Bull. Inst. Oceanogr. & Fish., ARE, 14 (3) 1988. 239-252.

FISH STOCK ASSESSMENT SURVEY IN MANZALA, EGYPT

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ABSTRACT

Total standing fish stocks (biomass) of Lake Manzala are estimated at 60,000 t, of which 85 % or 51,000 t are tilapia species.

In general, standing stocks range from 2,470 Kg/hectare in the southern region to 62 Kg/hectare in the northern region, corresponding well with catches on a regional basis.

Exploitation rates increase exponentially with standing stock, from 0.2 to 0.3 in low stock areas to over 1.0 in regions having the highest standing stocks.

Inspite of the intensive fishing pressure and very high yields and turnover rates in the southern region, there are some signs that the fishery is still under exploitation.

INTRODUCTION

Catch statistics can not as yet be used to derive measures of absolute stock abundance. However, work on fishing gear selectivity and efficiency has progressed rapidly during the past decade (Hamley, 1975) and it is conceivable that the appropriate models will be developed in the near future.

However, total catch and CPUE (Catch per unit effort) data are measures of relative stock abundance that can be used (with some limitation) to compare the abundance of a fish stock over a period of time.

Catch data are not normally an accurate reflection of the species composition or population structure of the stock. Some of the factors that may result in size and species bias are: fishing gear selectivity, selective areas, habitats and seasons, and active fishery selection (e.g. chasing and catching of high value species along migration routes).

Fish stock assessment is complicated by the three dimensional nature of the habitat. The practical application of most stock assessment methods is restricted to small water bodies with relatively homogeneous habitats. The financial and technical demands of comprehensive stock assessment programmes aimed at large, diverse and deep water bodies are usually prohibitive. The methods that have been applied successfully under such circumstances (usually indirect sampling methods like the mark recapture experiments) are often restricted to one or few species and do not provide comprehensive stock information.

However, a very shallow water body like Lake Manzala is essentially a two-dimensional sampling space and direct sampling using a series of quadrats is possible.

AREA OF STUDY

Lake Manzala, the biggest of the Egyptian Delta lakes, is situated in eastern Nile Delta between the Damietta Branch and the Suez Canal (Fig. 1). The Mediterranean Sea is immediately north of the narrow coast which separates the two water bodies. The total area of the Lake is approximately 280,000 feddans and the depth of water rarely exceeds two meters.

Lake Manzala is characterized by low salinities in the south (near the outlets of the agricultural drains and fresh water canals), brackish waters over most of the rest of the area and saline waters in the extreme northwest. Nutrients from the major drains have created eutrophic conditions in the southern parts of the lake. The eutrophic conditions have changed the aquatic biota lending to a less diverse but highly productive system (Tilapia based fishery).

METHODOLOGY

A total of 23 stock assessment sampling experiments were performed as part of this study between July, 1979 and August, 1980. Each sampling experiment consisted of enclosing a 15m X 15m area with a fine mesh (0.5 cm stretch mesh) blocking seine. An attempt was then made to remove all the fish inside the sampling quadrate or otherwise to estimate the total abundance and species composition of the fish stock.

Sampling sites were originally allocated on a regional basis, roughly proportional to stock abundance. This assured a greater sampling effort in higher stock areas which were relatively more important in terms of total lake stocks and where most of the uncertainity existed. The Lake has been subdivided into six regions on the basis of standing stocks (Fig. 1). The pattern of standing stocks on the Lake is very distinct and with one or two exceptions all the experimental results fall into the interval defining that region. Also the mean values of experiments in zones fall very close to the midpoints of the intervals (Table 1). The interval midpoints (i.e. the mean standing stock in Kg/feddan) were used for secondary calculations.

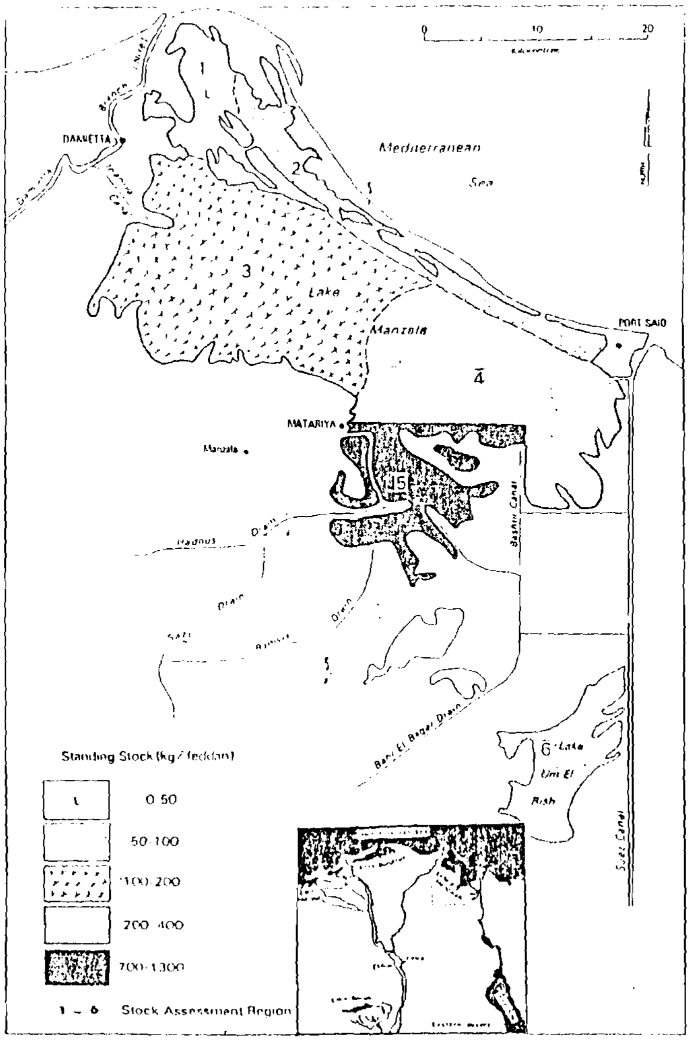

Fig. 1

Fish Standing Stock Densities

TABLE 1

STANDING FISH STOCKS (KG/FEDDAN) BY SPECIES

FOR STOCK ASSESSMENT REGIONS

Species	Stock Assessment Region					
	1	2	3	4	5	6
Tilapia zillii	8.2	21.7	16.8	67.8	111.0	85.4
Oreochromis niloticus	--	14.9	1.5	78.3	206.0	24.2
S. galilaeus	--	1.6	57.1	8.4	287.0	0.2
O. aureus	--	18.1	21.0	81.0	238.0	36.2
Juvenile Tilapia	6.0	11.0	12.3	26.4	13.0	0.5
Mugil cephalus	--	--	--	--	2.0	00
Liza ramada	1.8	--	--	7.8	--	--
Liza saliens	--	1.0	--	--	--	--
Clarias lazera	--	--	0.6	3.9	4.0	--
Bagrus bayad	--	--	0.9	0.3	36.0	--
Barbus sp.	--	--	0.2	--	40.0	2.9
Hemichromis bimaculatus	--	6.2	21.1	8.1	6.0	0.3
Haplochromis desfontainesii	--	1.5	18.2	16.8	44.0	--
Atherina mocon	4.6	--	0.3	--	-	-
Anguilla anguilla	--	--	--	--	12.0	--
Cyprinodontidae	4.0	--	--	1.2	1.0	0.3
Sygnathidae	0.4	--	--	--	---	--
Total (Kg / Feddan)	25	75	150	300	1000	150

Within the lake regions, specific sampling sites were selected more or less at random with the exception of very densely vegetated areas and exposed open water areas where sampling was technically unfeasible.

Inside the sampling enclosure, fishing has been done with a 10 m seine (0.5 stretch mesh) until very few or no fish were caught (usually 10 to 30 tows). Fish were counted and weighed after each tow, which consisted of pulling the seine from one side of the enclosure to the other on a random pattern. Mark recapture experiments carried out inside the enclosure indicated that the entire stock was not vulnerable and that only 50 to 70 % of the fish were being taken. Thereafter a mark-recapture experiment was incorporated into each stock assessment run. Two to three hundred fish were caught by seine net outside the sampling area, marked by cutting off the tip of the tail fin and released in the enclosure.

Confidence limits of stock estimates were not calculated for individual experiments but would fall within 10 % of the estimate at the 95 % probability level for the combination of marked fish and fish examined for marks according to Robson and Reiger (1971).

RESULTS AND DISCUSSION

Standing Stock Estimates

Experimental results indicate considerable variation in standing stocks among different regions of the Lake and among different habitats within regions.

Mean standing stocks range from 25 kg/feddan in the north-western region of the Lake to 1000 kg/feddan in the southern sector (Fig. 1). Stocks on the main body of the Lake range from 150 kg/feddan in the western sector to 300 kg/feddan in the eastern sector. Total lake stocks are estimated at 60,500 t of which 43 % (26,000 t) are found in the southern region (Table 2).

Twenty species of fish were identified from stock assessment experiments. Of these, the four tilapia species constituted 84 % of the total standing stocks on the Lake, ranging from 57 % in region 1 (north western) to 98 % in region 6 (Lake Um El-Rish).

In terms of total stocks, the four tilapia species were alomst equally abundant ranging from 17 to 23 % of the standing stock. However, on a regional basis, there are significant differences in relative abundance.

The relative percentage by weight of the four tilapia species are plotted by stock assessment regions in (Fig. 2). Several clear trends are evident:

- **Tilapia zillii** : Comprised 100 % of the tilapia stock in the saline north western region 1 where the saliniy is close to that of sea water, and declined to 13 % in region 5 which is the relatively freshwater southern sector.

- **Sarotherodon galilaeus** were present in very low abundance in more saline regions but increased to 36 % in the least saline regions.

- **Oreochromis aureus** exhibited little variation in relative abundance from region to region (22 to 32 %) with the exception of region 1 where only **Tilapia zillii** were found at the high sea water salinity.

- **Oreochromis niloticus** varied considerably in abundance from region to region but appear to live reasonably well at moderate salinities (less than 5000 mg/l).

The relative abundance by commercial size categories is similar for all the four species (Fig. 3) with 58 to 80 % of the total biomass in the small category (< 10.5 cm). The weighed mean for all species is as follows:

- small (< 10.5 cm) - 64 %
- Medium (10.5 to 16 cm) - 32 %
- Large (> 16.5 cm) - 4 %

TABLE 2

ESTIMATES OF TOTAL FISH STOCKS (TONNES) BY SPECIES FOR STOCK ASSESSMENT REGIONS.

Species	Stock Assessment Region						Total	
	1	2	3	4	5	6	(t)	(%)
Tilapia zill	102	408	1 399	3 905	2 908	580	10 302	17.0
Oreochromis niloticus	---	280	125	4 510	5 397	448	10 760	17.8
S. galilaeus	---	30	4 756	484	7 519	4	12 793	21.1
O. aureus	---	340	1 749	4 666	6 236	670	13 661	22.6
Juvenile Tilapia	74	207	1 025	1 521	341	9	3 177	5.3
% Tilapia species	57	90	72	87	86	98		84
Mugil cephalus	---	---	---	---	52	---	52	0.1
Liza ramada	22	---	---	449	---	---	471	0.8
Liza saliens	---	18	---	---	---	---	18	<0.1
Clarias lazera	---	---	50	225	105	-	380	0.6
Bagrus bayad	---	---	75	17	943	---	1 035	1.7
Barbus sp.	---	---	17	---	1 048	54	1 119	1.8
Hemichromis bimaculatus	---	117	1 758	467	157	6	2 505	4.1
Haplochromis desfontainesii	---	28	1 516	968	1 153	---	3 665	6.1
A therina moocon	57	---	25	---	---	---	82	0.1
Anguilla anguilla	---	---	---	---	314	---	314	0.5
Cyprinodontidae	50	---	---	69	26	6	151	0.2
Sygnathidae	5	---	---	---	---	---	5	<0.1
TOTAL (in tonnes)	310	1 428	12 495	17 281	26 199	2 777	60 490	100
Percent (%)	0.5	2.4	20.7	28.6	43.3	4.5	100	
Area (feddans)	12 400	18 800	83 300	57 600	26 200	18 500		

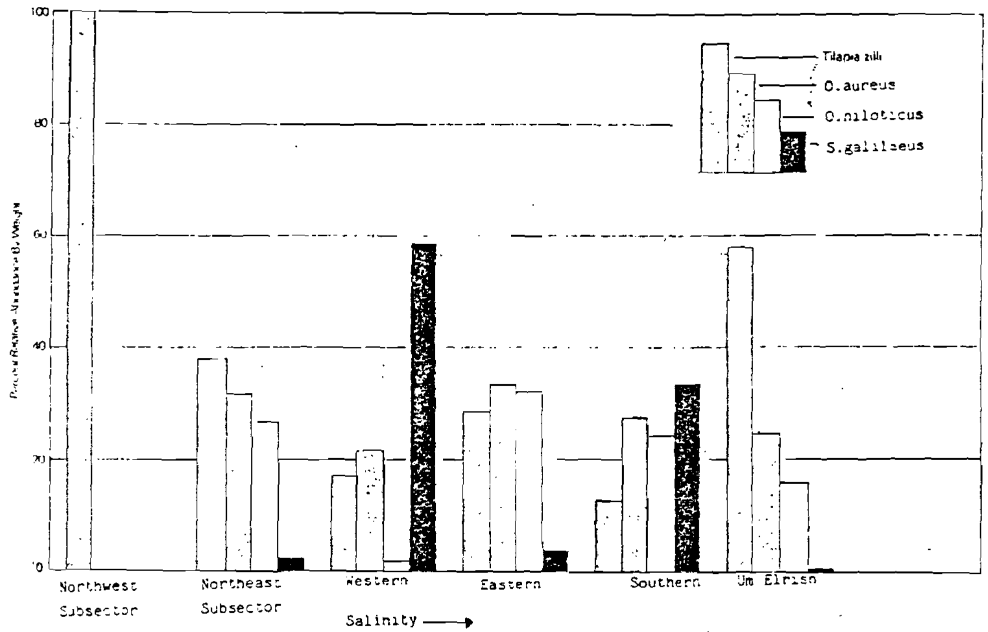

Fig. 2
Relative Abundance of Four Tilapia Species
by Stock Assessment Region

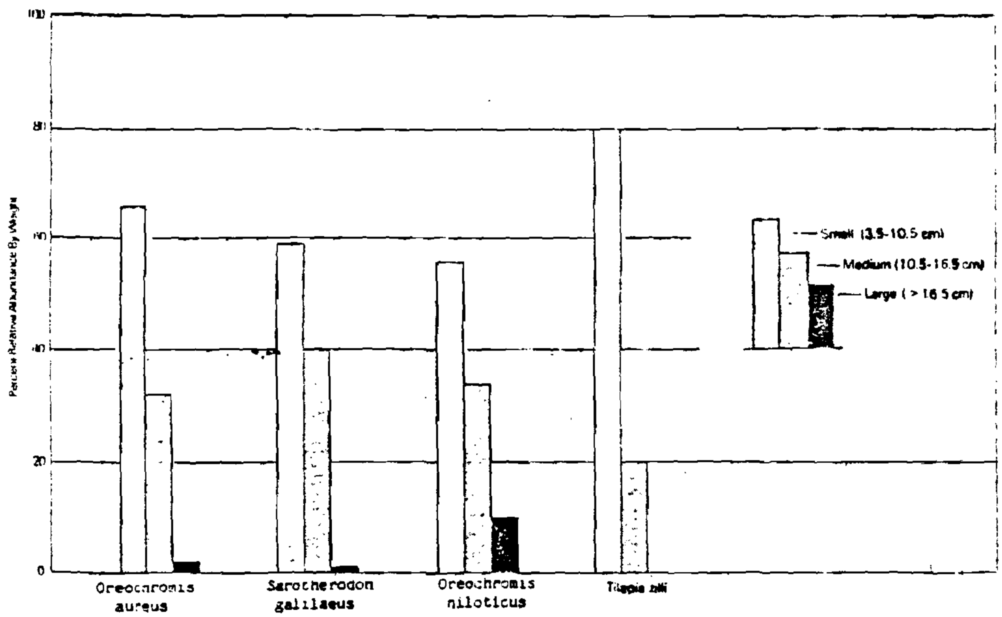

Fig. 3
Relative Abundance of Tilapia Stocks by Commercial Size Category

The stock assessment data generated by this study can be considered very comprehensive. There are few large aquatic systems for which such extensive data are available. However, Lake Manzala is very heterogenous with respect to water quality, habitat, productivity and fishing intensity (both in regional and seasonal terms) and a degree of generalization is necessary.

In general, stock abundance within a region or productivity zone is related to the density of aquatic vegetation in (i.e. stocks increase with vegetation density). This is consistent with results of other African systems that have tilapia dominated stocks (Lagler et al., 1971 and Toews, 1977).

The majority of the Lake area is covered with stands of submergent **Potamogeton** sp. and **Ceratophyllum** sp. vegetation of intermediate density during summer and autumn, when most of the sampling was done. The mean standing stock values for regions are considered a good approximation of mean values when all habitats are considered.

The growth and reproduction season for tilapia species extends from April through September. Thus, stock might be expected to be maximum in August and September and reach their lowest level in March. Total stocks would be declining during October and November as growth has slowed down and recruitment has ceased while fishing pressure remains very high. If we assume linear mortality between September and March, the deriverd stock estimates would probably fall between seasonal maximum and seasonal mean levels. However, fishing activity drops off during the winter months of December to March and an exponential mortality curve is more realistic (i.e. greater numbers die per month during October to December than during January to February). Based on this assumption, derived stock estimates would probably lie close to seasonal mean values.

Comparisons of Stock Assessment and Catch Results

The most significant points that emerge from a comparison of species composition based on stock assessment and on catch assessment results (Table 3) are :

- The predominance of **O. niloticus** in the catch (54 %) compared to stock estimate (18 %).

- The virtual absence of some freshwater species from the catch (0.2%) comparison to stock estimates (12.2 %).

- The underestimation of catfish and other high value species (i.e. mullet, eels and other marine fish) in stock assessment results as compared with the catch results.

There is some evidence that the three major fishing methods in use (seine nets, hand fishing and trammel nets) would all select **O. niloticus.**

TABLE 3

A COMPARISON OF SPECIES COMPOSITION ACCORDING TO STOCK ASSESSMENT AND CATCH ASSESSMENT RESULTS

Species	Relative Percentage	
	Stock Assessment	Catch* Assessment
Tilapia		
Tilapia zillii	17.0	8.1
Oreochromis niloticus	17.8	53.8
S. galilaeus	21.1	5.7
O. aureus	22.6	17.8
Juvenile Tilapia	5.3	--
Total Tilapia	84.0	85.4
Mullet Species	1.0	2.2
Clarias lazera	0.6	2.0
Bagrus bayad	1.7	2.7
Eels	0.5	0.8
Other Marine fish	0.2	0.7
Shrimp	--	6.0
Other Freshwater fish		
Barbus sp.	1.8	
Hemichromis bimaculatus	4.1	< 0.1
Haplochromis desfontainesii	6.1	
Other	-------	-------
Total Other Freshwater fishes	12.2	0.2
	100.0	100.0

* Khalil and Bayoumi (in press).

The species is the largest and fastest growing tilapia species in Lake Manzala. It has also been suggested that it may be more pelagic than the other species (Payne and Collinson, 1979). Seine nets are operated in relatively open water and hand fishing methods catch almost exclusively **O. niloticus** at many regions. Trammel nets, which usually have an inner mesh size of 5.2 cm (stretch measure) would select for larger specimen (i.e. **O. niloticus**).

Oreochromis niloticus peaked in abundance during May to July (66 % of total catch), but other tilapia species became more prominent during the period from August to April with some changes in fishing methods. Hand fishing and hand seine nets combinations declined during the winter months resulting in a decline in the relative abundance of **O. niloticus** in the catch: 27 % during February to April versus 24 % for **O. arreus.**

Three small fresh water species **Barbus perince, Hemichromis bimaculatus** and **Haplochromis desfontainesii** comprise 12 % of the stock but less than 0.1 % of the catch. These species have little commercial value and are often discarded along with small tilapia.

The stock assessment sampling method was not very effective for **Clarias,** and on several occasions many of them were observed inside the enclosure, but not caught. Lagler et al. (1971) found that **Clarias** was under represented in similar stock assessment experiments and suggested that the species might be able to avoid nets by burying itself in soft muddly bottoms. Also, eels were probably underestimated for similar reasons.

Shoals of mullet, which are most commonly found in shallow water areas, are fast moving and timid and not easy to encircle with a blocking seine unless a deliberate attempt was made to do so. Such a sample could not be considered random and this practice was not adopted. On the other hand, mullet and other high value marine species are activily chased and fished for. So, this would explain their relatively higher abundance in the catch and their underestimation in stock assessment results.

RELATIONSHIP OF YIELD, EFFORT AND EXPLOITATION RATE TO STANDING STOCKS

In general, a good positive relationship exists between yields and standing stocks in Lake Manzala (i.e. high standing stocks reflect high fish yield and vice versa). A similar pattern seems to exist for effort and exploitation rate (Fig. 4). Closer examination reveals that yields increase expontially with standing stocks. The exploitation rate (the fraction of the standing stock taken by the fishery on an annual basis) increases from 0.2 to 0.3 at low stock levels, to more than 1.0 at the highest stock levels. This seems to suggest either:

- The existence of unexploited stocks and yield potential at lower stock levels or

- Exploitation levels (turnover rates) are biologically limited at lesser stock levels.

There are no simple models or formulae for relating standing stocks to yield or potential yield. Standing stock values generally reflect environmental carrying capacity but might also indicate intensive fishing effort and high turnover or exploitation rates. Both effort and exploitation rates decline with standing stock so the assumption that stocks reflect environmental condition is probably valied.

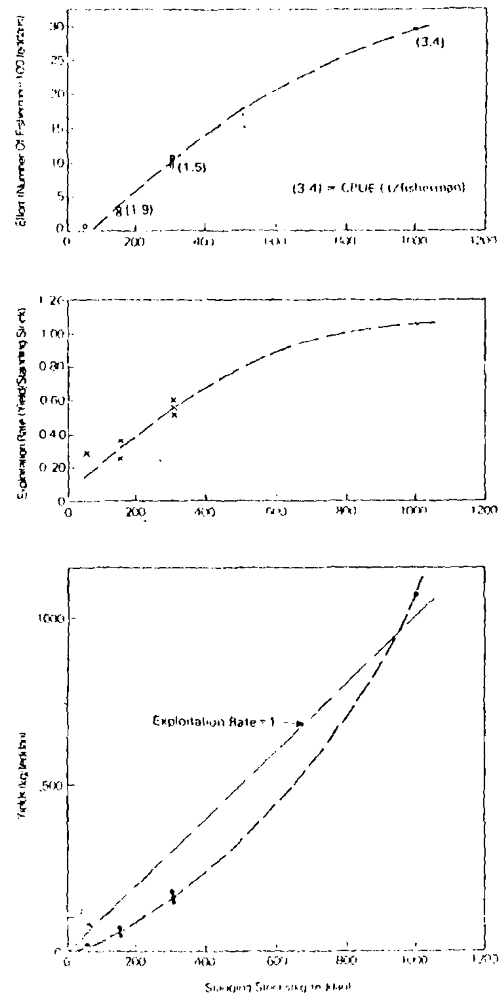

Fig. 4
Relationship of Effort Exploitation Rate and
Yield to Standing Stock

A close relationship appeares to exist between effort and exploitation level (Fig. 4) as both respond in a similar fashion to standing stock. However, while effort increases with stock The CPUE at the upper end of the scale (3.4/fisherman) is roughly two times the CPUE at the lower end (1.5-1.9/fisherman). This would indicate that the relative effort is actually less at high stock level (assuming that the efficiency of a unit of effort is the same for all lake areas), that is, areas of low stock levels are actually fished harder than areas of high stock levels. This anomaly may be explained by the fact that most of the high value fish species (which attract higher fishing effort) are found and caught in the low stock areas.

High turnover rates are a function of rapid growth and recruitment and intensive fishing pressure. Productive nutrient-rich environments (like the southern region) promote growth and recruitment which result in the high stocks which attract fishing effort. Intensive fishing effort reduces stock densities which further promotes growth and recruitment.

Tilapia are ideal fish species for such an intensive fishery. They are tolerant of the marginal environmental conditions that characterize highly eutrophic and productive systems. Tilapia can utilize a wide variety of food items but are mainly herbivorous primary consumers. This allows them to respond rapidly to changes in productivity.

Tilapia mature early and at a small size in Lake Manzala and have a high recruitment capacity. They are known for their ability to overstock a system in the absence of predators (i.e. in fish ponds) which may lead to reduced growth and stunting. There is some evidence that this is happening in the southern region of Lake Manzala. Stocks of juveniles are very high and growth rates relatively low. While fishing effort is intense, it is focused primarily on the mature stock. Natural predators which would exploit the juvenile stock are not well adapted for the intensive exploitation stress and thus are present in very low abundance.

Most tilapia species need shallow weeded littoral areas for spawning and nursing of fry. However, virtually the whole of Lake Manzala is such an area and tilapia nests are found everywhere. This reduces the possibility of the fishery to concentrate on spawning aggregation, thereby interfering with the reproduction and rearing process, which is the case in some deeper African lakes with limited shallow littoral areas (Toews, 1977).

Exploitation rates in the northern, eastern and western regions, roughly fall within the 30 to 50 % limit (based on mean standing stocks) that has been proposed by various authors (Holcik, 1970 a & b; Lagler et al., 1971; Jenkins, 1976 and Toews and Griffith, 1979) usually for more temperate waters. However, the exploitation rate of more than 1.0 for the southern region seems to be high but the fishery meets all the requirement of an intense high turnover system. Welcomme and Hagborg (1975), working with theoretical flood plain yield models, found exploitation rates of over one, i.e. (over 100 % of the mean annual biomass or standing stock).

Inspite of the intensive fishing pressure and very high yields and turnover rates in the southern region, standing stocks are still very high, growth rates are low and CPUE still the highest in Lake Manzala areas. But, it may be more appropriate to compare CPUE in net economic terms (i.e. considering the economic value of fish species, prices and costs to produce that yield) rather than in terms of yield alone: A CPUE of 3.4 t/fisherman in the southern region may give roughly the same net returns as 1.5 to 2.0 t/fisherman elsewhere.

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