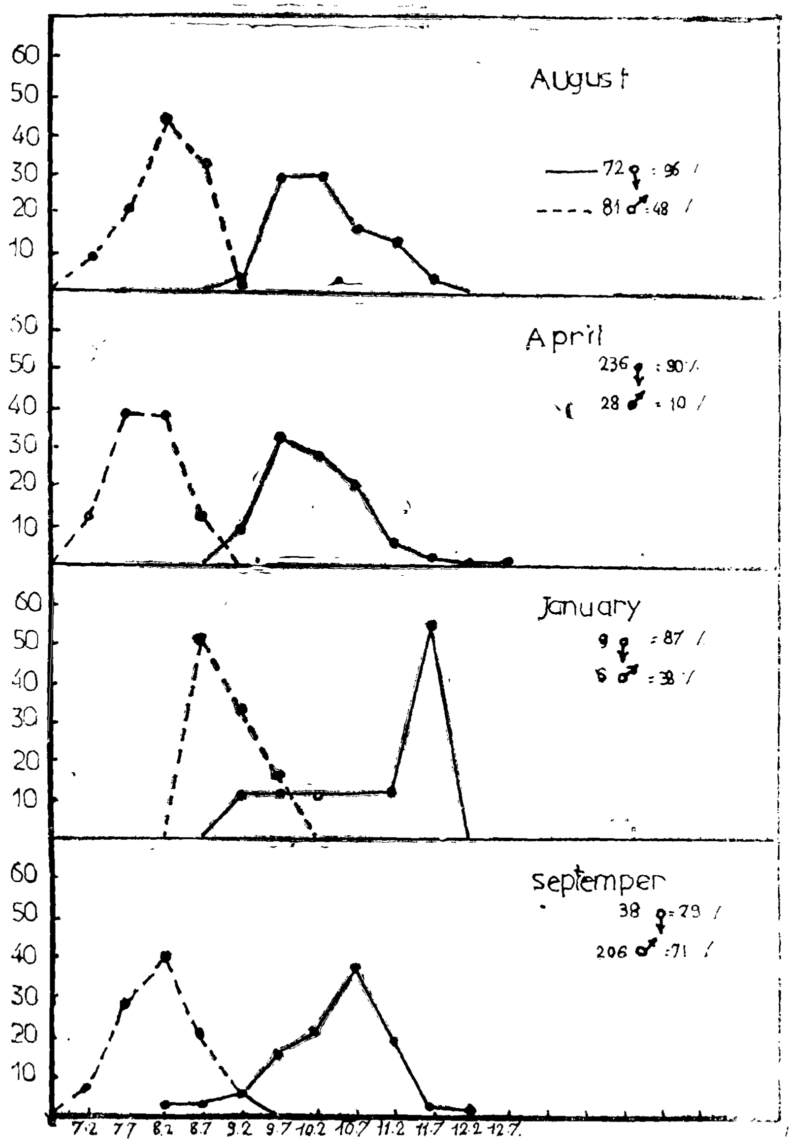


FIG. 64. Size composition of *M. stebbingi* in April (a), August (b), September (c) of 1971 on Egypt's Mediterranean shelf.

The main bulk of these shrimps inhabited depths of 20-40 m although in September of 1971 almost half of them inhabited smaller depth. Distribution of *T. curvirostris* in the investigated water body was irregular ; during all seasones rich zones were found practically in all areas at a depth of about 20 m (Fig. 65). The biggest accumulation were found in Borullos and Rosetta regions in April of 1971.

During 1971 the sizes of the mature part of the *T. curvirostris* population were very different (Fig. 66, & Appendix 7f). Within the period of January-August the length of females increased from 59 to 77 mm. and that of males from 56 to 83 mm. The antispawn phase of females was observed only in autumn (Fig. 59). Even in January, immature specimens of the first maturity phase prevailed. It seems that the spawning period was short and ended in autumn. The data of the autumn, 1971, (Fig. 66) shows that during this period the mature part of the population was replenished by young specimens. In 1970 their dimensions differed sharply from the old size group not exceeding 30-50 mm. However, in autumn of 1971 apparent replenishment was not observed.

Judging from the absence of considerable seasonal variations, the population size and notable difference between the seasonal sizes, one can say that the specimens of this species stay at sea during the most part of the year and do not migrate in mass towards the shore when the season changes. Therefore, their accumulations are stable.

(*g*) *P. longirostris*

Accumulations of this species were located only in the western part of the area under investigation. They were concentrated on the continental slope in Abukir and Rosetta regions and were not found at a depth *under 40 m. On these regions the population size of P. longirostris was quite* considerable. Although the specimens size was small (See below) the catch *yield reached 0.8 kg (Appendix 6 g).*

In 1970-1971 the size composition of *P. longirostris* was very complicated (Fig. 67). During all seasons females were represnted by a very wide range of 40-110 mm which was subdivided into several size groups. The seasonal changes of the size composition were clearly marked. This points to the absence of age (seasonal) migrations, the permanency of habitation of the main mass and the multi-age composition. All the year round males prevailed accounting, on the average, for 60 per cent and reaching in September as much as 93.6 per cent (Table 18).

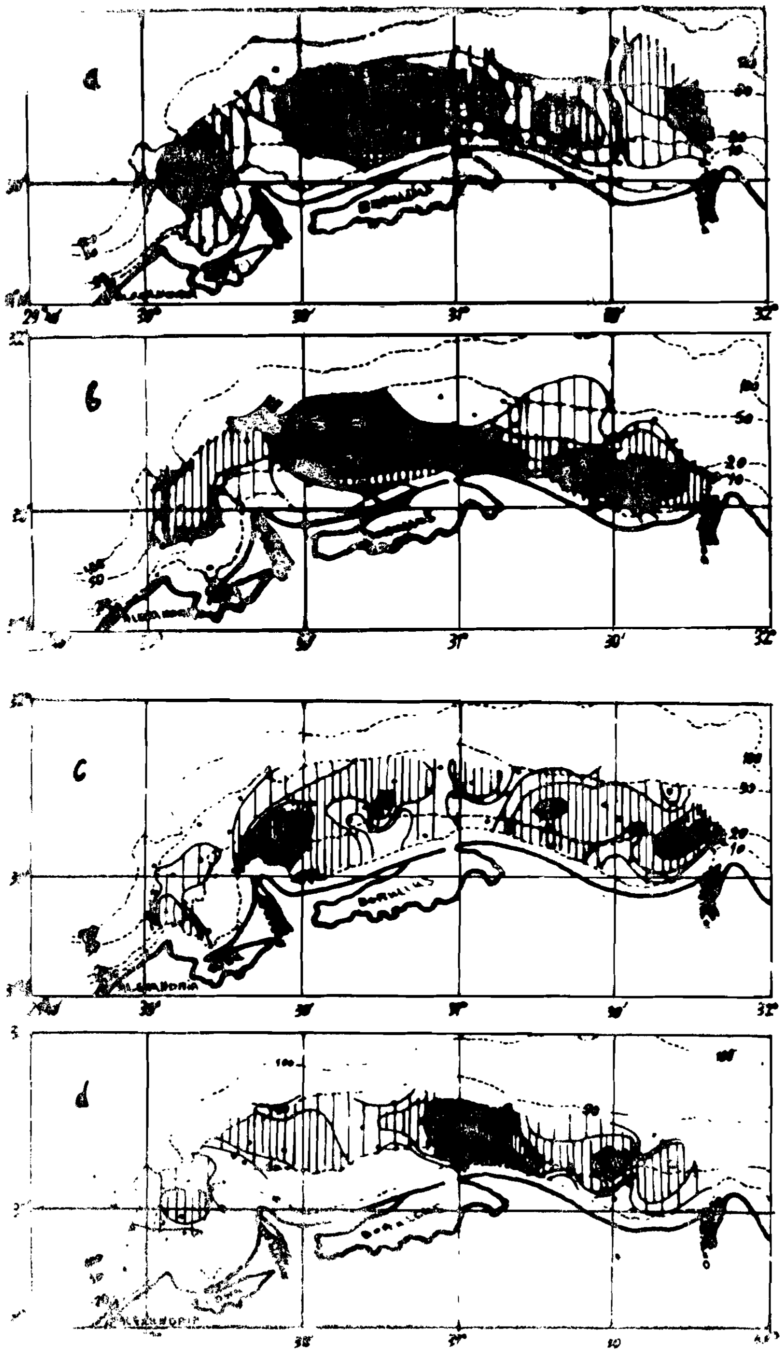


FIG. 65. Geographical distribution of *T. curvirostris* in January (a), April (b), August (c) of 1971, and in September, (d). 1970

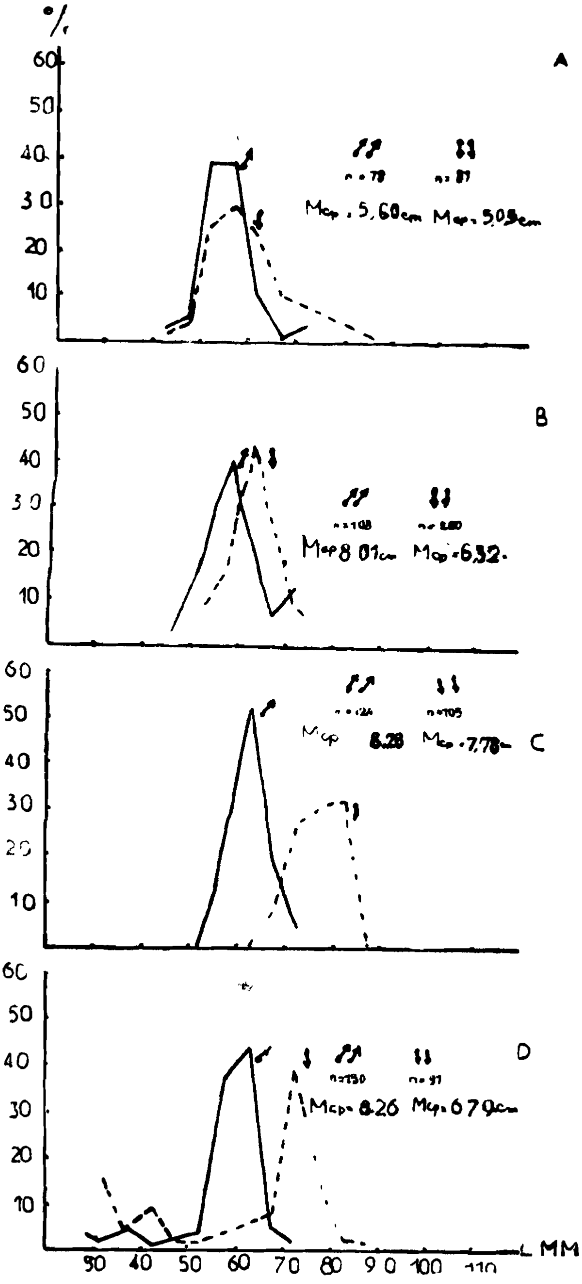


Fig. 66.—Size composition of *T. curvirostris* in January (a), April (b), August (c) of 1971, and in September, 1970 (d) on Egypt's Mediterranean shelf.

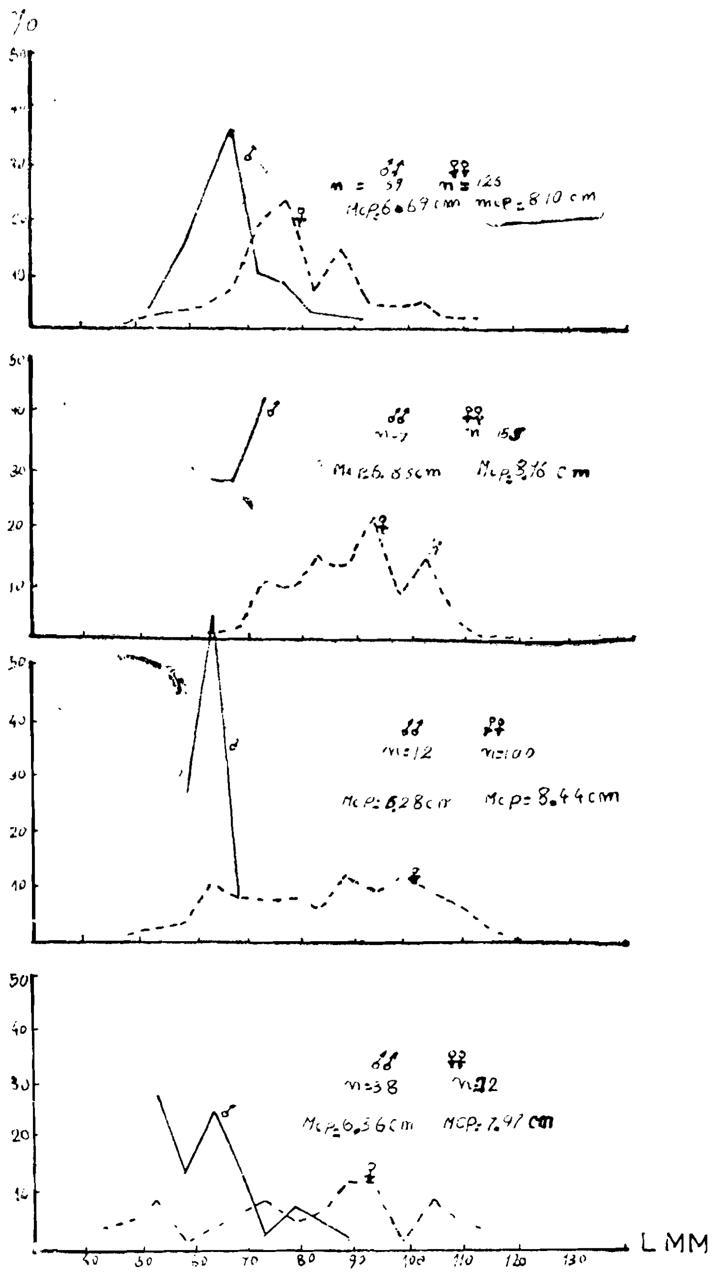


FIG. 67.—Size composition of *P. longirostris* in January (a), April (b), August (c) of 1971 and in September, 1970 (d) on Egypt's Mediterranean shelf.

Maturity of the females was very variable ; however by autumn the importance of specimens being in the 5th maturity phase increased (Fig. 59). Thus, it can be said that in 1971 the spawning time of this species was long having a certain intensification in autumn.

To sum up, it can be said that habitation of this species is not related to the shallow coastal areas. The long spawning time and permanency of the habitation place ensures stability of its concentrations.

ANALYSIS OF THE SHRIMP CATCH SIZE IN DIFFERENT SEASONS OF 1970-1971

We may judge on the commercial importance of shrimps in 1970-1971 by the results of the trawlings made during the expedition. As it was said above, the trawlings were carried out in the shelf zone located between Abukir Bay and Damietta Cape. The results of 186 trawlings were analysed and in all seasons the number of trawlings was approximately equal (Table 19).

a) In spring the shrimp catch size was comparatively high in all regions. (Fig. 68 & Table 19). The highest catch size was obtained in Borullos region · 16.057 kg (35 per cent of the total yield). In other regions in spring the catch size was approximately the same amounting to 9-10 kg each.

In summer the catch yield was considerably lower in all regions. The highest catch size was obtained in the Rosetta and Abukir regions amounting to 14 kg (57 per cent of total yield), the lowest-in Borullos region amounting to 4.482 kg (18 per cent).

In autumn the catch yield considerably differed from region to region. In Borullos it reached 8.753 kg (54 per cent) and in the Rosetta region - only 1. 574 kg (9 per cent).

In winter the catch yield was similar in all regions amounting to about 4 kg.

Summing up, we can say that according to the data of R/V "Ichthyolog" the total annual catch yield was maximum in Borullos region where it amounted to 32.8 kg. In all other regions it was almost similar : Damietta—23.7 kg, Abukir—24.4 kg and Rosetta—22 kg.

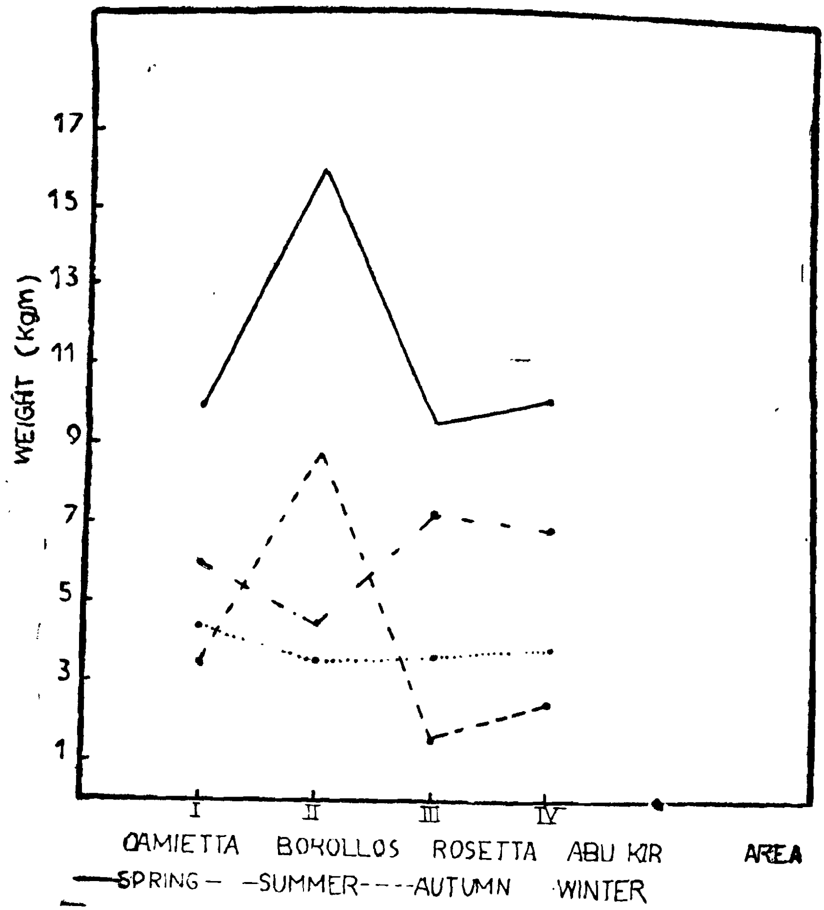


Fig. 68. Total shrimp catches during 1970-1971 in the various localities of Egypt's Mediterranean shelf.

b) Comparatively high shrimp catch yield in spring (April 1971) is explained by greater catch of many species (Fig. 69 a & Appendix 8a) in comparison with other seasons. In the investigated regions the catch size was as follows;

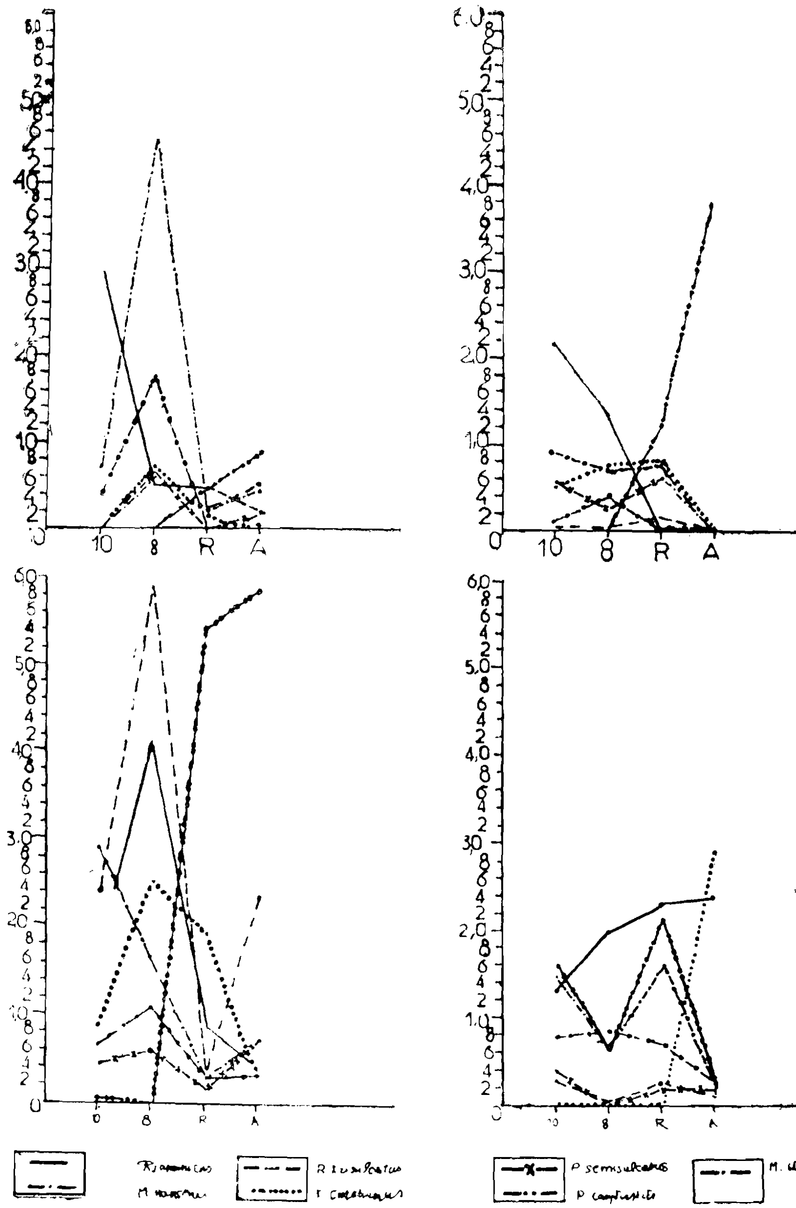


FIG. 69. Seasonal shrimp catches by species during 1970–71 on Egypt's Mediterranean shelf (based on the "Ichthyolog" survey).

Damietta :

M. monoceros — 5.958 kg

M. stebbingi — 2.439 kg

P. japonicus — 2.2449 kg

Borullos :

M. stebbingi — 5.929 kg.

P. japonicus — 4.118 kg.

T. curvirostris — 2.597 kg.

Rosetta and Abukir :

P. longirostris - 5.438 kg and 5.872 kg respectively.

As *M. stebbingi, P. japonicus* and *T. curvirostris* gave the biggest yields, therefore the maximum catch size was in Borullos region.

In summer (August 1971) when the shrimp yield was low every where (Fig. 69b. Appendix 8b) the catch size was determined by catches of *P. japonicus* amounting to about 2 kg in all regions and by catches of *P. longtrostris* (2.127 kg) in the Rosetta and Abukir regions. Due to this in these regions bigger yields were obtained.

In autumn (September 1970) only one species - *M. monoceros* Fig. 69c & Appendix 8c) had the greatest importance. Its maximum catch (4.450 kg out of 5.889 kg) was obtained only in one region i.e. Borullos. *P. Japonicus* rates second with regard to the catch size. Its maximum catches (2.299 kg) were obtained in the Damietta region being almost equal in all other regions (within the range of 0.5-0.8 kg).

In winter tow species prevailing : *P. japonicus* in Damietta and Borullos regions (2.197 and 1.343 kg respectively) ; *P. longirostris* in the Rosetta and Abukir regions (1.195 kg and 3.798 kg respectively). Since these species were caught in different regions their yield differred slightly from one region to another.

Damietta :

M. monoceros — 5.958 kg

M. stebbingi — 2.439 kg

P. japonicus — 2.2449 kg

Borullos :

M. stebbingi — 5.929 kg.

P. japonicus — 4.118 kg.

T. curvirostris — 2.597 kg.

Rosetta and Abukir :

P. longirostris - 5.438 kg and 5.872 kg respectively.

As *M. stebbingi, P. japonicus* and *T. curvirostris* gave the biggest yields, therefore the maximum catch size was in Borullos region.

In summer (August 1971) when the shrimp yield was low every where (Fig. 69b. Appendix 8b) the catch size was determined by catches of *P. japonicus* amounting to about 2 kg in all regions and by catches of *P. longtrostris* (2.127 kg) in the Rosetta and Abukir regions. Due to this in these regions bigger yields were obtained.

In autumn (September 1970) only one species - *M. monoceros* Fig. 69c & Appendix 8c) had the greatest importance. Its maximum catch (4.450 kg out of 5.889 kg) was obtained only in one region i.e. Borullos. *P. Japonicus* rates second with regard to the catch size. Its maximum catches (2.299 kg) were obtained in the Damietta region being almost equal in all other regions (within the range of 0.5-0.8 kg).

In winter tow species prevailing : *P. japonicus* in Damietta and Borullos regions (2.197 and 1.343 kg respectively) ; *P. longirostris* in the Rosetta and Abukir regions (1.195 kg and 3.798 kg respectively). Since these species were caught in different regions their yield differed slightly from one region to another.

As a result of the seasonal variation of different shrimp species, the composition of the total catch during the year was as follows : in the western part of the shelf within the area of Abukir and Rosetta, *P. longirostris* accounted for the greatest percentage in all seasons (except for summer) ; in summer it was *P. japonicus* while in the east - *P. japoincus* and *M. stebbingi* (Fig. 70).

c) Distribution of the fishing areas on the investigated shelf was different in different seansons (Fig. 71). In winter extensive areas with yields of 1-3 kg per trawling hour were located at a depth over 20 m in the western part of the shelf-Abukir and Rosetta - in places where *P. longirostris* inhabits. In spring they increased considerably on account of replenishment by off-shore accumulation of *metapaeneides* and *paeneides* being located both on the western part of the shelf and in the narrow coastel area of Borullos and Damietta.

The autumn months, when spawn accumulations of *M. monoceros* and paeneides are formed, were characterized by rapid change of the fishery situation. In August 1970 the best areas were found in the Rosetta zone while in eptember 1970- in SBorullos zone.

Unlike 1966 when accumulations of greatest concentration were found at the minimal investigated depth, in 1971 (spring excluded) the main shrimp accumulations were found at deeper places. As before, the lowest yields were registered in winter increasing in April and again decreasing in autumn.

d) The comparative importance of different regions and the general trend of the annual catch size can be determined by means of analysis af average yields per trawling hour (Fig. 72).

During the whole expedition period (1970-1971) the total yield per trawling hour did not exceed 5 kg, the average one bing 0.4-0.9 kg (Table 21). In some regions the catch yields were almost equal having the same tendency to increase slightly in April and August and to decrease in autumn-winter (Fig 72). Increase in the catch size in September was observed only in Borullos. Similar phenomenon was observed also in 1966 but in that year the autumn variations of the yields were greater and were observed not only near Lake Borullos but also near Lake Edku (Abukir zone).

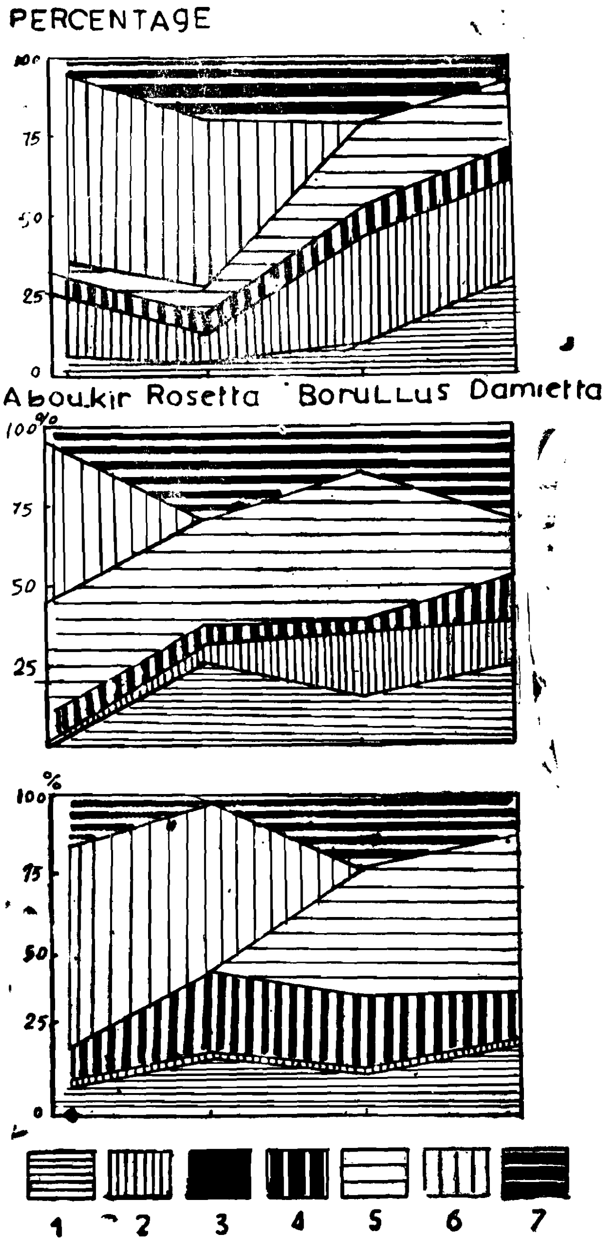


FIG. 70.—Species composition of the shrimp catches in April (top), September, and January, 1971 (based on the Ichthyolog survey). Legend :

1.—*M. monoceros* ;
2.—*M. stebbingi* ;
3.—*P. trisulcatus* ;
4.—*P. semisulcatus* ;
5.—*P. japonicus* ;
6.—*P. longirostris* ;
7.—*T. curvirostris*.

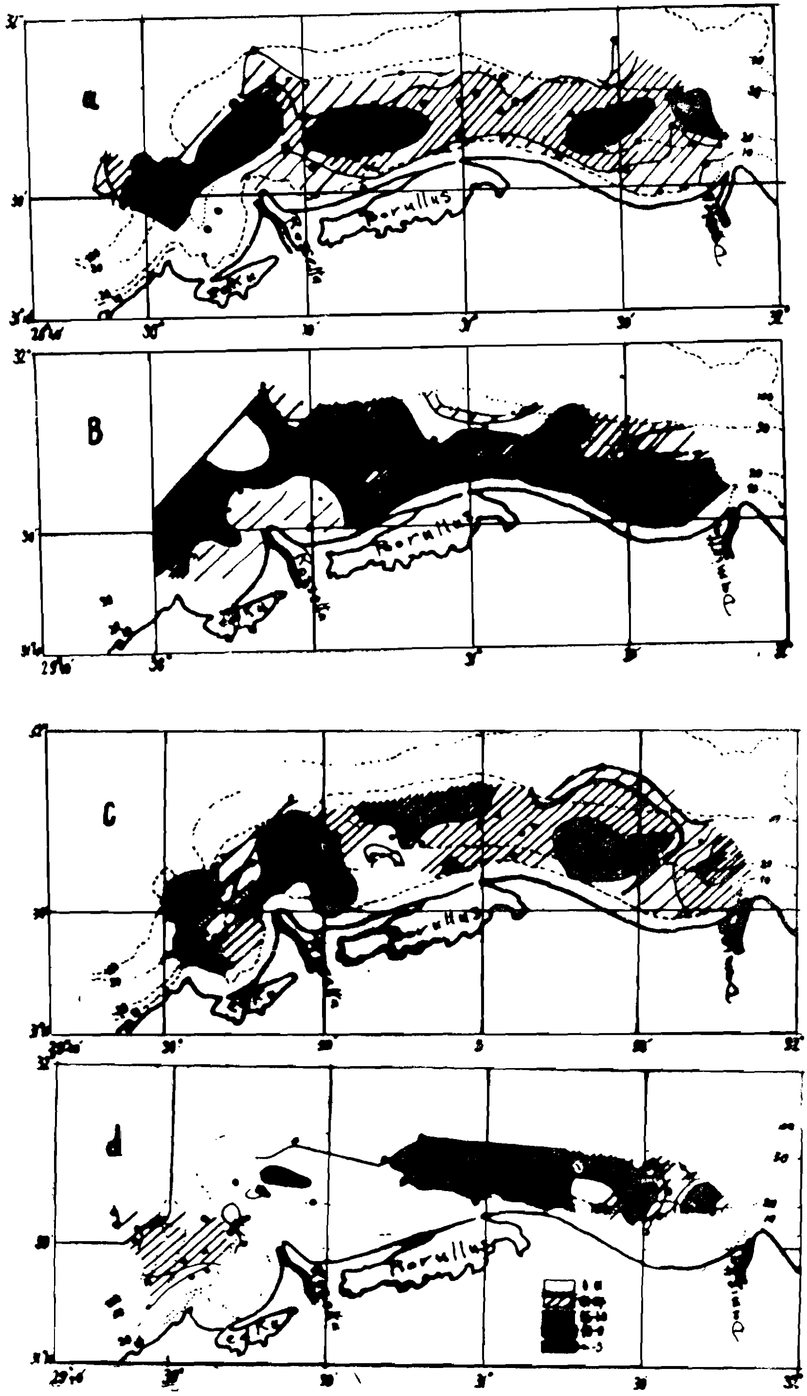


FIG. 71.—Location of the grounds yielding different catches per hour of trawling in January (a), April (b), August (c) of 1971, and in September, 1970 (d).

Legend (in kg per hr of trawling) : 0–0.1 ; 0.1–0.5 ; 0.5–1.0 ; 1.0–3.0 ; above 3.0.

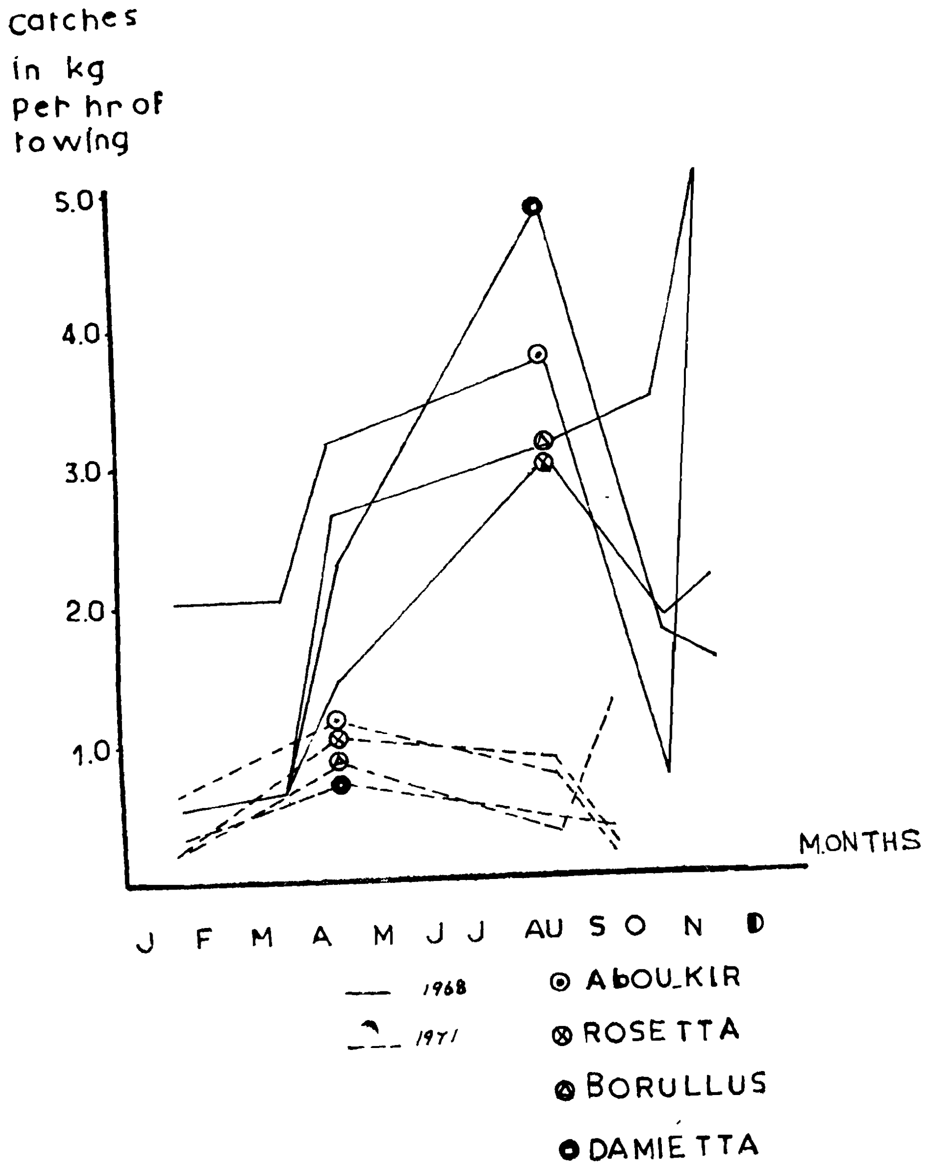


FIG. 72. Average shrimp catches (kg/hr) in 1966 and 1971 on Egypt's Mediterranean shelf (based an the data from the first and second expeditions o Ichthyolog).

Table 20.—TOTAL SHRIMP CATCH YIELD OBTAINED DURING FOUR CRUISES OF R/V "ICHTHYOLOG"
(*September* 1970-*August* 1971)

region	Autumn			Winter			Spring			Summer		
	Total catch	%	Number of trawlings	Total catch	%	Number of trawlings	Total catch	%	Number of trawlings	Total catch	%	Number of trawlings
Damietta	3.466	21	13	4.355	28	16	9 946	22	14	5 946	25	15
Borullos	8.753	54	3	3.487	23	15	16.057	35	19	4.482	18	14
Rosetta	1.574	9	8	3.586	24	15	9.552	21	10	7.267	29	10
Abukir	2.453	16	14	3.825	25	2	10.248	22	9	6.885	28	9
Total:	16.246	100	38	15.253	100	48	45.803	100	52	24.580	100	48

Table 21.- AVERAGE SHRIMP YIELD IN 1970-1971
(*in Kg / trwling hour.*)

Area	January	April	August	September
Abukir	0.6±0.3	1.1±0.4	0.7±0.3	0.14±0.06
Rosetta	0.2±0 1	1.0±0.5	0.8±0.3	0.2 ±0.1
Borullos	0.2±0.1	0.8±0.2	0.3±0.1	1.2±0.6
Damietta	0.3±0 1	0.7±0.2	0.4±0.1	0 3±0 1

± Statistical error of an average yield

During the year the best shrimp yields were obtained at different depths : in August, September and January the biggest yields corresponded to the depth range of 30-40 0m. in April - 10-30 m (Fig. 73). The April yields are explained by the highest concentration of *M. stebbingi* predominantly at small depths.

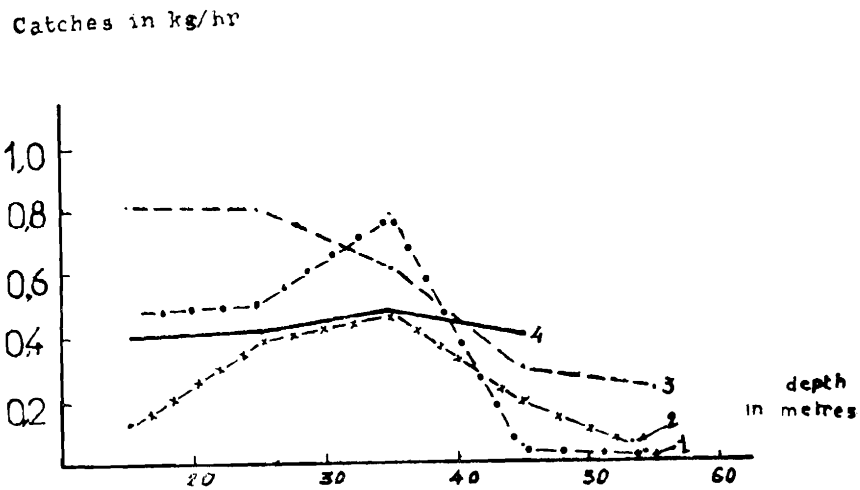


FIG. 73. Relationship between shrimp catches and the depth of water for the different seasons of the year of investigation.

1—August, 1971 : 3—April, 1971 ;
2—January, 1971 ; 4—September, 1970 ;

As compared with the data of 1966 (Drobysheva, 1970) shrimp yields decreased in all places. The season of maximum yield also Changed : in 1966 it fell within August while in 1971-April. In Borullos region where the most dense shrimp accumulations were always observed its yields decreased in spring from 2.6 kg/trawling hour in 1966 to 0.8 kg / trawling hour in 1971 and in autumn from 3 to 0.3 kg/trawling hour.

On the basis of the shrimp population investigation carried out in the shelf zone of the Abukir-Damietta area during 1970-1971, the shrimp reserves within the depth range of 10-50 m was calculated (Table 22). The maximum figure was obtained in April and it gives an idea about the level of reserves.

In 1971 reserves were at a level of 4.177 cent that is less than that of spring 1966 (10.488 cent) and greater than in spring of the same year (14.525 cent).

The total shrimp reserves on the investigated area are represented by 33.1 per cent of metapenaeids, 33.5 per cent of penaeids and 33.4 per cent of *Trachypenaeus* and *Parapenaeus.* Taking into account the life period of different shrimp species and their reproduction, the permissible catch yield can be not more than 2-2,5 thousand cent.

TABLE 22.—SHRIMP RESERVES IN THE SHELF AREA ABUKIR-DAMIETTA IN 1971.

(*In cents.*)

Region	Fishing area within the depth range of 10–50 m (sq.miles)	Number possible trawlings	Shrimp reserves (taking into account the catchability factor).			
			January	April	August	September
Abukir	244	15250	488	896.25	526.13	106.75
Borullos	346	21625	248.68	854.20	346.00	1297.5
Damietta	520	32500	503.75	1140.75	635.75	471.25
Rosetta	420	26250	301.88	1312.50	1063.13	315.0
Total:	1530	95625	1542.31	4203.70	2571.01	2190.50