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V: CONCLUSIONS & RECOMMENDATIONS

From this study we concluded that:

• The waters of Bardawil Lake were poor in its contents of nutrients and animal phytoplankton benthic animals.

• Water, soil and fish were free of heavy elements contaminants.

• Sandy soils ability to retain nutrients is weak to reduce Specific Surface Area.

• Sandy textures also weak ability in assembling heavy elements.

• Fish under study have high-quality meat is free of contaminants.

• The three studied stocks (seabass; seabream & mullet) in Bardawil lagoon is in a situation of overexploitation.

To improve and increase the annual production of fish in Bardawil Lake could be suggested that:

• Periodic follow-up to the quality of the waters of Bardawil Lake and the need to develop a plan to increase the fertility of the water.

• The need to increase the concentration of nutrient water, especially the major nutrient nitrogen, phosphorus and potassium.

• Work on a periodic cleansing of the Boughazes (1&2) to allow the exchange of water between the Mediterranean Sea and the lake.

• Work to create new Boughaz between the sea and the lake.

• Activation of the legislation which criminalizes throwing plankton in the water of the lake.

• Periodic follow-up rates of salinity in the waters of the lake in different locations.

• The need to provide the necessary equipment for the work of radial channels to ensure water exchange between the sea and the last point in the lake.

• Enact laws that prevent over-fishing.

• The need to determine the quality of fishing nets and fishing laws activation and increase the potential for border guards and ways to prevent over-fishing , which works to reduce the productivity of the catch in Bardawil Lake with surrounding economic factors influencing the catch.

• Study dynamic biological and fish next to the production cycle of the commercial fish in Lake Bardawil is considered an important step to lay the foundations for rational ways to manage fisheries in the lake.

• Enact legislation to prohibit and criminalize hunting small fish fry and older fish mature.

• Work on the lake supply sufficient stocks of fish fry and fish mature seabass, seabream, mullet and sole and high quality.

• Establishment of hatchery fish production Freight service to the lake.

• Establishment of nurseries for fish fry high-value next to the lake.

• The need to conduct further studies at intervals to prevent fishing in the lake and re-identified.

• Revise laws of Fisheries and reformulated through periodic follow-ups to work rotating body versions of Fisheries to improve the systems for collecting statistics Fisheries.

• Increase the potential of border guards and activation activities.

• The need to get security controls on the lake and fishing activities by using satellites.

SUMMERY

Bardawil Lake is one of the most important sources of Fisheries in the Sinai and Egypt in general. Bardawil Lake is the second largest lake after Manzala Lake Egypt and before Borollus Lake with an area of 165 thousand acres. Lake Bardawil located in the North Sinai Governorate. It constituted about 22% of the total northern lakes' area and connected to the Mediterranean Sea via two artificial openings in the west named Boughazes (I and II) and two eastern natural openings called Abo-Salah and Zaranik.

Bardawil lagoon is suffered from many problems, which might lead to environment degradation, shortage in fish catch and substantial changes in its ecosystem. So that this study aimed to ecological survey for Bardawil lake including that evaluation of water quality and soil properties; evaluation of plankton and survey to some heavy metals in water, soil and common fish species beside to biological studies including stock assessment of common fish species (mullet, *Mugil cephalus*; seabream, *Sparus aurata*; seabass, *Dicentrarchus labrax*) and management of Bardawil Lake.

Bardawil Lagoon has been divided into 12 stations for water and soil samples collection, while the fish samples are collected from the commercial landings. These stations namely as Kurn Hamd; Boughaz II; El-Kalsa; Matiblis; Mazfak; Tulul; El-Roak; Boughaz I; Rumia; El-Naser; Nigela and Rabba, respectively.

The following is summery of the results obtained:-

1- **Water quality parameters:**

Water temperature ranged between 14.2 °C in January to 31.8 °C in August, depending on the air temperature and the neighboring sites of the sea is the most sites decrease in temperature.

The pH values ranged from 7.6 (at winter) to 8.8 (at summer). Generally, the pH of Bardawil lagoon lies in alkaline side.

The highest value of DO was 6.6 mg/l during February at Boughaz (II), while the lowest value of DO was 1.6 mg/l at Tulul during August. Generally, the highest values of dissolved oxygen recorded during winter while summer recorded the lowest values of DO.

The monthly fluctuation in salinity of the lake ranged between 36.6 to 64.2 g/l. Tulu station recorded the highest values of salinity during the study and Boughazes (I&II) recorded the lowest values.

Total alkalinity in the lake water ranged between 210 mg/l in at Kurn Hamd and 130 mg/l at Rabba.

The annual concentrations of nitrite ranged between 0.014 mg/l at Rumia to 0.053 mg/l at Tulul. The highest concentrations of nitrite recorded at Tulul station during all months of the study.

Ortho-phosphate values ranged between 0.24 mg/l as the highest value at Tulul and 0.01 mg/l as the lowest value at Kurn Hamd; Boughaz (II); El-Kalsa and El-Roak.

The highest value of chlorophyll "a" recorded at El-Kalsa (12.22 µg/l; on May), while the lowest value was at Rabba (0.7 µg/l; on October).

2- Planktons (Phytoplankton & Zooplankton):

The highest total account of phytoplankton recorded at Boughaz (I). While, the lowest total account recorded at El-Roak during all seasons of the study. Average abundance of zooplankton ranged between 149 (org. /l) at El-Roak and 591 (org. /l) at Boughaz (I).

3- Soil properties:

Physical properties of soil:

The particle size distribution of soil the average content of sand in soil were ranged from 45.95 – 89.04 % before the study, where after the

study were from 47.62 – 72.5 %; the average content of silt in soil were ranged from 10.92 – 50.7% before the study, where after the study were from 27.5 – 50.26 %; and the average content of clay in soil were ranged from 0.0 – 3.88 % before the study, where after the study were from 0.0 – 3.36 %.

Organic matter ranged between 4.1 to 12.44% before the study while after ranged from 4.26 to 12.32%. The highest values of organic matter recorded in site Tulul and lowest in Boughaz (II).

pH of soil in Bardawil Lake lie in alkaline side. pH of Bardawil Lake soil ranged between 7.16 to 8.12 before the study, while after pH ranged between 7.96 to 7.24.

Chemical properties of soil:

The average values of salinity in soil ranged from 51.9 to 64.6 g/kg before, while after ranged from 55.5 to 65.5 g/kg.

Calcium and magnesium cations recorded as maximum at Kurn Hamd, Tulul, Mazfak, El-Roak and Matiblis respectively. For (Na^+) cation reach to the maximum value at Boughaz (II).

For anions concentrations (CO_3^{2-}, HCO_3^-, Cl^- and SO_4^{2-}) were fluctuated in the ranges of (0.0-0.0 meq/l, before & after); (32.2-42.5 meq/l, before & 34.5-46.3 meq/l, after); (44.4-47.6 meq/l, before & 47.9-51.9 meq/l, after) & (4.1-10.4 meq/l before& 4.5-11.1 meq/l) respectively.

For the content of nutrients major nitrogen, phosphorus and potassium, we find that the soil is poor in the content of these elements.

4- <u>Heavy metals (water, soil & fish):</u>

Heavy metals in water:

Fe concentration ranged between 138-876 µg/l; Mn concentration ranged between 8-142 µg/l; Zn concentration ranged between 84-612 µg/l; Cu concentration ranged between 5-41 µg/l; Pb concentration

ranged between 4-82 µg/l and Cd concentration ranged between 1-28 µg/l.

Heavy metals in soil:

The maximum values of the studied heavy metals were recorded at Tulul station: Fe, 17.88- 21.55 mg/g; Mn, 646.2 – 844.5 µg/g; Zn, 984 – 1155 µg/g; Cu, 535 – 574 µg/g; Pb, 455 – 512 µg/g and Cd, 276 - 282 µg/g before and after of study period.

The metals concentrations in sediment varied widely and exhibit fluctuations among different metals during before and after. The order of abundance of these metals in Soil of Bardawil Lake as follow: Fe > Mn > Zn > Cu > Pb > Cd.

Heavy metals in fish:

The heavy metals values in the organs of different fish spices (mullet, *Mugil cephalus*; seabream, *Sparus aurata*; seabass, *Dicentrarchus labrax* and sole, *Solea aegyptiaca*), showed that:-

- Accumulation of heavy metals in liver and gills were higher than in muscle in all fish species and ranked as follows liver > gills > muscle.
- Accumulation of Iron had highest concentration values of metals content in different studied organs (liver, gills and muscle) of Mullet; Seabream; Seabass and Sole and the sequence of metals was as follow: Fe > Zn > Cu > Mn > Pb > Cd.
- Accumulation of cadmium and lead in all organs were lesser than other elements in all fish spices and different locations.
- The highest concentrations of studied heavy metals recorded during winter, while the lowest concentrations recorded during summer except Pb and Cd which recorded the highest concentrations during summer and the lowest concentrations during the winter. Lead and cadmium were not detectable in muscles of differ fish species during different seasons expect summer.

- The values of heavy metals in muscles of different fish species were significantly lower than the permissible limits ($p<0.05$). **(WHO, 1984)**.

5- **Stock assessment studies of fish:**

Monthly random samples of the common species mullet (*Mugil cephalus*); seabream (*Sparus aurata*) and seabass (*Dicentrarchus labrax***)** were collected from the landing sites of Bardawil Lagoon during the study period (2010/2011) for stock assessment studies and population dynamics which showed that:-

- Both of European seabass and flathead grey mullet in Bardawil lagoon attained 6 years old, while the maximum life span of gilthead seabream was 4 years. The most dominant age group in the catch is the second age group for European seabass, while that for gilthead seabream and flathead grey mullet was the first age group.
- The back-calculated lengths of *D. labrax* were 23.0, 36.4, 44.8, 51.9, 57.2 and 60.1 cm TL with an annual increment 23.0, 13.4, 8.4, 7.1, 5.3 and 2.9 cm at the end of the 1^{st}, 2^{nd}, 3^{rd} , 4^{th} , 5^{th} and 6^{th} year of life, respectively, while *S. aurata* grew to 17.5, 23.5, 27.3 and 30.1 cm TL with an annual increment 17.5, 6.0, 3.8 and 2.8 cm by the end of the 1^{st}, 2^{nd}, 3^{rd} and 4^{th} year, respectively. The flathead grey mullet attained lengths of 24.5, 38.8, 45.0, 50.2, 54.1 and 57.1 cm TL with an annual increment of 24.5, 14.3, 6.2, 5.2, 3.9 and 3 cm by the end of the 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th} and 6^{th} year of life, respectively.
- The estimated length - weight equations for the three investigated species were:

European seabass : $W= 0.0183\ L^{2.8115}$

Gilthead seabream : $W= 0.0244\ L^{2.7984}$

Flathead grey mullet: $W= 0.0181\ L^{2.8152}$

- The obtained values of L_∞, K and t_0 for the three species were 68.38; 0.34; -0.2 & 35.5; 0.4; 0.054 & 59.78; 0.47; 0.068 for *D. labrax*, *S. aurata* and *M. Cephalus*, according to Back-calculation and Ford-Walford plot.
- According to the computed growth performance index, *D. labrax*, *S. aurata* and *M. cephalus* in Bardawil lagoon are characterized by a higher growth rate than *S. aurata*. Also, the growth rate of these species in Bardawil lagoon is higher than the other places.
- The length at first capture for *D. labrax*, *S. aurata* and *M. cephalus* was less than the length at first sexual maturity mentioned in the previous studies in an indication for the high level of exploitation.
- The total mortality coefficient "Z" values were estimated as 1.19 $year^{-1}$ for *D. labrax*, 2.73 $year^{-1}$ for *S. aurata* and 1.53$year^{-1}$ for *M. cephalus*. The estimated mean value of M was 0.38, 0.59 and 0.51 per year for *D. labrax*, *S.aurata* and *M. cephalus* respectively. Accordingly, the fishing mortality coefficient "F" was estimated as 0.81, 2.14 and 1.04 $year^{-1}$ for *D. labrax*, *S.aurata* and *M. cephalus* respectively.
- The exploitation ratio (E) of *D. labrax*, *S. aurata* and *M. cephalus* estimated as 0.68; 0.78 and 0.67 $year^{-1}$ respectively.
- The estimated $E_{0.5}$ was 0.34; 0.35 and 0.32 while the estimated E_{max} was 0.58, 0.65 and 0.54 for *D. labrax*; *S. aurata* and *M. cephalus* respectively.

It could be concluded that the three studied stocks in Bardawil lagoon is in a situation of overexploitation and to sustain this valuable fishery resource some management measures could be suggested :

1- Periodically observation for water quality of Bardawil Lagoon and controlling of it.

2- Continuous clearance of the openings for exchange of water masses between the lagoon and the open sea.

3- The need to establish radial channels for more water access from the Mediterranean to the last point in the lagoon.

4- Reduction of the present level of fishing effort and an increase in the length at first capture.

5- Regulation of mesh sizes, controlling gear types used and prohibition of the destructive ones and developing suitable fishing gear for shallow lagoons as well as detecting the economic factors affecting the fishery.

6- Monitoring salinities at various seasons and localities.

7- Setting up of a total allowable catch from the lagoon.

8- Revision of fisheries laws and improving the system for collecting and compiling fisheries statistics.

9- Prohibition of fish fry collection especially around the Boughazes and during the spawning migration.