Chapter 10
Fisheries Development

SOME NOTABLE FEATURES OF LAKE NASSER

Lake Nasser, which is an elongated water body, is among the largest man-made freshwater bodies in the world. Its various dimensions depend on the volume of its water (Table 1 & Fig. 1). The water volume in the Lake fluctuates greatly from year to year according to the annual net water input into the Lake. The highest water level (181.60 m) was attained in 1999, while the lowest one (150.62m) was recorded in 1988. The annual Lake level fluctuations are in the order of 5-10 m. The fluctuations of the Lake's water level is one of the most important factors affecting its ecology. The Tushka spillway was designed as a device to allow the discharge of excess flood water, it was used for the first time, since the construction of High Dam, in October, 1996.

One of the most outstanding features of Lake Nasser is the elaborate complex of numerous (85) major khors (dry desert wadies), the longest of which is Khor Allaqi, which has a length between 40 and 80 km. The khors are biologically the richest areas of the Lake. Their shallow waters provide better breeding grounds for fish and the gentle slopes of the inner khors, compared with the rocky and steep shores of most of the Lake, allow deep alluvial deposits to accumulate, providing a great chance for vegetation to grow. Dominant macrophytes in the shallow margins of the Lake are *Najas armata* and *Najas horrida.* Birds are the second most prominent faunal element after fish.

The Lake is a fairly hard-water, eutrophic lake, nitrate and dissolved phosphate concentrations in the water are moderate to high. Variations in water turbidity are partly due to variation in suspended sediment loadings, related to the seasonal flows of silt-laden flood water into the Lake, which takes place between August and October every year. At this time, transparency is reduced to 20-25 cm; outside the flood season transparency increases to 50-350 cm. A further factor leading to the increase

in turbidity is phytoplankton blooms in the oxygen saturated surface layers of the Lake. Transparency in the khors is less than that in the open Lake water, due to the abundance of inorganic suspended material.

Lake Nasser is one of the most important national sources of fish production, contributing from 10 to 15% of the total inland fisheries production in Egypt, or about 10% of Egypt's total country production.

One of the gratifying aspects of the creation of man-made lakes is fishery development. The rapid increase in nutrient level following filling of a lake is paralleled by increase of fish production (after a time lag) resulting in higher yields (Henderson 1973). Jackson (1966) reviewed the establishment of fisheries in tropical man-made lakes. The morphoedaphic index (MEI), which was originally described as a first-approximation method for yield assessment in north-temperate lakes (Ryder 1965), has been successfully applied to African inland waters (Regier & Henderson 1971, Henderson 1973, Ryder *et al.,* 1974, Bishai & Khalil 1987). The mean depth of the reservoir or lake and the mean value of total dissolved solids or any of its correlates such as conductivity or total alkalinity are used for the computation of the morphoedaphic index. Applying MEI for Lake Nasser, the potential yield was estimated as 19,000 ton at 180 m level or 32 kg/ha , which is considered as moderate compared with other African lakes (Ryder & Henderson 1974). Based on catch statistics for Lake Nasser, the estimated fish yield ranged from 18.01 to 27.52 kg/ha/yr during 1968-1971, and from 31.98 to 52.45 kg/ha/yr during 1972-1977, and from 63.36 to 116.99 kg/ha/yr during 1978-1996 (Table 141). The estimated fish yield, during the last period (1978-1996), is considered high compared with other African lakes.

FISH YIELD PREDICTIONS

The physical and chemical properties of Lake Nasser (Table 165), the positive and negative effects together with the unknown major factors affecting the productivity of the Lake (Table 166) were investigated by Ryder (1973). All these factors throw light on the problems of fisheries and help to get four potential yield predictions as follows:

Morphoedaphic Index (MEI) Method

This index was applied in north temperate lakes (Ryder 1965), then in African inland waters (Regier *et al.* 1971, Henderson 1973). It is based upon data on conductivity, where they are converted to TDS (total dissolved solids) from the values of Hutchinson (1957). When applying this method to Lake Nasser the potential yield was estimated as 10,000 m.t. at 160 m level and 19,000 m.t. at the level 180 m.

Table 165 **Some physical and chemical features of Lake Nasser (Ryder 1973).**

Parameter	Maximum	Minimum	Mean
Surface temperature (°C)	32	17	25
O_2 absolute (mg/1)	7.8	0	–
O_2 saturation (%)	160	0	–
pH	9.4	6.8	8.4
Conductivity (µmhos/cm)	225*	200	210
Total dissolved solids (mg/1)	200	175	185
Alkalinity (mg/1)	2.30	1.87	2.01
Transparency (m)	3.5	0.15	1.5

* Conductivity values may attain 300 µmhos cm^{-1}

Rawson Model Method (1962)

This was extended to African lakes and reservoirs by Fryer & Iles (1972). It depends on the mean depth. According to this method the yield of Lake Nasser would amount to 10,000 mt. at 160 m level and 16,000 mt at 180 m level.

Yield and Biomass (Gulland 1970)

This method depends on Gulland's relationships on the basis of known biomass of latent fish stocks:

Y = 0.4 MB

where,

Y = the long term yield.

M = natural mortality rate.

B = ichthyomass of exploitable stocks prior to fishing.

This method gave the figure of 11,000 mt. as an annual yield of fish.

Mediterranean fishery

Ryder (1973) found a close relation between Eastern Mediterranean catch and Lake Nasser catch (r = 0.952), but with 4 years earlier for the Eastern Mediterranean. Applying this method to Lake Nasser an annual yield of 8,000-13,000 ton was estimated.

THE YIELD PATTERN AT LAKE NASSER

In his mathematical model for estimating the yield pattern at Lake Nasser, Bazigos (1972) found that there is a close correlation between the

three variables

Table 166 **Some notable features of Lake Nasser (Ryder 1973).**

Positive effect	Negative effect	Major effect unknown
	Abiotic	
High shore development	Low transparency during flood due to inorganic turbidity.	Effect of sand storms.
	High mean depth of river channel.	
Low mean depth of khors.	High surface temperature during summer.	High rate of evaporation
Moderate to long growing season.	Low water temperature during winter.	
Increase of nutrients during floods.	Low dissolved O_2 in hypolimnion during summer.	
	Biotic	
High incidence of phyto-plankton blooms	Phytoplankton mainly blue-green algae.	Community interrelation-ships
Aquatic macrophytes and periphyton increasing markedly.	Relatively low fish species diversity for a tropical lake may be indicative of low stability and a lack of resilience following stresses.	
Well established zooplank-ton and benthos.	Low abundance and diversity of terrestrial vegetation.	
High mean size of fish and relatively high species di-versity suggesting insignif-icant effect of fishery in the southern part.	*Oreochromis niloticus* nests exposed by drawn- down.	
	Effects of fishery expressed in density dependent factors.	
	Low diversity of benthic and planktonic animals.	
	Low diversity of aquatic macrophytes and animals.	

which are total commercial landings, number of fishing boats and total surface area (annually).

The estimating equation is:

$$t^{X1} = a_{1.23} + b_{12.3}\, t^{X2} + b_{13.2}\, t^{X3}$$

where $x1$, $x2$, $x3$ express the variables respectively.

The surface area was found to be responsible for the annual changes in total landings 1.33 times more than the variable of "number of fishing boats". More reliable estimates of the expected value of fishing activity are needed to get more reliable estimates for those potential yields predicted.

FISHING INDUSTRY

In Lake Nasser, there were about 12,000 fishermen in 1990 and 1991. Their number declined to about 9,400 in 1992. Five associations control the different sections of the Lake. Each of them serves fishermen from one of three governorates : Aswan, Qena and Sohag. Many of the fishermen are unqualified and might use unsuitable, illegal or degrading fishing techniques, to compensate for their inexperience. The littoral or best fishing grounds are usually fished more intensively than other areas. Some other areas are almost never fished (either because they are poor in fish, or because they are far from access to transportation). The fishing areas are allocated by Aswan Governorate. All the catch from Lake Nasser has to be delivered to the Egyptian Fish Marketing Company (for distribution throughout the country), or to Misr Aswan Fish Company, which processes some fish for local consumption. Some fish species (mainly tilapiine species) are taken by a small Fillet Factory in Aswan. The fish are sold to these companies at fixed prices.

The fishermen practice their activity in small (usually mechanised) boats, and they live in temporary huts constructed along the shores of the Lake. They are usually based close to areas with road access or freezing facilities to ensure rapid transport of their fish, particularly during summer.

FISHING REGULATIONS

1. It was suggested to enforce a closed fishing season in the whole Lake area yearly from March 15^{th} to May 15^{th} to prevent catching mature fishes, especially *Tilapia* spp. during spawning. This regulation started in 1990. Table 167 shows the variation of CPUE before and after applying prohibiting fishing in 1990. Adam & Mohamed (1995) considered the difference of the two means (2.3 ton / boat / month) as an effect of prohibiting fishing in 1990, especially that the water level during these years (before and after prohibiting fishing) was nearly the same (about 167 m). This regulation, however, was not applied during certain years due to political reasons.

Table 167 **Variation of CPUE before and after the enforcement of prohibiting fishing in Lake Nasser (Adam & Mohamed 1995).**

Year	CPUE (ton / boat / month)
Before prohibiting fishing	
1989	13.32
1990	11.43
Total	24.75
Mean	**12.40**
After prohibiting fishing	
1991	**16.00**
1992	**13.37**
Total	29.37
Mean	14.70
Difference between the two means	14.70 - 12.40 = 2.3 ton / boat / month (=18.5 %)

2. Regulations on fishing gears by prohibiting the use of bottom gill nets and trammel nets with small mesh size (< 12.5 cm) in order to prevent fishing tilapia at lengths less than 25 cm or body weight less than 500 gm.

FISHERIES POTENTIALS

As previously mentioned, the maximum fish landings was 34,206 ton from Lake Nasser in 1981. However, the potential of Lake Nasser fisheries appears to be higher, as it is one of the most productive large bodies of water in Africa. Primary productivity as well as the standing crop of plankton are known to be very high (2-3.5 $g/C/m^2/day$). Also, Lake Nasser is 4-5 times richer in total dissolved solids and 3-4 times richer in total alkalinity, when compared with other large African reservoirs studied (Entz *et al.* 1971), and it is obvious that the shoreline of Lake Nasser is 2-5 times longer in relation to its surface area. All these conditions indicate a large potential for fish production in the lake. The fertility of Lake Nasser is greater than that of Volta Lake, where the catch is estimated to be 60,000 ton per annum. Therefore, in spite of the comparatively small size of Lake Nasser (i.e. when the Lake is full, it amounts to approximately two thirds of Volta Lake), the maximum sustainable catch may be of the same magnitude in both lakes. It should be taken into consideration that the area of Lake Nasser fluctuates due to annual changes in water level. Also, the available living space will be changeable. On the whole, assessment of the stocks of Lake Nasser could be safely undertaken for concrete estimation of the potential of its fisheries.

It is worth mentioning that the khors of Lake Nasser are more productive than the main channel. Thus, the mean value of chlorophyll *a* concentration is about 10.8 mg/m^3 inside Khor El-Ramla, while it is only 7.8 mg/m^3 outside the khor (Habib 1992 b). Consequently, fish production is higher in khors and littoral areas than in the main channel. As a matter of fact, the main channel, i.e. the deep areas, are not well exploited.

About 90% of the total fish production is *Sarotherodon galilaeus* and *Oreochromis niloticus* caught in the coastal area of the Lake. The offshore area of the Lake is not well utilized for fisheries except some catch of *Hydrocynus* spp., *Alestes* spp. and others.

Recently, much attention has been focused on the insufficiently utilized offshore region in order to increase fish production from the Lake by introducing a new commercial fish suitable to the Lake environment. The introduction of silver carp was suggested for open water areas of the Lake. However, it is advisable not to introduce any new fish species into the Lake, otherwise any impact due to its stocking will be difficult if not impossible to remedy.

RECOMMENDATIONS

Needless to say that the future economics of Lake Nasser fisheries look bright. But, in fact, various problems confront the Lake fisheries development. The factors affecting the decline of fish production may be summerized as follows:

1. The decline in Lake water volume changes the ecology of a large portion of the Lake. Thus, the spawning and nursery areas decrease sharply and this causes certain fish species to decline or disappear from the Lake. Also, the fishing grounds decrease and consequently there is a decline in fish production.

2. The coastal fishing grounds (the best fishing areas), which represent 20% of the total Lake area, are usually fished more intensively than the open water fishing areas (about 80% of the total Lake area). Some areas are almost never fished, because they are far from access to transportation.

3. Although the open water areas are rich in phyto- and zooplankton, there appear a few species that are able to feed on plankton in the Lake.

4. The competition between various fishing associations might lead to intensification of fishing efforts, and vice versa.

5. The number of fishermen declined from 12,000 (at the peak productive period of Lake Nasser) to 9,400 in 1992.

6. Many fishermen are unqualified and might use unsuitable fishing gears. They practice their activity in small mechanized boats and live in temporary huts.

7. There are problems due to the nature of the Lake, being relatively very long and narrow in the middle. Transportation of fish is a major problem. Fishermen have no facilities along the Lake to store the catch, but have to wait to use the facilities of the few carrier boats available. Considerable fishing time is lost just waiting for supplies to keep fishermen going. Transportation problem has two major aspects:

a. Transportation of catch to High Dam Harbour.
b. Transportation from Aswan to inland markets especially Cairo.

To improve fisheries of Lake Nasser, some suggestions are recommended:

I- For the best use of the Lake, comprehensive and continuous applied research should be considered in the following aspects :

a. *Environmental and fish stock assessment studies*. It is well known that remarkable changes both in the environment and fishery have been occurring in Lake Nasser since the construction of the High Dam. Due to yearly fluctuations in the water level of the Lake, physical, chemical and biological changes should be followed continuously so that a clear picture of Lake conditions will be known. Continuous monitoring of the physical, chemical and biological factors affecting fish population dynamics are needed.

The knowledge of changes in surface area and volume of water at different water levels is very important for fish stock assessment and fishery development. For instance, the increase in the surface area of the khors, which represents the suitable breeding and nursery grounds for tilapiine species, the most important fish species, leads to an increase in total fish production, and vice versa . Changes in length of the shoreline and its slope are important factors for the development of periphytes and littoral fauna, the main food for tilapiine species, which form the major part of fish production (more than 90%).

It is required to investigate the trophic level interactions, and to determine food requirements for different fish species inhabiting Lake Nasser. Further studies on the biology of *Tilapia zillii* and its impacts on Lake Nasser ecosystem should be carried out in the near future. Thus, details of ecological and biological constraints are needed for the effective management and monitoring.

Adequate scientific knowledge on the present fish stocks, under the changing environmental conditions, should be taken into consideration. Assessment of the level of exploitation of the fishery relative to its potential is urgently needed for correct estimation of the maximum sustainable yield.

There is need to collect information on: the number and location of fishermen camps, the number of fishing boats and fishermen in camps, average days of operation per fishing boat during the year, average daily frequency of the haul per boat, length and mesh size by type of fishing nets used, size of the collected fish species in different months and according to various fishing grounds, the size and distribution of the hauled fish by species, release of tagged fish, and survey by echo-sounder. The accumulation of the aforementioned data will greatly contribute to detect early signs of overfishing and thereby enable a quick adaptation of corrective measures.

b. ***Aquaculture studies.*** These include both coastal and open water areas.

Coastal fishing areas : *Tilapia* species do not migrate far from their normal habitat. Hence, the fingerlings of *Oreochromis niloticus* released into the khors grow up to marketable size after few years. This is one of the effective methods to increase fish stocks.

Open water fishing areas: These areas are rich in both phyto- and zooplankton (Fishery Management Center, 1992). Since, there appears to be a few fish species that are able to feed on plankton, silver carp *(Hypophthalmychthus molitrix)* culture in net cages had been practiced in open water areas of Lake Nasser to fullfil the following:

a) The utilization of the open water area.

b) To utilize phytoplankton and also avoid the pollution which may happen owing to the decay of a large amount of these organisms.

c) To ensure other additional income for fishermen.

II- The total catch in the southern fishing grounds is 1.4 times as much as that in the northern fishing grounds, and also the value of CPUE in the southern fishing grounds is 1.7 times as much as that in the northern fishing grounds. Hence, it is suggested that higher number of fishing boats could be used in the southern part of the lake.

Ill- The hot climate of the Lake particularly during summer time, the presence of many fishing grounds far from Aswan, and that Aswan is far from the main consuming centre (Cairo), all these factors are in favour of encouraging fish processing in Lake Nasser. So, in addition to the two small factories (Fillet and Fish Meal) at Aswan, larger factories could be constructed at Aswan, where appropriate methods of fish processing have to be developed so that more products acceptable by the consumer can be developed. Tilapias *(Oreochromis niloticus* and *Sarotherodon galilaeus)* which are the most common species in the Lake can give a good sundried product and the climate is suitable for this process. Kalb *(Hydrocynus* spp.) and raya *(Alestes* spp.) give a good smoke-canned product and as these fishes are common in the Lake, such a method of processing can be initiated.

IV- A fair percentage of fish caught from the Lake is salted in a very simple and primitive way. The main salted fishes are raya *(Alestes* spp.), kalb *{Hydrocynus* spp.), lebeis *(Labeo* sp.) and shilba *(Eutropius* and *Schilbe* spp.). Appropriate methods of salting of the aforementioned fish species may be developed to obtain good products of high quality and acceptable by the consumer.

V- Fishermen

a. To establish a policy on improving the conditions of fishermen to attract them to Lake Nasser. A project for settlement of fishermen at both the eastern and western sides of Lake Nasser, where the required services are already available, ought to be initiated.

b. To operate training courses for fishermen by staff members, in order to supply them with the necessary information to improve fishing and to be aware of the risks of using illegal gear which lead to destruction of the Lake fishery.

c. To improve transportation and preservation methods of fresh fish particularly from fishing grounds to High Dam Harbour.

CONCLUSIONS

The water volume in the Lake fluctuates greatly from year to year according to the annual net water input into the Lake. The highest water level (181.60 m) was attained in 1999, while the lowest one (150.62 m) was attained in 1988. The fluctuation of the Lake's water level is one of the most important factors affecting its ecology. The Tushka spillway was designed as a device to allow the discharge of excess flood water, which was used for the first time since the construction of High Dam, in October, 1996.

The physical and chemical properties of Lake Nasser, the positive and negative effects affecting the productivity of the Lake are discussed. All these factors throw light on the problems of fisheries and help to get four potential predictions as follows:

a- Morphoedaphic Index Method.

b- Rawson Model Method (1962).

c- Yield and Biomass (Gulland, 1970).

d- Mediterranean Fishery.

Applying the four mentioned methods, the annual yield prediction from Lake Nasser was found to range between 8 to 19 thousand tons. However, recent studies showed that the potentials of Lake Nasser fisheries appear to be higher and the maximum sustainable yield of tilapiine species, estimated by various methods ranged between 29,005 and 58,970 ton (p. 410). It seems that the possible maximum sustainable yield of *Oreochromis niloticus* and *Sarotherodon galilaeus* (representing about 93% of the total fish catch) is around 55,000 ton.

Based on catch statistics for Lake Nasser, the estimated fish yield ranged from 18.01 to 27.52 kg/ha/yr during 1968-1971, and from 31.98 to 52.45 kg/ha/yr during 1972 - 1977; and from 63.36 to 116.99 kg/ha/yr during 1978 - 1996. The estimated fish yield during the last period (1978-1996) is considered high compared with other African lakes.

In the mathematical model for estimating the yield pattern at Lake Nasser, there is a close correlation between the three variables, which are total commercial landings, number of fishing boats, and total surface area (annually). The surface area is found to be responsible for the annual changes in total landings 1.33 times more than the variable of "number of fishing boats".

The khors (85 major) of Lake Nasser provide the most important habitat for fish to breed and feed, because of their shallowness and abundance of phytoplankton. The open and deep waters of the Lake are poor in fishes in spite of the fact that they are rich (to a certain extent) in plankton.

Five associations control the different sections of the Lake. The number of fishermen declined from 12000 in 1990 and 1991 to 9400 in 1992, and most of them are unqualified and might use illegal or degrading fishing techniques. The bottom gill nets and trammel nets with small mesh size (< 12.5 cm) must be prohibited. The best fishing grounds are usually fished more intensively, while other areas are almost never fished. All the catch has to be delivered to the Egyptian Fish Marketing Company. Some fish species (mainly *Tilapia* species) are taken by a small Fillet Factory in Aswan.

Regulation of a closed fishing season from March 15th to May 15th started since 1990. The difference between the two means of CPUE for 1989 / 1990 and 1991 / 1992, which was 2.3 tons / boat / month (18.5 %) may be considered as an indication of effectiveness of prohibiting fishing during 1990.

The maximum fish landings was 34,206 ton from Lake Nasser in 1981. However, the potential of Lake Nasser fisheries appears to be higher, as it is one of the most productive large bodies of water in Africa. Suggestions are recommended for fisheries development.