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Research Article

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Some Targeted Reference Points for Thin Lip Grey Mullet *Liza ramada* Management in Bardawil Lagoon, North Sinai, Egypt

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Abstract

The evaluation and management of fisheries resources requires knowledge of spatial and temporal changes in the habitat-associations of fishes as well as studying the biology and dynamics of commercial fishes of that fishery. The thin lip mullet, *L. ramada* is one of the most important and high valued species in Bardawil lagoon, Egypt. Long term commercial catch statistics show a significant decrease in the commercial landings of grey mullet in Bardawil lagoon since 1995. By learning more about this species and protecting the habitat upon which it depends, we can ensure that this important valuable fish remains abundant. Age was determined based on scale's readings of fish collected in May 2017 to December 2017 and in May 2018 to October 2018. Growth parameters, mortality rates, exploitation level as well as the critical lengths and ages were estimated. Based on yield per recruit analysis, the mullet fishery in Bardawil lagoon was found to be heavily exploited. The study suggested some applicable reference points for sustaining and optimizing the thin lip grey mullet yield in Bardawil lagoon.

Keywords: Egypt; Bardawil lagoon; Mugilidae; Population dynamics; Management

Introduction

Grey mullets (Family: Mugilidae) are extremely important fish, which are cultured in many countries due to their high quality flesh, superior growth and wide salinity and temperature tolerance. The grey mullets are the most important fish species inhabiting Bardawil lagoon. Their catches fluctuated between 733 and 1590 ton during the last 15 years [1] forming about 38% of the total lagoon production and 60% from fish production of the lagoon. In 2016, 1548 ton of grey mullets were landed forming a net profit of about 80 million Egyptian pounds. Mullet's catch is composed mainly from *Mugil cephalus*, *L. ramada* and *L. aurata*, while both *Chelon labrosus* and *L. saliens* are found in very small amounts and recorded under the "others" group. Although the mullets in Bardawil lagoon contribute greatly to the economy of Egypt, very limited studies concerning their dynamics and management are available [2-5]. On the other hand, the biology and dynamics of mugilid species were studied in the different water bodies in Egypt [5-13].

Effective management decision making requires knowledge of the state of the fishery relative to management targets or limits, and of the likely responses of the fishery to alternative management options. Providing such knowledge typically in a quantitative form is the aim of fisheries stock assessment [14-16]. To assess fish stock, many detailed information such as age and growth, mortality and exploitation rates should be available. The present paper provides an up to date data about the biology and dynamics of *L. ramada* in Bardawil lagoon required for proposing some targeted reference points for its management.

Materials and Methods

Sampling site

Bardawil lagoon (Figure 1) is one of the northern lakes in Egypt and it is a part of the Mediterranean coastal lands of Sinai. It is an important source of local and economic fishes in North Sinai, and it plays an essential role in the fish production in Egypt, where it produces very economically important species of fishes such as seabass, seabream, sole, grey mullet, eel, meager and white grouper.

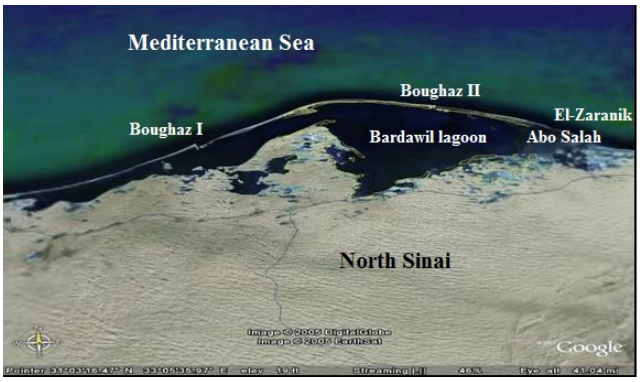

Figure 1: Bardawil lagoon.

Bardawil lagoon is a shallow hypersaline lagoon. Its area is about 685 km^2 extends for a distance of about 95 km, from a point 45 km east of Port Said and extending to a point 18 km west of El-Arish. Its maximum width is 22 km and The average depth is 135 cm with a maximum depth next to inlets 1 and 2, whereas, reach to (2-5) m, while in the main opening reach to (4-7) m. A long sand-bar, (200-1000) m wide maximum, separates the lagoon from the adjacent Mediterranean.

Sampling and measurements

Monthly random samples of *L. ramada* were collected from the Bardawil lagoon during the period from May 2017 to December 2017 and from May 2018 to October 2018 (almost two fishing seasons). The length frequency for about 3000 *L. ramada*, 1080 males (12 cm to 42 cm TL) and 1920 females (11 cm to 47 cm TL), were grouped in 1 cm length groups.

For each fish data on total length (measured to the nearest millimeter), total weight (weighed to the nearest gram), and scale samples were collected. Age determination from scale readings was performed and only 2650 scale (88.3%) were accepted for age determination, the rest (11.7%) were regenerated scales and were rejected.

Length-weight relationship

The general power equation ($W=a\ L^b$) was applied to estimate the length-weight relationship, where a and b are constants whose values were estimated by the least square method. Confidence intervals of 95% were calculated for the slope (b) to see if these were statistically different from 3.

Population parameters

Age composition was constructed based on scales' readings and the resulting mean lengths at age were used in the construction of growth models. The von Bertalanffy [17] growth parameters were estimated using the Ford et al. [18] version as described by FAO [19]. Total mortality rate Z was computed using three different methods; the semi-logarithmic regression method of Ricker [21] as $\text{Ln } N_t=\text{Ln } N_o - Zt$, this is a straight line with a slop equal to −Z, Jones et al. [22] as $\text{Ln(CN)}=a+(Z/K)*\text{Ln}(L\infty-L)$ where CN is the cumulative frequency, K is the growth coefficient and a and b are constants and Hoenig formula [23] as $Z=1/(c_1\cdot(t_{max}-t_c))$ and $SE(Z)=(c_2\cdot Z^2)^{½}$ where the SE is the standard error of the estimated Z, c_1 and c_2 are table values and a function of N [24]. Natural mortality coefficient was calculated as the geometric mean of three different methods; Ursin [25] as $M=W^{-1/3}$, Rikhter et al. [26] as $M=((1.52/t_{mass})^{0.72})-0.16$ and Pauly [27] as $\text{Log}M=-0.0066-0.179\ \text{Log}\ L\infty+0.e43\ \text{Log}\ K+0.4634\ \text{Log}\ T$. where T is the mean annual water temperature of the lagoon.

Critical lengths and ages

The length at first capture (L_c) was estimated by the analysis of catch curve using the method of Pauly [28]. The length at first sexual maturity Lm was estimated by the empirical formula of Froese et al. [29] as $\text{Log}\ L_m=0.8979\ \text{Log}\ L_\infty-0.0782$. While the corresponding age at first sexual maturity (T_m) was computed using the von Bertalanffy growth equation as $T_m=t_0-(1/k*\ln[1-(L_m/L_\infty)])$. Besides, the smallest individual in the catch was considered as the length at recruitment L_r.

Relative yield per recruit (Y'/R)

The model of Beverton et al. [30] as modified in Pauly et al. [31] was applied to analyze the relative yield per recruit (Y'/R) of *L. ramada* as follows:

$$(Y'/R)=EU(M/K)\ [1-3U/(1+m)+3U2/(1+2m)-U3/(1+3m)]$$

Where: $M=1-E/(M/K)=K/Z$ and $U=1-(L_c/L_\infty)$.

Resource status

Resource status was evaluated by comparing estimates of the fishing mortality rate with target (F_{opt}) and limit (F_{limit}) biological reference points (BRP) which were defined as: $F_{opt}=0.5M$ and $F_{limit}=2/3M$ [32].

Results and Discussion

The present study has established some target reference points for management the *L. ramada* stock which are exploited in Bardawil lagoon, Egypt. These regulations are suggested based on the study of population parameters and biological characteristics of this species including age and growth, length-weight relationship, mortality and exploitation rates and yield per recruit.

Age and growth

Scales were used for age determination of *L. ramada* collected from Bardawil lagoon. Scales have been proven as a reliable and valid method for ageing grey mullets [3,12,33-39]. The results showed that the maximum life span of *L. ramada* is five years for males and seven years for females and age group one was the most frequent group in the catch. The back-calculated lengths were (19.25, 28.08, 33.92, 38.71 and 40.94) cm for males for 1st, 2nd, 3rd, 4th and 5th year of life respectively and (20.15, 29.04, 35.19, 39.2, 42.39, 44.89 and 46.31) cm for 1st, 2nd, 3rd, 4th, 5th, 6th and 7th year of life respectively for females. The greatest incremental growth in length occurred during the first year of life and declined gradually thereafter (Figure 2). The same finding was recorded in the previous studies in different localities (Table 1) [3,12,13,33,34,36,37,39-41].

Locality	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
Medit. Coast	14.7	23.8	31.4	37.7	41.7	46.2	-	-
Nozha hydrodrom								
Male	16.8	24.2	33.2	-	-	-	-	-
Female	18.1	26.8	36.4	44.5	-	-	-	-
Lake Timsah								
Male	19.4	23	25	-	-	-	-	-
Female	21.6	25.4	29.9	32.1	34.9	41.8	-	-
Lake Borollus	12.8	17.5	23.1	29	32	34.7	-	-
Wadi El-Raiyan	20.1	28.6	34.6	39.1	42.9	45.8	47.8	48.9
Bardawil lagoon	21.09	30.05	36.33	39.26	41.08	-	-	-
Lake Timsah	20.35	29.24	35.49	38.91	41.21	-	-	-
Bitter lakes	19.75	28.88	34.12	38.71	40.64	-	-	-
Bardawil lagoon								
Male	19.25	28.08	33.82	38.11	40.24	-	-	-
Female	20.15	29.04	35.19	39.2	42.39	44.93	46.31	-

Table 1: Length at age (cm) of *L. ramada* given by different authors in the Egyptian water bodies.

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Length-weight relationship

A total of 3000 individuals of *L. ramada* have been collected from the commercial landings in Bardawil lagoon. The total lengths of males varied from 12 cm to 42 cm, while their weights ranged between 20 g and 670 g. The total lengths of females varied between 11 cm and 47 cm TL and between 15.8 g and 790 g in weight. The length-weight relationship equations were: $W=0.0173\ L^{2.7695}$ for males and $W=0.0173\ L^{2.7687}$ for females (Figure 3). The allometry coefficient of the length-weight relationship indicates negative allometric growth. Also, there is no significant difference between sexes in length-weight relationship. The b-value is more or less similar to that obtained by the previous workers (Table 2).

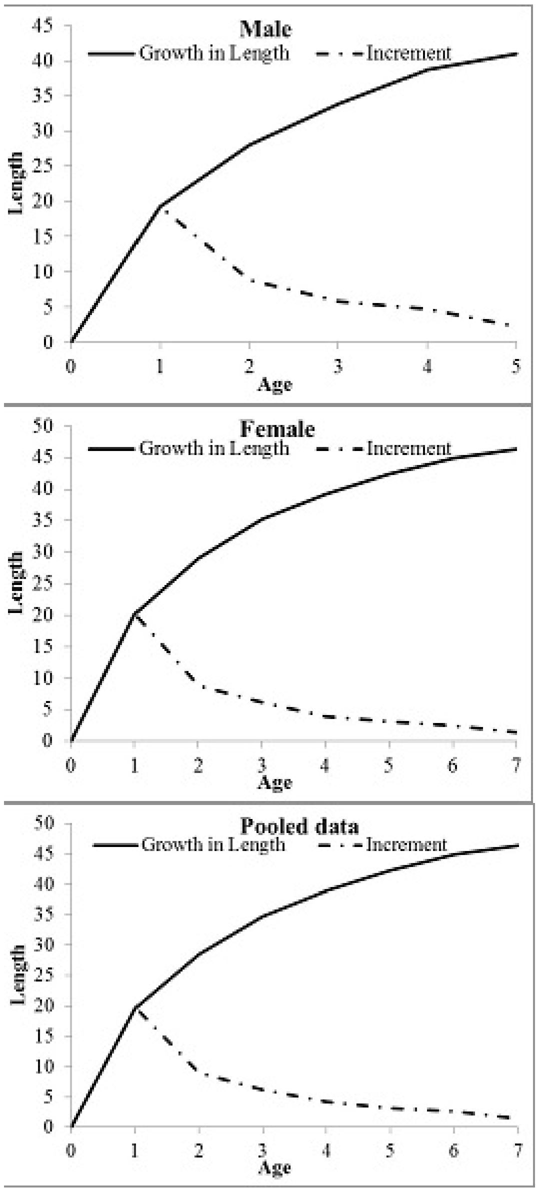

Figure 2: Growth in length and growth increment of *L. ramada* from Bardawil lagoon.

The difference between estimated b-value between localities and in the same area in different periods is may be due to the fact that b-value could be an indicator of the physiological condition of the fish and vary seasonally in response to seasonal variations in environmental condition and changes in the fish wellbeing [42]. The length-weight relationship and the b value can also be influenced by fishing pressure that excessively catches the adults. This is can explain the difference in growth type in Bardawil lagoon in 2006 and in the present study.

Locality	b
Egyptian Mediterranean	2.9142
Lake Mariut	2.8715
Lake Manzalah	2.9287
Lake Borollus	2.8071
Nozha hydrodrome	3.1066
Lake Temsah	2.806
Lake Borollus	3.0764
Wadi El-Raiyan Lakes	3.0719
Bardawil lagoon	3.134
Bardawil lagoon	2.7509

Table 2: "b" constant of length-weight relationship of *L. ramada* in different Egyptian water bodies.

Population parameters

Parameters of the Von Bertalanffy growth function were calculated for *L. ramada* population in Bardawil lagoon, the parameters of growth were $L_\infty=45.79$ cm TL, K=0.40 per year and $t_0=-0.36$ year for male, $L_\infty=49.92$ cm TL, K=0.35 per year and $t_0=-0.41$ year for female and for pooled data were $L_\infty=50.25$ cm, K=0.34 per year and $t_0=-0.42$ year. Thomson et al. [43] mentioned that the average K value for this species is 0.15 per year and varies between 0.11 and 0.45 per year, which is in accordance to the findings of our study. The K-value indicates that this species undergoes a rapid growth. Also, the negative t_0 value worked out in the present study indicated faster growth rate at the juvenile stage [19,44-46].

As there is no sex specific fishing gear in Bardawil lagoon, the growth parameters for sexes combined were used for the subsequent calculations. Total mortality (Z) was estimated at 1.38 per year, natural mortality was estimated at 0.42 per year, while the fishing mortality was estimated at 0.96 per year. The exploitation ratio was computed at 69.6%. Based on the mortality data, the percentages of non-survivors were: From natural causes =1−e-M=34.3% and from fishing =1−e-F=61.7%.

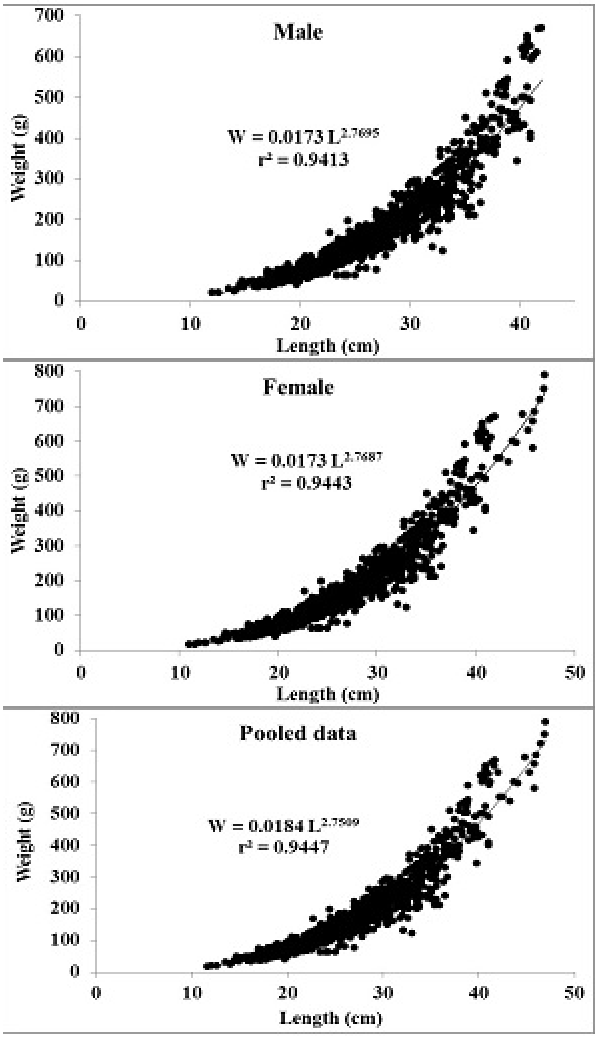

Figure 3: Length-weight relationship of *L. ramada* from Bardawil lagoon.

Critical lengths

Length at first sexual maturity Lm is of great importance when determining the optimum mesh size and SSB. The Lm of *L. ramada* in Bardawil lagoon fishery was found to be 28.2 cm TL for sexes combined. The corresponding age was 1.9 yrs, which means that the exploited *L. ramada* must be protected till their second year of life in order to be able to spawn at least once. The estimated length at first capture L_c in the present study was 22.9 cm TL. Both the estimated L_c and the observed lengths of fish captured indicated growth and recruitment overfishing. In the light of these results, a minimum size limit should be implemented for *L. ramada* in Bardawil lagoon.

Reference points and management

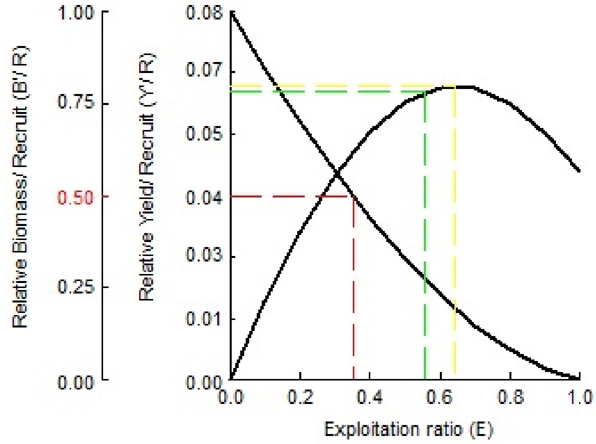

Figure 4: Relative yield per recruit analysis of *L. ramada* from Bardawil lagoon.

The relative Y/R analysis (Figure 4) showed that the EMSY was 0.65 which is lower than the current one (0.696), so the current E should be reduced from 0.696 to 0.65. For the sustainability of this fishery resource, it should be work at E value that conserves 50% of the spawning stock. In the present study the $E_{0.5}$, the target reference point, was 0.32 and the current E should decrease from 0.696 to 0.32.

Conclusion

In conclusion, the obtained F (0.96) and E (0.696) values revealed that the thinlip grey mullet in Bardawil lagoon is overexploited. It is worth mentioning that the excessive fishing effort is not the only reason responsible for the declining of fishery resources in the lagoon, the illegal harvesting of fish fry and spawners, using destructive fishing methods as well as gazzering the sea grasses which represent the shelter and nursing areas for grey mullets are other important reasons. There are many efforts now to maintain the different fish stocks in the lagoon such as prohibition of destructive gears, dredging the boughazes (the connections with the sea) and monitoring the illegal fishing practices in the lagoon but more detailed study about the interaction between species and between species and the ecosystem as well as the multiple objectives of all stakeholders should be done.

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