BULL. INST. OCEAN. & FISH., A.R.E. VOL. 7, 1977

SOME ASPECTS ON THE HYDROGRAPHY, PHYSICO-CHEMICAL CHARACTERISTICS AND FISHERIES OF LAKE MANAZALA

BY

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ABSTRACT

Some chemical characteristics of lake Manzala water as derived from three different sources are traced. Variable features of the waters in the South-eastern, North-eastern, Western and the navigational route are identified and helped to consider them as belonging to modified water types in the corresponding regions. The variations of chlorosity, inorganic phosphate and reactive silicate are highly significant. Clear relation is observed between the progressive dilution by the drain waters and the concentration of nutrient salts in the lake water. The productivity of the lake is shown to attain high magnitude.

INTRODUCTION

Lake Manzala contributed about 50% of the total annual fish catch of the country during the most recent years, while the mullet fishery of the lake gave 60—80% of the annual country yield of mullets during 1962—1968. Despite the importance of the lake to the country's fisheries, only few detailed studies were carried out on hydrology, chemistry and fisheries of the lake (Paget, 1922; Montasir, 1937; El-Maghraby *et alii* 1963; El-Wakeel & Wahby, 1970 a & b; El-Wakeel *et alii*, 1970; Wahby *et alii*, 1972).

The present work deals with the fisheries of the lake and its mullet yield. The hydrochemical characteristics are given in order to study their effect on the survival, distribution and abundance of mullet at various stages of their life throught the year.

DESCRIPTION OF THE LAKE

Lake Manzala is a brackish and very shallow lake with a mean depth of one metre, i.e., light penetrates to the bottom of the lake and the whole volume of water is productive. It is located in northeastern extremity of the Nile Delta. It is bounded on the east by the Suez Canal and on the west by Damietta branch of the Nile and is separated from the Mediterranean Sea by a narrow sandy fringe at the north. It is the largest of the Delta lakes covering an area of approximately 300,000 feddans (=311400 acres). The morphometry of the lake is given by El-Wakeel & Wahby (1970a) as follows :

Maximum length	64.5 km.	Length of shore line	293 km.
Maximum width	49.0 km.	Area of the lake	1275 km^2.

The bottom of the lake is covered with mud and sand while accumulations of lamellibranch "cardium" predominate in certain areas. Numerous islets of varying areas are scattered in the lake. They may be sandy, clayey or formed of shelly sands and clays (El-Wakeel & Wahby, 1970a). Occasionally, submerged barriers known as "gasat" or "asat" extend from an islet to another. The height of water covering the barrier (gas or ass) differs from one barrier to another and differs, for the same barrier, from one place to another where in some places the barrier may emerge. Both islets and barriers divide the lake into several basins where the water depth reaches a maximum of about 120 cm. Each basin is known as "Bahr" (Fig.1). During the fishery survey which started from 1961, it was possible to locate the barriers; the location and names of the barriers are given for the first time as shown in Fig.1 and Table 1.

The main lake-Mediterranean Sea connection lies about 10 kilometres west of Port Said, at El-Gameel. It is a narrow opening called "Ashtoum or Boughaz El-Gameel". There are other connections with the sea, but are indirect via Damietta Nile Branch, north to the town Faraskour through three canals : Inaniya, Ratama and Souffara. To the south of Port Said, at Qabuti, there is a connection between the lake and Suez Canal. This connection is provided with a lock and is of prime importance for navigation. At the eastern side of the lock, i.e., towards the Suez Canal, there is one movable gate which opens by the pressure of water from the Suez Canal. The connection is thus of no benefit to lake fishery until the construction of several wider gates as well as a canal from the side gates to the navigation canal in the lake before the lock.

The lake's principal influent are drains emptying into the southern shores; some flow into the southeastern portion (Ginka region) and these are Bahr El-Baqar, Bahr Hadus and Bahr Ramsis drains. The drains flowing into the western portion of the lake are El-Serow drain and a canal from Faraskour pump station. Small quantities of freshwater drain into the lake through Inaniya canal.

Fig. (1). Lake Manzala and the location of the barriers

Table (1) The submerged barriers at Lake Manzala.
(Serially numbered in the same order as in Fig.1).

No.	Name of barrier	Location: Islets at the end of the barrier		Basins separated by the barrier	
1	Ghassûla	El-Gami'(North end of Sidi Bedeir)	Ghassula	Zeheiri (El-Gameel)	Hiddadiya (Bain El-barrain)
2	Fahham	Midawwara	Tarhet Elsira	El-Fameel	Elkuwar
3	Gazâyir	a)-Danis b)-Kassab	Kassâb Kurmullus	Kassab Kassab	Qantara Kurmullus
4	Basharûsh	North end of Nigayila	Elwet Elbasharush	Kantara (Bashtir)	Lagan
5	Khayal	a)-Lagan b)-Khaiya	Khaiya Abu Misallam	Kurmullus	Lagan
6	Deshish	South end of Nigayila	Ras Elhamam (Kunayissa)	Bashtir	Lagan
7	Merass	'Ain	Samara qibliyia	Lagan	'Ain
8	Asan	Lawindi	Meida	Timsah	Diba
9	Meida	Meida	Nâ'is	Timsah	Hamra
10	Kurum	Deibet Sebâiyikha	Kurûm	Hamra	Miheigar
11	Qat'	Samara	Meghwar	Miheigar	Dishdy
12	Mala'ib	Bughdadi	Sheikha Fatma	Diba	Baraghita
13	Hagar	Ghazalat	Abu'Omar	Baraghita	Hamra
14	Abu 'Omar	Abu 'Omar	Mahluq (Dakhlet Elnuqt)	Hamra	Shirk
15	Nuqt or Wazza	Sham'a	Dakhlet Elnuqt (Limaiyissa)	Hamra	Abwat
16	Qarqawisha	Farsha	Qarqawisha	Baraghita	Elturqah
17	Sagati (Raqiq)	Qarqawisha	Haddadiya	Baraghita	Elturqah
18	Ma'amil	Bahr Elshirk	Ma'amil	Elturqah	Zarqa
19	Rukn Elgharak	Rukn Elgharak	Nearly 2/3 distance towards Garawat	Zarqa	Bein Elgasat
20	Taffashin	'Alawi Elriqqa	Nearly 2/3 distance towards Damrû	Bein Elgasat	Digu
12	Maqtu	Maqtu'	Lazqa	Zarqa	Diyamu
22	Sirga	Hatab	Sirga		

PHYSICO-CHEMICAL CHARACTERISTICS OF THE LAKE

Investigated areas, the Methods & Material

Wahby *et alii,* (1972) studied the hydrography and chemistry of the lake during 1967, i.e., as the studies on the biology and fisheries of Mugilidae were carried out, so, use of their original material and methods is made, together with additional data concerning chlorosity and nutrient contents of samples collected from experimental fishing areas throught the present investigation . The system adopted by El-Wakeel & Wahby (1970a) and by Wahby *et alii,* (1972) in which the lake is divided into three regions, is taken in consideration. It was found necessary for the present study to divide their northeastern part of the lake into three regions which are characterised by different hydrographic and chemical conditions that affect the mullet distribution. The following are the regions studied (Fig. 2) :

1 — Gameel (northern) region receiving mainly sea water through the lake-sea connection.

2 — Middle region, situated in the central part of the lake bordered from the north and south by Gameel and southern regions, respectively.

3 — Southern region, situated in the central part of the lake west to Ginka region.

Both the middle and southern regions are affected by both sea and fresh water depending uopn the level of the lake.

4 — The near western region which is affected by drainage water that drains into the western part of the lake and also by sea water that enters the lake through Souffara and Ratama canals in addition to small quantities of freshwater permitted through Inaniya canal.

5 — Ginka (southeastern) region which receives nearly fresh water from large drains especially Bahr El-Baqar and Hadus drains.

Results

Results of the analysis are shown in Fig. 3 and a brief account of these results is given below. Other details are discussed by Wahby *et alii,* (1972).

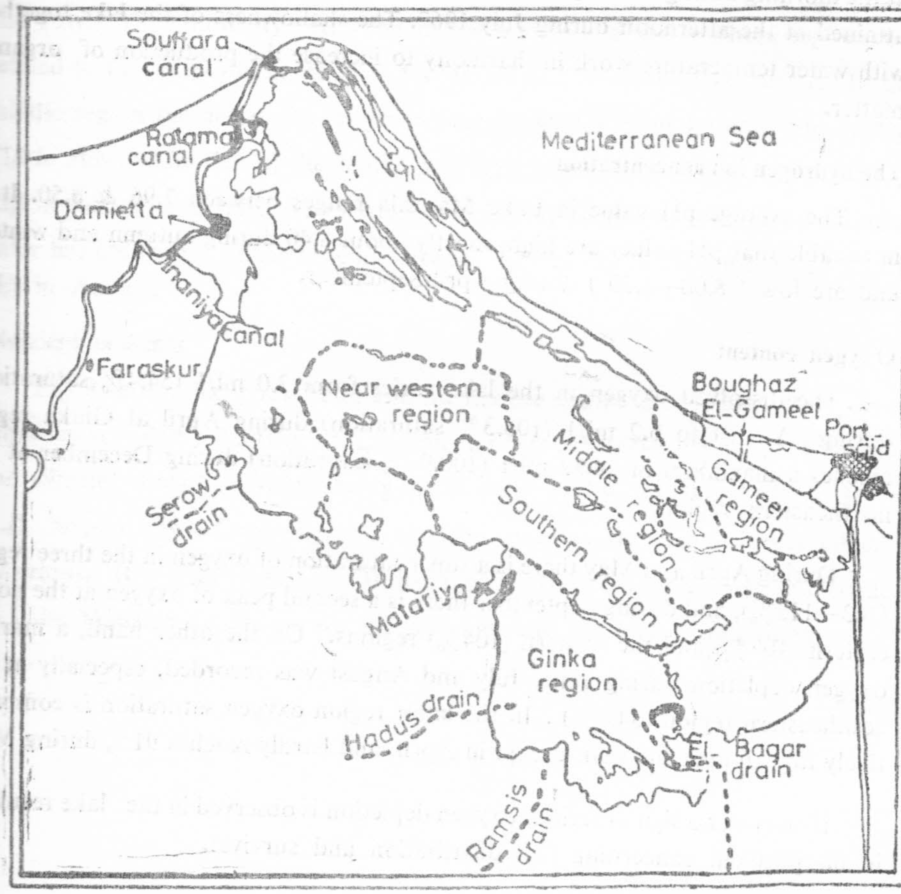

Fig. (2) A map of Lake Manzala showing the regions studied.

Temperature

In lake Manzala the average minimum water temperature is 11.3°C recorded at the morning during January 1967 and the maximum water temperature is 31.1 °C attained at the afternoon during July 1967. The shallowness of the lake together with water temperature work in harmony to increase the production of organic matter.

The hydrogen ion concentration

The average pH value in Lake Manzala ranges between 7.96 & 8.50. It is noticeable that pH values are high, mostly about 8.40 during autumn and winter, and are low (8.00—8.20) during April-September.

Oxygen content

The dissolved oxygen in the lake varies from 3.0 ml/l (54.4% saturation) during August to 6.2 ml/l (105.3% saturation) during April at Ginka region, reaches a maximum of 6.82 ml/l (100.9 % saturation) during December at the northeastern region.

During April and May there is a super saturation of oxygen in the three regions (103—113%), and during September there is a second peak of oxygen at the northeastern (107%) and the western (104%) regions. On the other hand, a marked oxygen depletion during June, July and August was recorded, especially at the southeastern region (54.7%) . In the latter region oxygen saturation is comparatively low all over the year, except in April, and hardly reaches 91% during May.

However, no sign of serious oxygen depletion is observed in the lake resulting in no problem concerning fish distribution and survival.

Chloride content

The average chlorosity variations at the five regions of the lake are shown in Fig. 3. The noticeable high chlorosity recorded during February is due to the fact that the drain water discharge is minimised to a large extent during this month as a result of complete limitation of fresh water supply for irrigation in all Delta canals.

The southern region which receives large quantities of fresh water from drains at the southern side of the lake has the lowest chlorosity values ranging between 0.71 g. Cl/l in January and 1.94 g. Cl/l in June. From the northeastern part, Gameel region has the highest chlorosity values because it is affected by the lake-sea connection. Its chlorosity ranges between 3.90 & 15.30 g. Cl/1 in October and July. The chlorosity variations in the middle and the southern regions are related to the water discharge from the drains and invasion of sea water. In the middle region the chlorosity ranges between 2.44 g. Cl/l in January and 8.14 g. Cl/l in July, while that of the central southern region varies from 1.07 to 3.89 g. Cl/l in January and July. The western region which is mainly affected by drainage water has chlorosity values ranging between 1.29 g. Cl/l in November and 3.12 g. Cl/l in August.

Nutrient contents

Fig. 3 shows that phosphates and nitrites are comparatively low. Phosphates range between 0.08—2.50 µg. at./l,and nitrites between 0.00—2.00 ug. at./l. Nitrates and silicates show high values being of the range 0.34 — 24.50 and 61 — 383 ug. at./1, respectively . Generally, the nutrient contents are high in areas affected by drains. It is clear from Fig. (3) that high nutrient concentrations ar recorded in Lake Manzala during spring and autumn. and are low during summer.

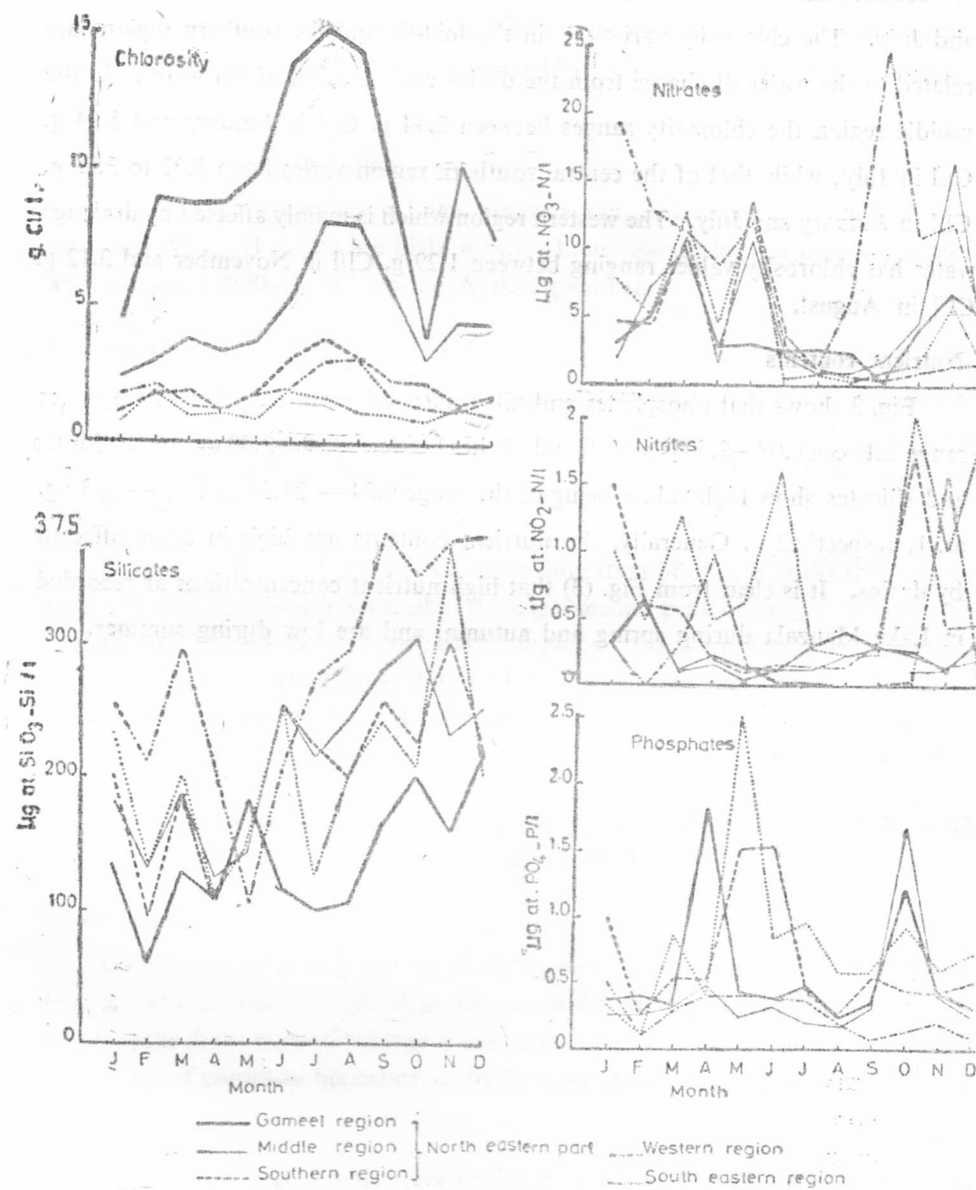

Fig. (3). Monthly variations of chlorosity, silicates, nitrates, nitrites, and phosphates in surface waters of Lake Manzala

LAKE FISHERIES

Lake fish production and its importance

Lake Manzala is one of the major sources of fish production in Egypt. Estimates based on the fisheries statistics of the country for the years 1962—1968 show an increasing percentage of the lake production relative to the annual fish yield of Egypt (Table 2). It varies between about 20% in 1962 and 53% in 1967. However, it is to be noticed that the production of inland waters, lagoons and Lake Borollos is not included in the Reports of Statistics of Fisheries in A.R.E. The same should be taken into consideration when studying the importance of Lake Manzala for mullet fishery (p. 44 & Table 5). Moreover, it was found necessary for comparison to add to the total country fish production during 1962—1964 (Table2), 2000 metric tons which is nearly the utmost annual production of Lake Quarun during 1965—1968.

Table 2 — The percentage of fish production of Lake Manzala and the other sources in Egypt during 1962—1968.

Year	Total** discharged Nile water x 10^9 m^3	Total country fish production (tons)	% of fish production: Red & Mediterranean Seas	% of fish production: Lake Manzala	% of fish production: Other lakes	Total production of Lake Manzala (tons)	Discharged+ water into Lake Manzala x 10^9 m^3
1962	42.9	94159	65.7	20.2	13.0	19396	5.63
1963	42.9	91740	62.6	21.2	16.2	19410	5.96
1964	52.9	81233	54.3	26.9	18.8	21862	6.06
1965	18.0	72543	54.4	26.3	19.1	19186	6.11
1966	traces	62461	43.4	40.2	16.4	25129	6.28
1967	traces	51161	36.2	52.9	10.9	26649	5.81
1968	—	52049	44.1	47.6	8.3	24757	5.20

** (Data provided by the Delta Barrage Directorate, Ministry of Public Works, "after Halim *et alii*, 1967").

\+ (Data provided by both El-Sharkiya and Eastern of Dakahliya Irrigation Directorates, Ministry of Public Works).

It can be seen from Table (2) that the peroentage of fish production of the three sources (Lake Manzala, other Egyptian Lakes and the Mediterranean and Red Seas) in 1965 are closely the same as those of 1964. These two years can be looked at as "transitional years" in fish production. It is noticed that since 1966 the percentage of the production of the lake has doubled as compared to previous years. Corresponding to this sharp increase in the percentage of Lake Manzala production during 1966, there is a sharp decrease in the production percentage of the other lakes and the Red and Mediterranean Seas.

b. Species composition of the Lake

From chlorosity studies given above it is expected that fish of fresh water origin will be found at the southern basins of the lake while marine fish will be found at Gameel basin.

The order of abundance of the various species found in the commercial catches was similar over the seven years (1962—1968). *Tilapia* species including *T. zillii* Gerv., *T. nilotica* L. and *T. galilaea* Art., ranked first and made up about 57—83% by weight of the recorded catches (Table 3). The mullets *Liza ramada*, *Mugil cephalus* and *L. saliens* ranked second (8—17%). During each year marine fish ranked third in abundance being 3.6—10.6% by weight and the fresh water fish other than *Tilapia* spp. ranged from 3.2 to 5% of the total commercial catch.

Among the other fresh water fishes living in the lake are, *Clarias lazera* C. & V., *Bagrus bayad* Forsk., and *Lates niloticus* C.& V. The marine fishes found in the lake include *Morone labrax* Blg., *Morone punctata* Blg., *Sciaena aquila* Cuv. and *Çhrysophrys aurata* C.& V. *Penaeus* spp. had their maximum percentage of 6.6 of the total annual lake production in 1963, then it decreased; while *Callinectes sapidus* Rath. (blue crab) increased from 0.9% of the total catch of the lake in 1962 to 9.8 % in 1964, then it decreased to 0.14 % in 1968.

However, though the absolute values of the contribution of Lake Manzala to the Egyptian fisheries is high, yet a close analysis of the length distribution of the endemic *Tilapia* species (56—80 % of the lake production) shows that 60% of the samples are fishes of total length not exceeding 10 cm which are not of economic value, while fishes of total length more than 12 cm constitute only 15% (Table 4.).

Table (3) — Percentage species composition of Lake Manzala fishes during 1962 — 1968.

Year	Total catch (metric tons)	*Tilapia* species	other fresh water fish	*Anguilla vulgaris*	*Mullet* species	Other marine fish	*Penaeus* spp.	Blue crab	*M. cephalus*	*L. ramada*	*L. saliens*
1962	19396	70.1	5.00	0.7	12.9	6.6	3.9	0.9	3.9	8.8	0.1
1963	19410	65.1	4.9	0.9	13.6	6.0	6.6	2.9	3.8	9.5	0.3
1964	21862	58.0	4.6	0.9	15.6	6.4	4.6	9.8	2.5	12.9	0.3
1965	19186	56.5	4.5	0.8	17.1	10.6	2.9	7.6	2.0	14.4	0.7
1966	25129	69.2	4.4	0.4	9.1	7.9	2.4	6.6	1.3	7.7	0.1
1967	26649	75.5	4.0	0.4	11.6	5.6	1.2	1.7	1.0	10.6	0.01
1968	24757	83.2	3.24	0.6	8.3	3.6	0.9	0.1	0.9	7.3	0.06

Other freshwater fish : *Clarias lazera, Bagrus bayad, Lates niloticus, etc.*

Other marine fish : *Morone labrax, Morone punctata, Sciaena aquila, Chrysophrys aurata, etc.*

Table (4) — Cumulative percentage by number of *Tilapia* species at each centimetre length interval during late winter and summer (1968).

Length interval (cm.)	Cumulative percentege		
	February - March	June—August	Total
6	2.2	—	1.o
7	10.0	1.4	5.1
8	23.8	12.0	17.2
9	42.6	31.3	36.2
10	59.8	60.6	60.2
11	71.8	79.4	76.1
12	79.5	89.0	84.9
Total number	30600	40453	71053
Total weight (Kg.)	2700	2840	5540

MULLET FISHERY IN THE LAKE

a) Importance of Lake Manzala for mullet fishery

Mugil cephalus and *L. ramada* are fished from the Delta lakes, Lake Quarun, lagoons, Mediterranean and Red Seas; *L. saliens* from Lake Manzala and Quarun; *M. seheli(L. carinata* (Ehrenberg in Cuv. & Val.) (Trawavas & Ingham, 1972) only fished from the Red Sea and Suez Canal. Table (5) shows that the total mullet catch of Lake Manzala during 1962—1968 consititutes more than 60% of the country's yield of mullet reaching 80% during 1967.

The major constituent of total mullet in the lake is *Liza ramada* while *Mugil cephalus* decreases prograssively during 1962 —1968 and the maximum percentage of *L. saliens* is 0.7 % of lake fish production during 1965 (Table 3). Fishery status of *L. saliens* in other localities is obscure since it is mostly taken as *L. ramada* (El-Zarka & Koura, 1965; Report of Statistics of Fisheries in U.A.R., 1966; El-Zarka, 1968) and hence its comparison is non-satisfactory.

Table 5 — Total catch and percentage composition of mullet species in Egyptian waters and Lake Manzala during 1962—1968

Year	Mullet yield				*M. cephalus* yield			*L. ramada* yield			*L. salians* yield		
	Country		Manzala		Country	Manzala		Country	Manzala		Country	Manzala	
	Metric tons	% of total fish catch	Metric tons	% of country yield	Metric tons	Metric tons	% of country yield	Metric tons	Metric tons	% of country yield	Metric tons	Metric tons	% of country yield
1962	3965.6	4.21	2492.7	62.9	1030.4	764.8	74.2	2457.1	1704.5	69.4	23.4	23.4	100.0
1963	4401.1	4.85	2627.6	60.1	1087.6	733.1	67.4	2701.2	1846.9	68.4	121.9	47.6	39.0
1964	5196.2	6.61	3419.9	66.2	815.6	537.3	65.9	3766.3	2814.1	74.7	68.5	68.5	100.0
1965	5136.8	7.08	3265.2	63.6	795.9	374.9	47.1	3796.3	2762.1	72.8	128.2	128.2	100.0
1966	3779.5	6.05	2295.8	60.7	603.7	336.5	55.7	2720.3	1946.9	71.6	12.4	12.4	100.0
1967	3965.6	7.50	3070.0	80.5	480.7	256.0	53.3	3265.6	2810.4	86.1	36.0	36.0	100.0
1968	2675.7	5.14	2049.6	76.6	440.7	225.2	51.1	2188.7	1808.0	82.6	17.5	16.4	94.7

q) Fishing Methods :

Different types of nets are used at the lake, e.g. three layer gill nets (trammel nets), cast nets, siene nets, set nets and wire traps. In addition, local fishing methods that catch mullets together with other fish are adopted. A brief description of he common four local fishing methods is given below.

1 — "Shebak El-Habl" Method :

This method is used during summer and autumn and fishes all kind of fish in the lake. It involves a group of boats not less in number than 4 and not more than 8 boats. Each boat with about 8 fishermen, contributes nearly 90 metres of the total net length which varies between 350 and 600 metres. The width of the net varies from 5 to 6 metres and the mesh size is about 13 mm bar length.

The way in which this method is undertaken is shown in Fig. 4(a—e) and can be summarised as follows :

The net is coiled in two equal portions each on a fishing boat. The top edge of the net is kept about 150 cm above the water by fishermen with sticks, the lower edge is kept down with about 250 to 350 cm of the width spread on the bottom of the fishing place. The net at first takes the form of a curve (Fig. 4,b) with the middle of the net fastened with a pole beside a third large boat (Fig. 4,a). While the two ends of the net are gradually brought together by means of two boats (Fig. 4,c), men and boys on the other boats-standing at a considerable distance from the net (about 2 km)-rush into water towards the net making a noise and beating of the water in order to drive the fish which move ahead (Fig.4,b). When the two ends are closed (Fig. 4,d), fishermen holding up the net meet in the middle line and keep the two edges close together preventing fish from jumping out (F g 4,e). The net is then hauled onto the boat stationed at the middle of the net.

2 — Tawanis Method

This method fishes only *Morone labrax* and *Mugil cephalus* and sometimes *L. ramada* and always fish caught are of large size. This kind of net is used during aummre and early autumn.

The number of boats used are 13 and the net is about 450 metres long, 2 metres width and 15—20 mm mesh size. The net is fixed, at equal intervals, to sticks of dried reed stalks.

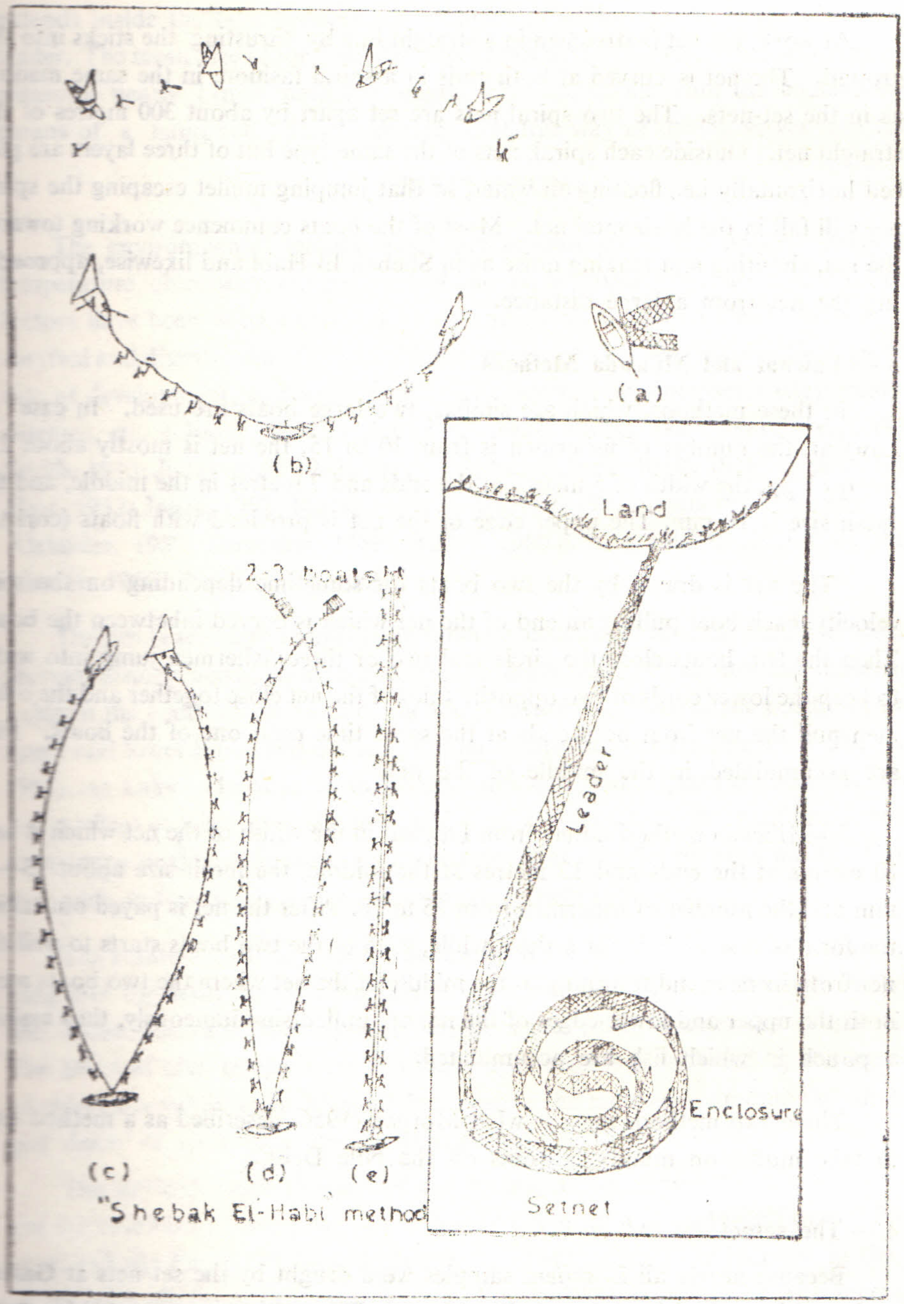

Fig.(4) Diagramatic Sketchs for Shebak El-Habi and the Setnet method:

At work, the net is stretched in a straight line by thrusting the sticks into the ground. The net is curved at both ends in a spiral fashion, in the same manner as in the set-nets. The two spiral nets are set apart by about 300 metres of the straight net. Outside each spiral, nets of the same type but of three layers are placed horizontally i.e., floating on water, so that jumping mullet escaping the spiral net will fall in the horizontal net. Most of the boats commence working towards the net, shouting and making noise as in Shebak El-Habl and likewise, approaching the net from a large distance.

3 — Lawwat and Mi'awda Methods

In these methods, which are similar, two large boats are used. In case of Lawwat, the number of fishermen is from 10 to 15, the net is mostly about 250 metres long, the width of 5 metres at the ends and 7 metres in the middle, and the mesh size is 18 mm. The upper edge of the net is provided with floats (cork).

The net is drawn by the two boats for sometime depending on the wind velocity, each boat pulling an end of the net which is curved inbetween the boats. Then the two boats close the circle and two or three fishermen jump into water to keep the lower cords of two opposite sides of the net close together and the other men pull the net from both ends at the same time onto one of the boats. Fish are accumulated in the middle of the net.

El-Mi'awda method differs from Lawwat in the width of the net which is here 10 metres at the ends and 12 metres at the middle, the mesh size about 13—14 mm and the number of fishermen from 15 to 20. After the net is payed out taking the form of a semicircle for a short while, each of the two boats starts to pull the net from its near end returning to the middle of the net where the two boats meet. Both the upper and lower edges of the net are pulled simultaneously, thus making a pouch in which fish are accumulated.

These two methods may be what Morgan (1956) described as a method used to take mullet on muddy bottoms off the Nile Delta.

4 — The setnet

Because nearly all *L. saliens* samples were caught by the set nets at Gameel region, this method is represented in Fig. (4). The netting is supported by stakes of phragmites. The leader extends from the shore towards the interior of the lake with different lengths and it ends by one or two enclosures. Sometimes the leader extends inside the lake between two couples of enclosures on both sides of the leader. The mesh size of the leader is larger than that of the enclosure which mostly measures nearly 14mm mesh bar length. Fish are taken from the enclosure by means of a hand net. Thus it is clear that this way of fishing serves as a trap.

DISCUSSION

The environmental factors which are considered in the present study are temperature, chlorosity, oxygen content and the hydrogen ion concentration. These factors have been shown experimentally and by deduction to affect not only the survival and distribution of fish at different stages of their life, but also their growth, rate of development, activity, activation of reproductive processes, susceptibility to diseases, etc. (Juday, 1924; Juday *et alii*, 1924; Philip, 1927; Wattenberg, 1933; Smith, 1940; Juday *et al*, 1943; Fry, 1947; Smith,1952; Brett, 1956; Collins, 1952; Hart, 1952; Jones, 1952; Black, 1957; Doudoroff, 1957; Hrebert & Mann, 1958, Alabaster, 1959; Hourston, 1959; Bishai, 1960 a, b, c, 1961 a, 1962, a, b, 1965; Blaxter, 1960; Parry, 1960; etc.).

The fish reaction to temperature differs according to species, size, age, season, thermal history, acclimation temperature, salinity, state of fish, etc. The differences being in the width of the band of the temperature tolerated, in the position of the upper and lower limits and in the optimum temperature (Rounsefell & Everhart, 1953). At Lake Manzala no thermal stratification takes place on account of the direct effect of wind on a shallow body of water which is manifested by the continuous mixing of water. This accelerates heat transfer between air and water and adds to the dissolution of atmospheric oxygen in water.

The chlorosity of the lake is affected by three major factors: freshwater draining into the lake, the introduction of sea water into the lake through the lake-sea connection, and high summer temperature which accelerates evaporation. The effect of high temperature causing evaporation is manifestad by the increase of chlorosity values from May till July despite the increasing amounts of discharged drain of freshwater during this period.

The noticed small changes of the hydrogen-ion concentrations in the lake are the resultant of many factors including chemical and biological ones. Juday *et al*, (1924); Philip (1927) & Juday *et al*, (1943) related the increase in the pH values with photosynthetic activity, and Smith (1940) correlated it with increased carbonate concentration. Both factors may operate, increasing the pH value during some seasons and in some areas of the lake. On the other hand, several investigators had given reasons for the decrease in the pH values. Such decrease may follow the decay in the bottom (Juday, 1924), decrease in oxygen content (Wattenberg, 1933; Smith, 1952) and sulphide accumulation (Strom, 1936). Of these factors the first (i.e., the decay in the bottom) seems to be the one operating at Lake Manzala and causing the decrease in the pH values.

The main factors influencing oxygen concentration are the temperature, salinity and photosynthetic activity of the phytoplankton and the submerged plants (Welch, 1952). Supersaturation indicates increased photosynthetic activity, for which abundance of phytoplankton, primarily, and the rooted hydrophytes and epiphytes are responsible. During this investigation high nutrient concentrations were recorded during spring and autumn, while low concentrations were found during summer (Fig. 3). The high nutrient concentration is associated with abundance of phytoplankton which is responsible for increased photosynthetic activity leading to supersaturation with oxygen . Ghazzawi (1939) working at Suez Canal pointed out that the quantity of nutritive substances in water are the prime deciding factor in the seasonal abundance of phytoplankton. This accounts for the supersaturation of water with oxygen found in April, May and September and the depletion recorded during the summer months June-August. Undersaturation of oxygen also indicates periods of marked decomposition. It seems that waters of the southeastern region of the lake which is rich in the settled organic matter carried by drainage waters, exhibit lower saturation of oxygen due to its consumption through the oxidation and fermentation processes of the organic materials. This occurs, but to a lesser extent, in the western region. The presence of the water hyacinth (*Eichhornia crassipes)* and water lilies *(Nymphaea* spp.) in the draining canals and in the vicinity of its mouths in the southeastern region of the lake may lead to undersaturation of oxygen. Bishai (1961b) recorded a marked oxygen depletion from 99 to 20 % saturation in regions covered by the water hyacinth (*Eichhornia crassipes)* in the River Nile.

In addition to the high concentrations of nutrient salts in Lake Manzala during spring and autumn and low ones during summer they were found higher in areas affected by drains (Fig. 3). In the Egyptian lakes Aleem & Samaan (1969) pointed out that although nutrient level is low in summer, yet the primary production is high, a fact indicating that the high turnover rate assisted by high temperature supplies the growing plankton with its nutrient needs. The shallowness of Lake Manzala plays an important role in the nutrient exchange processes leading to more enrichment of the overlying waters. Welch (1952), showed that among the various factors contributing to the productivity of lakes is the close superposition of the photosynthetic zone over the decomposition zone.

The silicate content in Lake Manzala is high. Elster & Georgy (1959) pointed out that silicates are high in the Egyptian lakes due to the influx of drainage water rich in silica into these lakes. The low values of silicates at the southeastern region of Lake Manzala, which receives drainage waters, indicate that the high silicate content is thrown out of circulation. This may be probably due to the presence of coagulants or precipitants; the silicates that escape precipitation and which are distributed progressively to further regions have, at the end, to undergo the same fate (Twenhofel, 1939). This assumption is supported by the observed decrease in the silicate content in Gameel region. Moreover, for Lake Manzala the results indicate that silicate content dereases with increasing chlorosity (Fig. 3). Armstrong (1965) showed that any departure from such a relationship can be ascribed with some confidence to biological agents. The minimum silicate concentration recorded at the lake during the period April-July may be explained on the basis given by different investigators that seasonal variation in silicate concentration is correlated with the producton of organisms utilizing silicate for their shells particularly diatoms (King & Davidson, 1933; Spencer, 1950; Bishai, 1961b).

Lake Fishery

The present data show that the lake fish production contributed nearly half of the total country yield during 1967 & 1968. Although the decrease in total fish production is observed since 1962, the data (Table 2) suggest that the remarkable decrease from about 81,000 to 62,000 metric tons during 1964—1966 is caused primarily by depriving most of the Egyptian fishery grounds of large quantities of the fresh Nile water which decreased, as a result of the construction of Aswan High Dam, from 53 x 10^9 m^3 in 1964 to 18 x 10^9 m^3 in 1965 and to no more than traces since 1966.

Ghazzawi (1939) showed that the Nile flood completely shaped the diatom picture in the northern end of the Suez Canal and Steuer (1935) noticed that when the Nile begins to rise, the amount of phytoplankton likewise begins to increase at Alexandria. Halim (1960) found that the diatoms appear in great quantities after the arrival of the Nile flood water in the areas infront of both the river mouths. The abrupt disçarge of such a large amount of river water during a relatively short time is followed by drastic changes in the hydrography and biological economy of the southeastern area of Levantine Sea, from Alexandria to Beirut (Halim *et al.*, 1967). This is due to the fact that the plankton furnishes the basic food supply for all aquatic life. Salah (1961, 1963) has given a complete review for the positive correlation between the density of the phytoplankton and the density of fish population recorded all over the world. Ghazzawi (1939) and El-Maghraby (1960) reported that soon after the Nile waters reach the sea great shoals of sardines aggregate in the coastal waters off the Nile Delta from Alexandria to Port-Said and feed vigorously on diatoms which are abundant in these waters at that time. Thus we see the effect of Nile flood, i.e., fresh water on the flourishing of the plankton and in turn on at least one item (sardines) which was considered very important, of the Egyptian fisheries. El-Zarka & Koura (1965) showed that the sardine contributed 48 % of the commercial production from the Mediterranean Sea during 1962 and that a positive correlation exists between the monthly Nile outflow and the sardine catch in the same month. The most outstanding loss of the sardines had begun since the fertile Nile water ceased to drain into the Mediterranean.

The present data (Table 2) show a relationship between the annual fish production of Lake Manzala and the amount of introduced fresh water per annum into the lake. It is clear that despite the decreasing amount of the Nile fresh water to nearly nil, during the successive years from 1962 to 1966, the lake received an increasing amount of freshwater through the drains. The quantities of Nile waters previously introduced into the lake through Souffara, Ratama and Inaniya canals are now compensated by drainage water together with a small quantity of freshwater introduced into the lake through Inaniya canal. The latter amounted in 1967 to 113 x 10^6 cubic metres (Wahby *et al.* 1971). This fact may partly account for the non-appreciable decrease in the fish production of lake Manzala, especially because the water supply of the lake, whether drainage or fresh water, besides its contained organisms is laden with silt, and is rich in nutrient salts necessary for the flowering and flourishing of the phytoplankton. In addition to the effect of freshwater on the fish production, other factors may participate in this respect, such as pollution, the increase or decrease in fishing effort per unit time and area, or overfishing. It seems that pollution has not reached the level to affect fish production. However, future investigations on this aspect are needed.

In all cases the total lake's mullet fishery contributed more than 60% of the annual Egyptian mullet yield. But, a negative relationship is observed between the production of *Tilapia* and mullet species except in 1967; the mullet species increase while *Tilapia* species decrease, and vice versa (Table 3). In 1965, the production of marine fishes was the highest and freshwater fishes was the lowest. The percentage catch of the total freshwater fishes rises sharply in 1966 and in 1968 when they constitute 86.4% of the total catch. This high value compared with that of 70% in 1963 may be attributed to the decrease in chlorosity in all regions of the lake except in the southeastern region which receives fresh drainage water. Wahby *et alii* (1972) found that during 1967 chlorosity values were slightly higher than during 1963 in the southeastern region, slightly lower in the northeastern part and also lower in the western region.

SUMMARY

1 — An account of the physical and chemical characteristics, bottom topography and fisheries of the lake is given. The barriers which -together with the islets-divide the lake into basins are described for the first time. On account of the tremendous policy of converting the lake from fishing to agricultural production , these barriers would serve as natural boundaries of fish farms proposed in the future within the lake's area.

2 — Remarkable seasonal and regional chlorosity changes are recordad. The changes depend on the amount of drain water discharge and introduced sea water through the lake -sea connection by the effect of wind, and the increased evaporation accelerated by high summer temperature. Average chlorosity as high as 15 g. Cl/l is found at Gameel region and as low as 0.7 g. Cl/l in Ginka region.

3 — A change of the hydrogen ion concentration is recorded from high values (8.4) during autumn and winter to lower values (8.0—8.2) during April-September.

4 — The percentage of oxygen saturation in the lake varies from 50—113%. Supersaturation with oxygen (103—113%) is observed during april and May associating increased photosynthetic activity.

5 — Silicates are generally high in the lake, while the concentrations of nitrates, phosphates and nitrites are high during spring and autumn and low during summer.

6 — The study of the fisheries of the lake shows that it contributed 52.9 and 47.6% of the country annual fish production during 1967 & 1968, respectively. The fresh water fish constitute 61—86.5% of the annual yield of the lake during 1962—1968; the remaining production constitutes marine fish or fish of marine origin, 50% of which are mullet species,i.e., these species form 8—17% of the annual lake production during 1962—1968.

7 — During 1962—1968 the lake contributed more than 60% of the country mullet yield, constituted mainly of *L. ramada*, *M. cephalus* and *L. saliens*, so arranged according to their importance in fisheries.

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