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Fisheries Management based on Yield per Recruit Analysis of the Sammara Squirrel Fish (*Neoniphon sammara*; Forsskal, 1775) from Hurghada, Red Sea, Egypt

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ABSTRACT

The present study used the assessment models to evaluate the fishery status of *Neoniphon sammara* in Hurghada fishing area, Red Sea, Egypt. The critical lengths of *N. samara* were estimated at 17.1, 14 and 15.7cm for length at first capture (L_c), length at recruitment(L_r) and length at first sexual maturity respectively with corresponding ages 2.99, 2.0 and 2.50 year respectively. Estimated L_m in relation to estimated L_c revealed that there is no risk on the sammara squirrel fish stock in Hurghada fishing area. Yield per recruit analysis with different values of T_c and M showed that Y/R and B/R are more affected by natural mortality than age at first capture. Relative yield per recruit analysis revealed that *N. sammara* in Hurghada, Red sea Egypt is over exploited where the current exploitation rate (E= 0.57) is much higher than $E_{0.5}$= 0.39. Target (F_{opt}) and limit (F_{limit}) biological reference points (BRP) compared to current F revealing that *N. sammara* in Hurghada, Red Sea is overexploited. To protect the fish stocks of *N. sammara* in Hurghada, Red Sea, the fishing effort should be reduced by reduction of fishing vessels and/or reduction of fishing hours.

INTRODUCTION

Family Holocentridae (squirrelfishes) are a group of commercially important demersal species in Egypt. They mainly inhabit coral reef and rocky regions (**Randall & Heemstra, 1985**) and they live at depths ranging from 0 to 46 m (**Lieske & Myers, 1994**). This family comprises eight genera and up to 90 species that are distributed in the tropical Atlantic, Indian, and Pacific Oceans (**Froese & Pauly, 2023**). Holocentrids are well known reef-dwellers with nocturnal habits. It feeds on small fishes, small crabs, and shrimps at night (**Sommer *et al.*, 1996**).

Fisheries in Egypt require sustainable management to achieve the potential sustainable catch and to ensure the greatest benefit to the fishermen and to the country especially those of the Red Sea that are among the most diverse and interesting water bodies (**FAO, 1985; Mohammad, 2007**).

Stock assessment of commercially important fishes, if not controlled will lead to a collapse of all fish species caught for food and commercial purposes (**Worm *et al.*, 2006**). This is because, stock assessment gives the basic information for determination the status of commercially important fishes and managing their fishery sustainability (**Ecoutin*et al.*, 2005**).

Yield per recruit (Y/R) analyses provides an alternative means of assessing fish populations for which there is some knowledge of growth and mortality (**Thompson and Bell, 1934; Ricker, 1945, 1958, 1975; Beverton and Holt, 1957**).

The present study is the first attempt to estimate the critical lengths and to analyze the yield per recruit of the sammara squirrelfish, *N. sammara* from Hurghada fishing ground, Egyptian Red Sea. Thus, this study aims to evaluate the status of *N. samara* fisheries in the Red Sea.

MATERIALS AND METHODS

1. Age and population parameters

Age and growth parameters, mortality and exploitation rates were derived from **El-Mahdy *et al*. (2023**) (Table 1).

Table 1. Length-weight relationship and population parameters of *N. sammara* from El-Mahdy *et al.* (2023)

a	0.026
b	2.756
L_∞	26.49
K	0.28
$t_\circ$	-0.71
Z	1.39
M	0.57
F	0.82
E	0.59

Where; a, b are length-weight constants, $L\infty$, K, $t_\circ$ are the von Bertalanffy parameters; Z, M, F are total, natural, fishing mortality rates resspectively and E is the exploitaion rate.

2. Critical lengths and its corresponding ages

2.1 Length and age at recruitment

The length at recruitment (L_r) was determined as the smallest squirrel fish specimen in the catch, while the age at recruitment (T_r) was computed as the youngest fish in the sample.

2.2 Length and age at first capture

The length at first capture (L_c), the length at which 50% of the squirrelfish retained in the gear was estimated by the analysis of catch curve using the method of **Pauly (1984**), while the corresponding age at first capture (T_c) was computed by converting L_c to age using the von Bertalanffy equation (**Gulland and Holt, 1959**) as follows:

$T_c = t_0 - (1/k * \ln[1- (L_c /L_\infty)])$

2.3 Length and age at first sexual maturity

The length at first sexual maturity (L_m), the length at which 50% of squirrel fish reach their sexual maturity was estimated by the empirical relationship of Froese and Binohlan (2000) 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 as follows:

$T_m = t_0 - (1/k * \ln[1- (Lm /L_\infty)])$

3. Management

3.1 Yield per recruit (Y/R) model

The steady-state model of Beverton and Holt (1957) using the Gulland (1969) formula as mentioned in Sparre and Venema (1998) was applied, the formula is expressed as: $Y/R= Fe^{-M(Tc-Tr)}\, W\infty*[(1/Z)– (3S/ (Z+k))+(3S^2/(Z+2k)- S^3/(Z+3k)]$

Where $S = e^{-k\,(Tc – to)}$ and $W\infty$ = asymptotic body weight.

3.2 Relative yield per Recruit (Y/R)' model

Beverton and Holt (1966) model was used to analyze the relative yield per recruit (Y/R)' of *N. sammara* as follows:

$$(Y/R)' = E*U\ (M/K) * [1- 3U/(1+m) + 3U^2 / (1+2m)- U^3/ (1+3m)]$$

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

RESULTS AND DISCUSSION

1. Critical lengths and its corresponding ages

Length at recruitment, length at first capture and length at first sexual maturity are important parameters for determination the optimum length for catch and fishing prohibition time (**Mehanna *et al.*, 2018; Osman *et al.*, 2021; Hassanien and Mehanna, 2022).**

Length (Lr) and age (Tr) at recruitment

Recruitment can be described as births, i.e. number of fish born within a given time interval that survive to the juvenile stage (**Kilduff *et al.*, 2009**). Recruitment also refers to the entrance or addition of young fish each year into an exploited fishing area where they become vulnerable to a particular size (**Pauly, 1984**).

The length at recruitment (L_r) was determined as the smallest length in the collected sample, while the corresponding age at recruitment (T_r) was the youngest fish in the sample

In the present study, length at recruitment (L_r) of *N. sammara* was 14 cm and age at recruitment (T_r) was 2.0 year.

Length (L_c) and age (T_c) at first capture

The length at first capture L_c is used for detection the appropriate mesh sizes of applied gears (**Mohammed *et al.*,2020**). For *N. sammara*, length at first capture (L_c) was estimated at17.1 cm which is corresponding to an age T_c of 2.99 year. Figure (1) shows the probability of capture of *N. sammara* from Hurghada, Red Sea, Egypt. The probability of capture values were estimated as L_{25}= 16.48 cm, L_{50}= 17.1 cm and L_{75}= 17.71 cm.

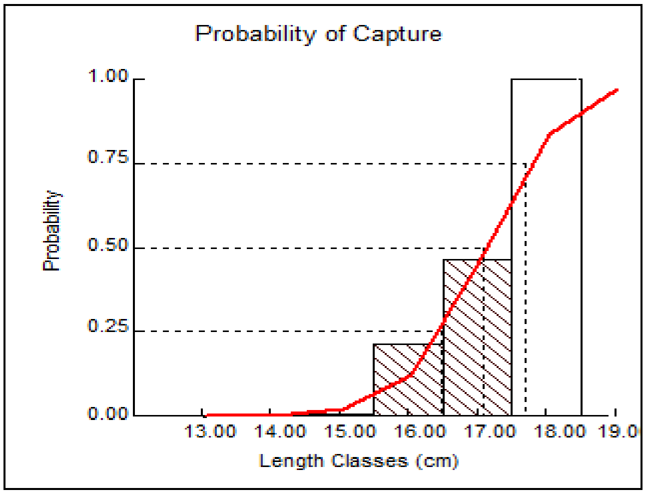

Fig. 1. Probability of capture of *N. sammara* from Hurghada, Red Sea, Egypt.

Length (L_m) and age (T_m) at first sexual maturity

The age at first maturity (L_m) in relation to the age at first capture (L_c) can be considered as a biological reference point for any target species. If $T_c$fall below T_m, there is a risk of recruitment over fishing (**Froese and Pauly, 2000**). In the present study, The length at first sexual maturity (L_m) of *N. sammara* was estimated at 15.7 cm TL and consequently the age at first maturity was 2.50 year. Fortunately estimation of L_m and (in turn T_m) in relation to L_c referred to the no risk of recruitment overfishing of squirrel fish species under investigation.

2. Management

Fishery managers can control the two parameters "F" and "T_c" because "F" is proportional to the fishing effort and "T_c" is related to the mesh size (**Mehanna, 1997**).Beverton and Holt's yield per recruit (Y/R) model allows to calculate Y/R with different values of F and T_c and then assess the effect of various input values on Y/R . Moreover, Beverton and Holt's biomass per recruit (B/R) were also considered and hence the effect of mesh size was assessed under current growth characteristics.

Yield per recruitment model

Yield per recruit is the expected yield per fish recruited in the stock at a specific age; it plays an important role in fisheries management, as it relates to size controls (**Restrepo, 1999**). Fisheries management needs estimates of harvest levels that provide maximum yield on a long term basis. **Beverton & Holt (1957)** model can be used to predict the effects of assessment and management measures, such as increase or decrease of fishing fleets, changes in mesh sizes, etc.

In the present study, the yield per recruit (Y/R) of *N. sammara* was estimated by means of **Gulland's (1969)** equation. Figure (2) shows that the curve starts at the origin, where the yield-per-recruit and fishing mortality are zero, then the yield-per-recruit increases as fishing mortality increase. It is noted that there is no definite MSY's for the curve. MSY/R may be estimated in higher fishing mortalities beyond F= 6.

To study the variation in yield per recruit with changing of age at first capture (T_c) which is related to the estimation of optimum mesh size, the yield per recruit of *N. sammara* was calculated using different values of T_c; T_c= 1.5, 2.99 (current) and 4 years (Fig. 2). The present level of T_c is optimum for the stock of *N. sammara* in Hurghada fishing area. Therefore, keeping T_c at the present level will permit harvest of most of the potential yield and avoid stock-recruitment problems.

Figure 3, shows the effect of natural mortality (M) on yield per recruit using different values of M; M= 0.40, 0.57 (current), 0.80 y^{-1}. It is noticed that with the increase of M, the Y/R decreases, i.e. the natural mortality affects the fish production directly. This may be related to a high level of competition, predators and unfavorable environmental conditions such as pollution, high temperature and climate change.

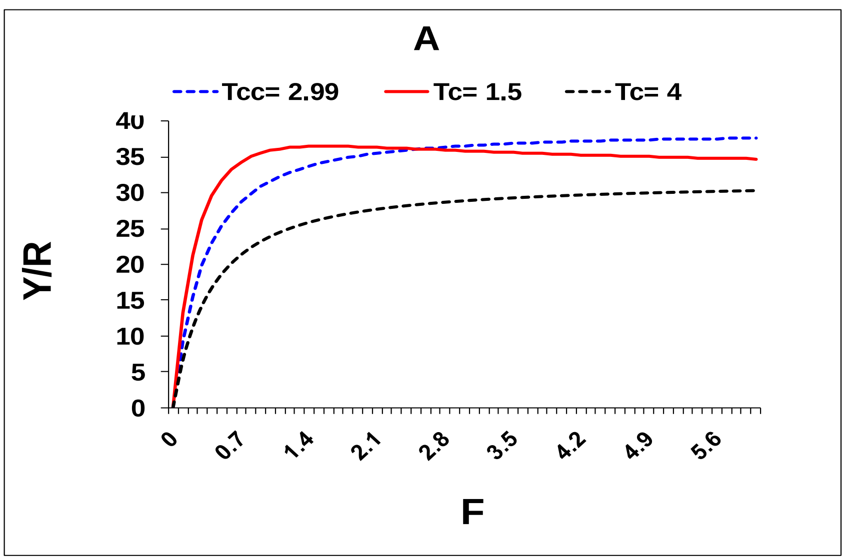

Fig. 2. Yield per recruit (g) of *N. sammara* collected from Hurghada, Red Sea, Egypt as a function of fishing mortality (F) and different ages at first capture (T_c)

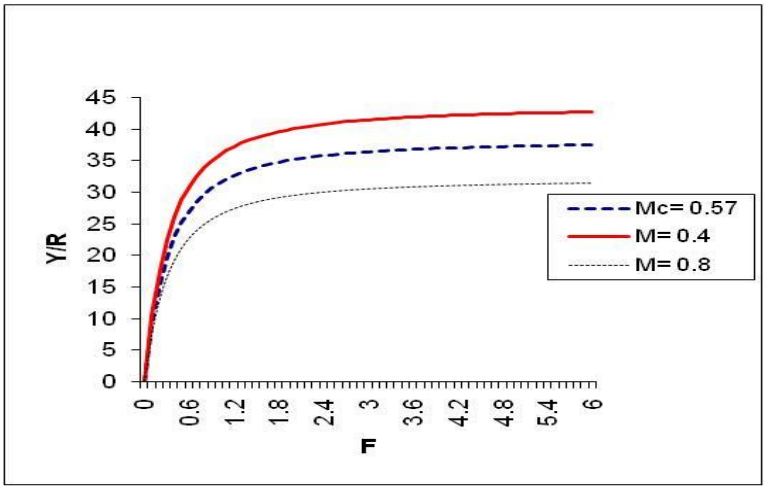

Fig.3. Yield per recruit (g) of *N. sammara* collected from Hurghada, Red Sea, Egypt as a function of fishing mortality (F) and different natural mortality rates (M).

Relative yield per recruit model

The relative yield per recruit (Y/R)'and relative biomass per recruit (B/R)' were estimated by the model of **Beverton and Holt (1966).** This model allows to calculate (Y/R)' for different values of exploitation rate. The length-at-first-capture (L_c) is an important input in the computation of relative yield-per-recruit, relative biomass-per-recruit and in estimation of the exploitation level that produces the maximum yield-per-recruit (E_{max}).

In the present study, the current exploitation rate is E= 0.59 and the exploitation rates obtained from (Y/R)' analysis were $E_{0.1}$= 0.66; $E_{0.5}$= 0.39 and E_{max}= 0.79. The current E is lower than the E which achieves the maximum (Y/R)' and higher than $E_{0.5}$ which conserve 50% of the spawning stock biomass. From management point of view, the exploitation rate should be reduced from 0.59 to 0.39 (34%) to protect the spawning stock biomass of *N. sammara* (Fig. 4).

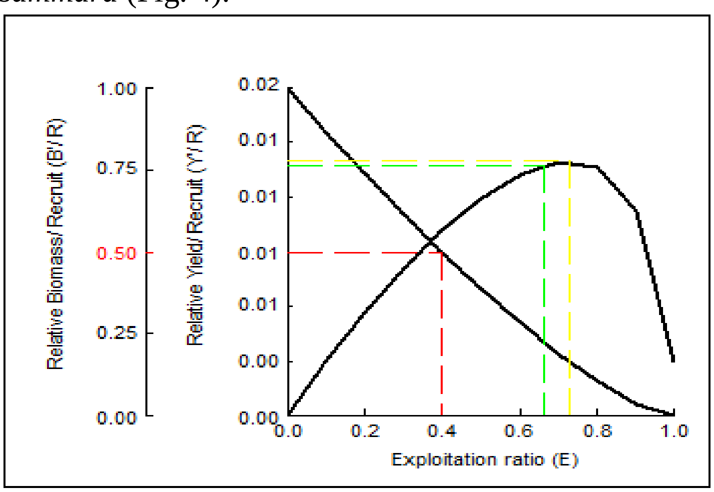

Fig. 4. Relative yield per recruit for *N. sammara* collected from Hurghada, Red Sea, Egypt.

3. Biological reference points

Fisheries status was evaluated by comparing estimates of the current fishing mortality rate with target (F_{opt}) and limit (F_{limit}) biological reference points (BRP) which were defined as: F_{opt} = 0.5M so that E= 0.5 (**King, 2007**) and F_{limit} = 2/3M. The present F was much higher than F_{opt} and F_{limit} revealing that *N. sammara* in Hurghada, Red sea is overexploited.

CONCLUSION

In conclusion, the samara squirrel fish *N. sammara* is in situation of growth overfishing due to higher fishing pressure on the stock. Proper management of this resource requires reduced exploitation and fishing effort by reduction of number of fishing vessels and/ or reduction of fishing hours.

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