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Dynamical parameters and relative yield per recruit of the Japanese anchovy *Engraulis japonicus* (Schlegel, 1846) in the Gulf of Suez, Red Sea, Egypt

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ABSTRACT

Pelagic fishes, caught by purse seine in the Gulf of Suez, represent up to 65 % of the total annual fish production from the Gulf (GAFRD, 1999-2012), hence they contribute to a major fishery in Egypt. The most represented pelagic fish species in the purse seine catch are; anchovy, carangids, clupeids and scombrids. The population dynamical parameters of Japanese anchovy *Engraulis japonicus* are estimated based on 4086 specimen (3.1 – 10.4 cm TL), collected from the Gulf of Suez during the fishing season 2011/2012. The growth of this species is positive allometric based on the b-value of length weight relationship. From the length frequency distribution analysis, the population parameters were: asymptotic length $L\infty$ = 12.27 cm TL, growth coefficient K = 0.66/y, total mortality Z = 2.58/y, natural mortality M = 1.00/y, fishing mortality F = 1.58, exploitation ratio E = 0.61/y, length at recruitment L_r = 3.1 cm TL, length at first capture L_c = 6.1 cm TL and length at first sexual maturity L_m = 5.9 cm TL. The high values of both F and E reflect the over exploitation situation. The relative yield per recruit Y'/R analysis shows that although the maximum Y'/R achieved at higher E (0.71) than the current one, the E value which will conserve 50% of the spawners is much lower (0.36). From the management point of view, the exploitation level of Japanese anchovy stock should be reduced by at least 30% to conserve and optimize its yield.

INTRODUCTION

The pelagic fish community of the Suez Gulf is large, and includes representatives of the horse mackerel, scads and jacks "Family: Carangidae"; anchovies "Engraulidae"; sardines and sardinellas "Clupeidae"; mackerels "Scombridae"; barracudas

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"Sphyraenidae" and silversides "Atherinidae" (**Elsherbeny, 2015**). Recently, anchovies are considered one of the most abundant pelagic fish in the Gulf of Suez, and is represented by one species; the Japanese anchovy *E. japonicus*.

E. japonicus has been caught by purse seine net, has a commercial interest in the Gulf of Suez fisheries, due to the gradual increase in the catches during the last few years. *E. japonicus* is not only an important species for commercial fishing; it is also a major food source for other economically important fishes in the Gulf.

Since *E. japonicus* is being caught and consumed in large amounts in the Gulf of Suez, the objective of the current study was to estimate the dynamical parameters of *E. japonicus* to obtain basic information necessary for an appropriate management system for it. This study is considered the first investigation to *E. japonicus* population dynamics, stock assessment and its fishery management in Egypt.

MATERIALS AND METHODS

A total of 4086 *E. japonicus* specimens were collected from Ataka fishing harbor, in the Gulf of Suez (**Fig. 1**), between September 2011 and May 2012.

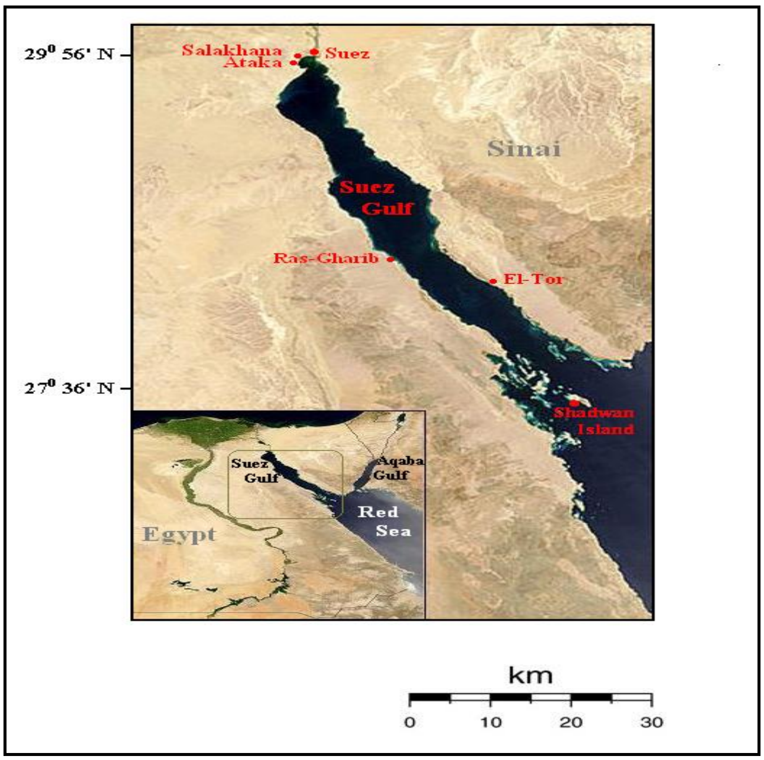

Fig. 1. A map of the Gulf of Suez showing the main four fishing harbors along it; Salakhana, Ataka, Ras Gharib and El-Tor.

- To calculate length - weight relationship for *E. japonicus*, the commonly used equation: $W = a L^b$ was applied, where W = the total weight (g), L = the total length (cm) and a & b are constants computed by **Beckman (1948) and Le Cren (1951)**.

- The FISAT II software (**Gayanilo *et al.*, 1997**) was used for data analysis.
- Estimates of the asymptotic length ($L\infty$), growth coefficient (K) were computed according to **Powell (1979) - Wetherall (1986) and ELEFAN I (Pauly, 1987)**. The growth performance index "$Ø'$" described in **Pauly and Munro (1984)** was calculated using the equation $Ø' = Log_{10} K + 2 Log_{10} L_{\infty}$.
- Total mortality coefficient "Z" was calculated by two methods; **Jones and Van Zalinge (1981) and Pauly (1983)** methods. Natural mortality coefficient "M" was estimated by two methods; **Ursin's method (1967)** as $M = W^{-1/3}$ and **Pauly's empirical equation (1980)** as $\log M = -0.0066 - 0.279 \log L_{\infty} + 0.6543 \log K + 0.4634 \log T$, Where T = average annual temperature of the stock's habitat in °C. Fishing mortality coefficient "F" was estimated as F = Z – M. The exploitation ratio "E" was estimated by the formula suggested by **Gulland (1971)** through the relation E = F / Z.
- Critical lengths; length at recruitment L_r, length at first capture L_c and length at first sexual maturity L_m were determined. L_r is considered as the smallest fish in the catch; L_c (the length at which 50% of the fish retained in the gear) was estimated by the analysis of catch curve using the method of **Pauly (1984)**, while L_m was estimated by fitting the percentage maturity against mid lengths. L_m was estimated as the point on X-axis corresponding to 50% point on Y-axis.
- Relative yield per recruit (Y/R)' model was performed according to the procedures of **Beverton and Holt (1966)** as follows: $(Y/R)' = EU^{M/K} [1 - (3U/1+m) + (3U^2/1+2m) - (U^3/1+3m)]$ Where: m = (1-E)/(M/K) = (K/Z) and U = 1 - (Lc/L∞).

RESULTS AND DISCUSSION

1. Length – Weight Relationship:

A total of 4086 specimens "sexes combined"; of *E. japonicus* (3.1 – 10.4 cm total length & 0.12 – 8.2 g total weight) were used for the estimation of total length - body weight relationship (Fig. 2), and the equation was $W = 0.004TL^{3.281}$ ($R^2 = 0.905$). The value of the exponent (b) was over 3, indicating positive allometry growth. No previous estimates of "b" have been published for *E. japonicus*.

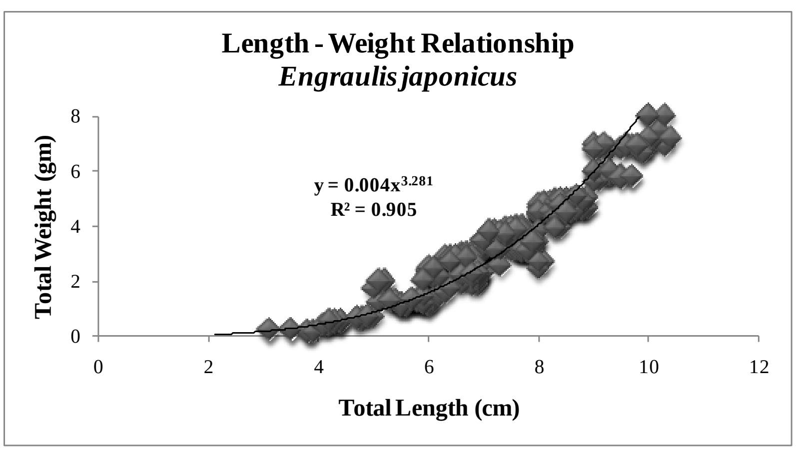

Fig. 2. Length – Weight Relationship of Japanese Anchovy *E. japonicus*.

2. Growth Parameters & Growth Performance Index:

The von Bertalanffy growth parameters "L∞ and K" for *E. japonicus* were estimated using the methods of Powell (1979) - Wetherall (1986) and ELEFAN I (Pauly, 1987) (Fig. 3). It is clear that there is a good agreement between the values of the two applied methods. So, the values obtained by Powell - Wetherall were chosen for subsequent calculations. The obtained value of asymptotic lengths "L_∞" was 12.27 cm, whereas the obtained results of "K" was 0.66 / year and the computed value of growth performance Index (Ø') equals 2.02. Because of the lack of published data of Japanese anchovy growth parameters in the Egyptian waters, it is not possible, to compare the value of "$L_{\infty,}$ K" in the present study with those of the same species in other areas. Thus, present results provide the first estimates for this species. On the other hand, few studies about this species were found worldwide. Barange *et al*. (2009) and Yatsu (2019) stated that small pelagics like Japanese anchovy are short-lived and fast-growing, and are characterized by high and often variable levels of natural mortality, resulting in the dependence of their stock size on recruitment. Liang and Pauly (2017) determined the growth parameter K at 0.51 per year and the asymptotic length at 15.73 cm in China.

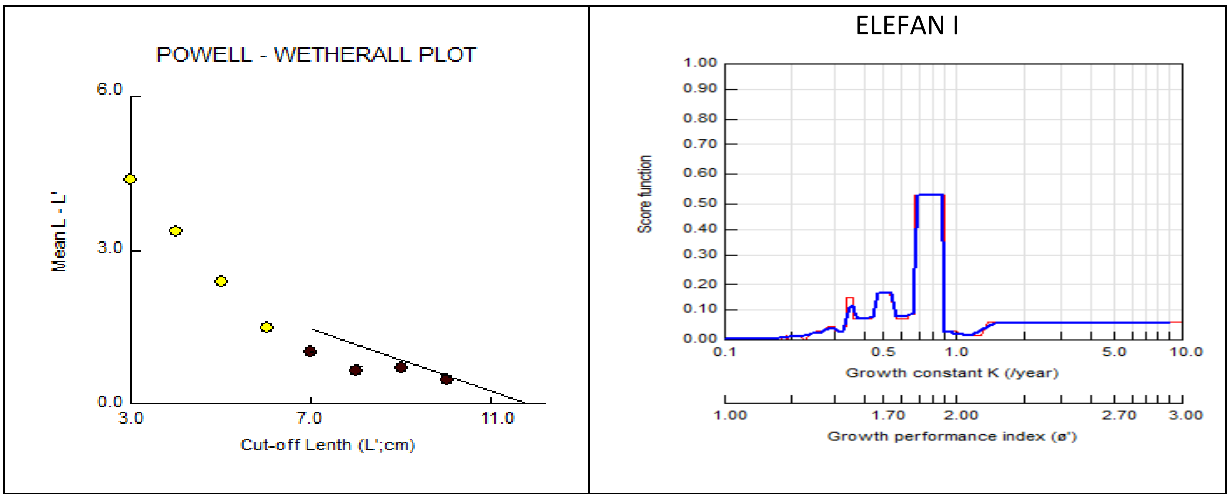

Fig. 3. Powell – Wetherall and ELEFAN I plots of Japanese Anchovy *E. japonicus*.

3. Mortality and Exploitation Rates:

The mean values of total mortality coefficient (Z), for *E. japonicus* estimated from the two methods; Jones and Van Zalinge (1981) as well as Pauly (1983) (Figs. 4) , was 2.58/year. On the other hand the mean value of natural mortality coefficient (M) was 1.00/year, correspondingly the value of fishing mortality coefficient (F) was 1.58/y. The estimated exploitation ratio (E) was 0.61/year, which seemed to be higher than the optimum level of exploitation (E = 0.5), that is based on the assumption that a stock is optimally exploited at E = 0.5 when F equals M (Gulland, 1971). So this high value of "E" indicating that the stock of *E. japonicus* is overexploited. No previous studies concerning the estimation of mortality coefficients and exploitation ratio were carried out on Japanese anchovy.

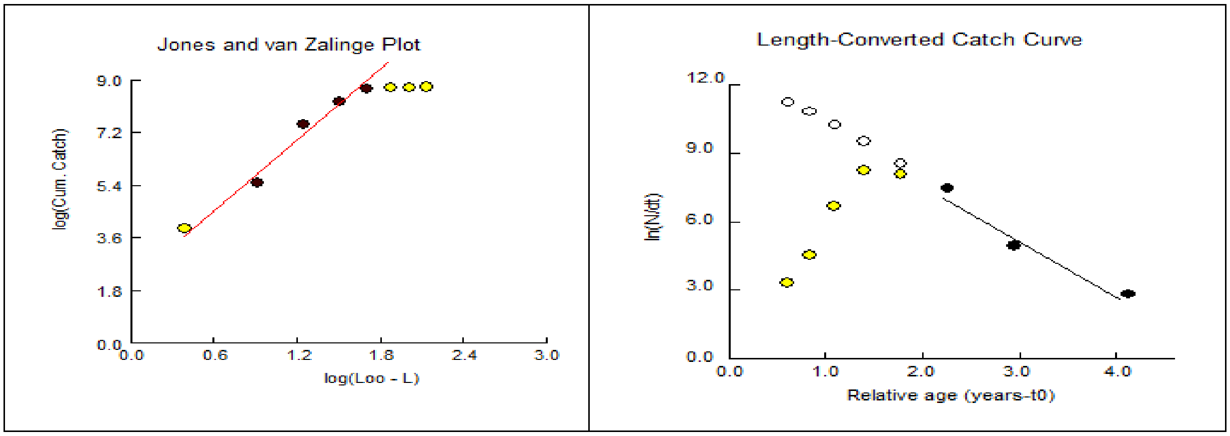

Fig. 4. Cumulative catch curve and length converted catch curve of *E. japonicus*.

4. Critical Lengths:

The smallest individual measured in this work (L_r) for *E. japonicus* was 3.1 cm, while the value of L_c was 6.1 cm, whereas the value of L_m was 5.9 cm (Fig. 5). The small individuals recorded in the catch (L_r) indicating very small mesh sizes that prevent them from escaping. This is an indicator for over-fishing where they caught before they grow large enough to contribute substantially to the stock biomass. Additionally, the estimated values of L_c was found to be less than the estimated L_m which was further evidence of over-fishing that prevent them from spawning at least once before being fished.

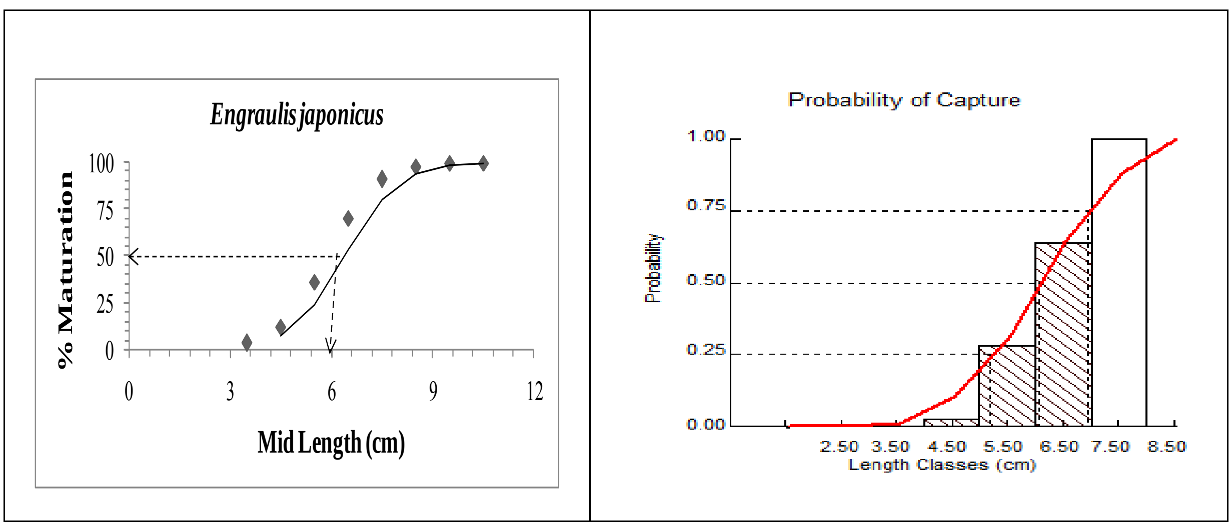

Fig. 5. Lengths at first maturity and at first capture for Japanese Anchovy *E. japonicus*.

5. Relative Yield per Recruit:

The maximum allowable limit of exploitation level (E_{max}) that gives the maximum relative yield-per-recruit and the exploitation level ($E_{0.5}$) which corresponds to 50% of the relative biomass per recruit of the unexploited stock for *E. japonicus* were estimated from the plot of Relative Yield per Recruit (Y'/R) against E that showed in Fig. 6. The estimated values of E_{max} and $E_{0.5}$ were 0.71 and 0.36, respectively. The present relative yield per recruit analysis showed that the current estimated exploitation rate (0.61 /year) is above the predicted $E_{0.5}$ value of 0.36. The implication is that the stock of Japanese anchovy in the Gulf of Suez is overexploited.

Finally, the obtained results indicated that the Japanese anchovy *E. japonicus* stock in the Gulf of Suez is in a situation of overexploitation, so, the fishing effort must be reduced as well as the age at first capture must be raised to maintain the productivity of this stock.

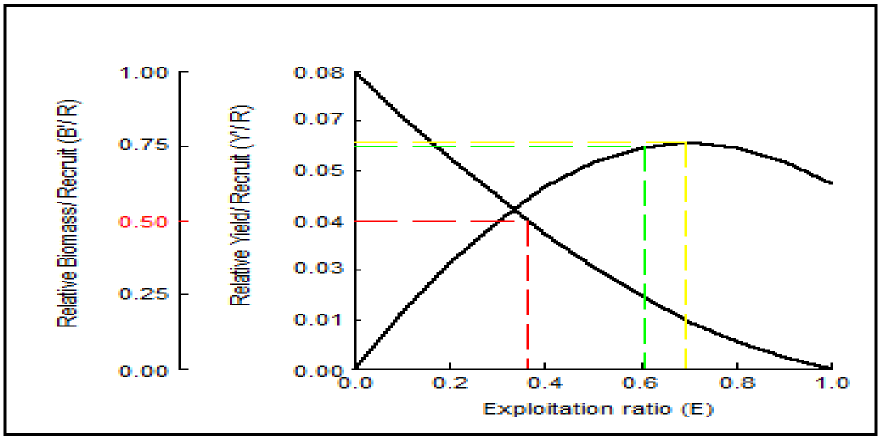

Fig. 6. Relative yield per recruit curve of Japanese Anchovy *E. japonicus*.

REFERENCES

Barange, M.; Bernal, M.; Cercole, M.C.; Cubillos, L.; Cunningham, C.L.; Daskalov, G. M.; De Oliveira, J. A.; Dickey-Collas, M.; Hill, K.; Jacobson, L.; Køster, F.W.; Masse, J.; Nishida, H.; Niquen, M.; Oozeki, Y.; Palomera, I.; Saccardo, S. A.; Santojanni, A.; Serra, R.; Somarakis, S.; Stratoudakis, Y.; van der Lingen, C.D.; Uriarte, A. and Yatsu, A. (2009). Current trends in the assessment and management of small pelagic fish stocks. In: Checkley, D. et al (eds) Climate change and small pelagic fish. Cambridge University Press, Cambridge, pp. 191–255.

Beckman, W. C. (1948). The length – weight relationship, factor for conversions between standards and total length and coefficient of condition for seven Michigan fishes. Trans. Amer. Fish. Soc., 75: 273-256.

Beverton, R. J. H. and Holt, S. J. (1966). Manual of methods for fish stock assessment. Part 2. Tables of yield functions. FAO Fish. Tech. Pap./ FAO Doc. (38) Rev. 1: 67pp.

Elsherbeny, A. S. (2015). Application of remote sensing techniques, geographical information systems and analytical models for the pelagic fisheries management in the Gulf of Suez, Egypt. Ph. D. Thesis, Zool. Dept., Fac. Sci., Ain Shams. Univ., 199 pp.

GAFRD (1999-2012). General Authority for Fish Resources Development. Annual fishery statistics report, Cairo, Egypt.

Gayanilo, J. F.; Sparre, P. and Pauly, D. (1997). The FAO-ICLARM Stock Assessment Tools (FiSAT) Reference Manual. FAO Computerized Information Series (Fisheries). Rome, FAO. No. 8, 262 pp.

Gulland, J. A. (1971). The fish resources of the Ocean. West Byfleet, Surrey, Fishing News, Ltd., FAO, 255 p.

Jones, R. and Van Zalinge, N. P. (1981). Estimates of mortality rate and population size for shrimp in Kuwait waters. Kuwait Bull. Mar. Sci., 2: 273-288.

Le Cren, E. D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviattilis*). J. Anim. Ecol., 20: 201-219.

Liang, C. and Pauly, D. (2017). Growth and mortality of exploited fishes in China's coastal seas and their uses for yield-per-recruit analyses. J. Appl. Ichthyol. 33: 746–756. doi: 10.1111/jai.13379

Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. Cons. CIEM, 39 (3): 175-192.

Pauly, D. (1983). Length-converted catch curves. A powerful tool for fisheries research in the tropics. Part I. ICLARM Fishbyte, 1 (2): 9-13.

Pauly, D. (1984). Length-converted catch curves. A powerful tool for fisheries research in the tropics. (part II) . ICLARM Fishbyte, 2 (1): 17-19.

Pauly, D and Munro, J. L. (1984). Once more on the comparison of growth in fish and invertebrate. Int. Living Aqua. Res. Manag. Fishbyte, 2 (1): 21p.

Pauly, D. and Soriano, M. L. (1986). Some practical extensions to Beverton and Holt's relative yield-per recruit model. In: J. L. Maclean, L. B, Dizon and L. V, Hosillo (eds) The First Asian Fisheries Forum, 491-496.

Powell, D. G. (1979). Estimation of mortality and growth parameters from the length-frequency in the catch. Rapp. P.-V. Réun. CIEM, 175: 167-169.

Ursin, E. (1967). A mathematical model of some aspects of fish growth, respiration and mortality. J. Fish. Res. Bd. Can., 24: 2355-2453.

Wetherall, J. A. (1986). A new method for estimating growth and mortality parameters from length-frequency data. ICLARM Fishbyte, 4 (1): 12-14.

Yatsu, A. (2019). Review of population dynamics and management of small pelagic fishes around the Japanese Archipelago. Fisheries Science https://doi.org/ 10.1007/s12562-019-01305-3.