ISSN 1110-0354
Bull. Nat. Inst. of Oceanogr. & Fish., A.R.E., Vol. (29) 2003: 31 - 49

STOCK ASSESSMENT AND MANAGEMENT OF PENAEUS LATISULCATUS IN THE GULF OF SUEZ, EGYPT.

BY

SAHAR FAHMY MEHANNA
National Institute of Oceanography and FisheriesP.O. Box 182, Suez, Egypt.

ABSTRACT

Monthly length frequency data of **Penaeus latisulcatus** *from the Gulf of Suez were analyzed to study age, growth, mortality, relative yield per recruit and relative biomass per recruit. The maximum life span of* **P. latisulcatus** *was found to be 12 months for males and 15 months for females. The asymptotic total length was estimated as 21.35 cm for males and 24.13 cm for females. The growth parameter K was assigned as 1.91 year^{-1} for males and 1.70 year^{-1} for females. The total mortality coefficient Z was estimated as 9.87 year^{-1} for males and 7.14 year^{-1} for females where as the natural mortality coefficient M was 2.74 year^{-1} for males and 2.45 year^{-1} for females. Exploitation rate E was found to be 0.72 for males and 0.66 for females. Relative yield per recruit and relative biomass per recruit analysis show that P. latisulcatus stock in the Gulf of Suez is in a situation of economic overfishing and the present level of exploitation rate should be reduced by about 46.4% to maintain a sufficient spawning biomass.*

INTRODUCTION

The penaeid shrimp are the most important fishery resource in the Gulf of Suez. They are caught by trawl fishery and their catch is sorted according to size into two groups: large shrimp and small shrimp. The large shrimp consists of three species *Penaeus semisulcatus, P. japonicus* and *P. latisulcatus*, and constitutes about 10% of the total trawl catch (during the period from fishing season 1989/90 to 2001/02) (Fig. 1). This contributes more than 55% of the gross revenue of the trawl fishery. Due to the high price of shrimp and strong demand on the local market, a rapid increase in the fishing effort was injected into the trawl fishery. This increased fishing effort had already affected the total trawl production and consequently the shrimp production.

Although the penaeid shrimp contribute greatly in the economy of Egypt, only very limited studies of these species are available. Mehanna (1993) studied the fishery statistics, age and growth, mortality and survival rates, exploitation rates, maximum sustainable yield and yield per recruit of *Penaeus japonicus* in the Gulf of Suez. El- Gammal and Mehanna (1999) estimated the maximum sustainable yield and the corresponding level of fishing effort for shrimp fishery also in the Gulf of Suez. Later on, Mehanna (2000) studied the longevity, growth parameters, mortality and exploitation rates and yield per recruit of *Penaeus semisulcatus* in the same Gulf.

The present study is intended to estimate the basic parameters required for the management of *P. latisulcatus* in the Gulf of Suez.

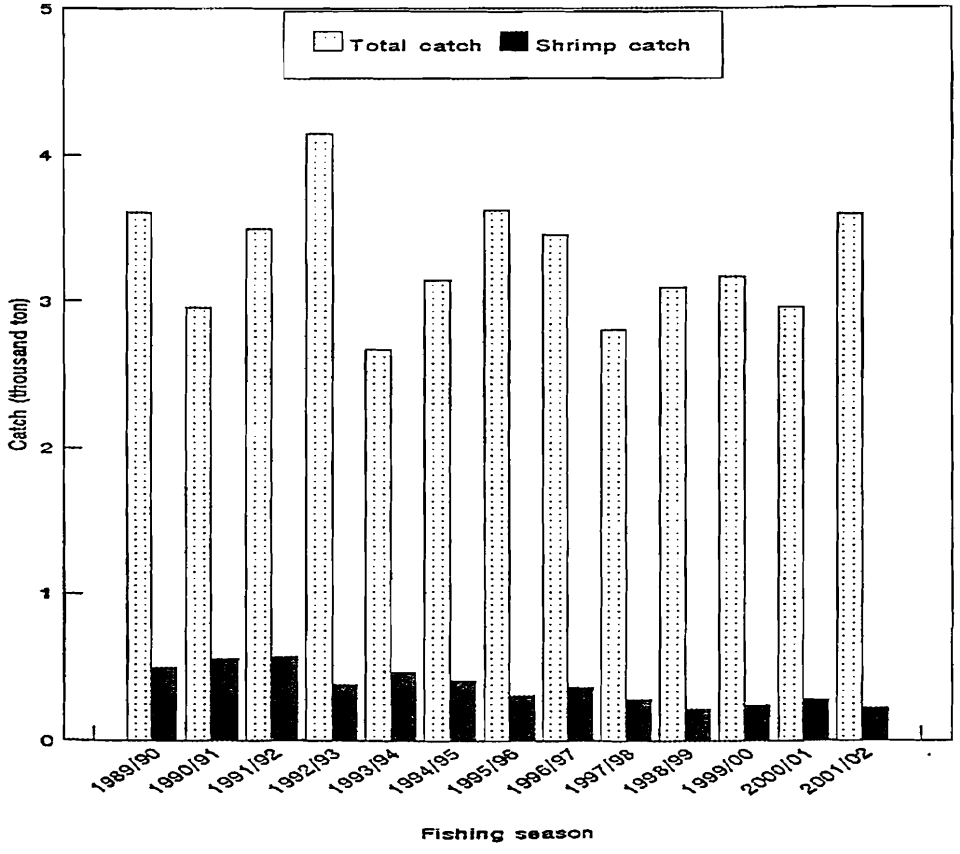

Fig.(1). Total trawl catch (ton) and shrimp catch from the Gulf of Suez during the fishing seasons from 1989/90 to 2001/02.

MATERIALS AND METHODS

Material

Monthly random samples of *P. latisulcatus* were collected from the commercial catch of trawl fishery in the Gulf of Suez during the fishing season 2001/02. The collected samples were separated by sex and the following measures were taken: total length to the nearest mm and total weight to the nearest 0.1 gram. The length data was grouped into 0.5cm classes.

Methods

- Age was determined by using the integrated method of Pauly (1983a). In this method, the length frequency data of *P. latisulcatus* collected during the first three months at the beginning of the fishing season (Oct., Nov. and Dec.) were used for construction of the growth curve. In these months the length-frequency data can be considered as a representative samples of shrimp stock in the Gulf of Suez due to the relatively high abundance of shrimp stock in these months. This length frequency data are repeated along the time axis (quarter year) until a single stabilized curve inter- connect most of the peaks.

- The length-weight relationship was estimated using the power equation $W = aL^b$ where W is the total weight in gram, L is the total length in cm.

- The population parameters; growth parameters of the von Bertalanffy growth model (L_∞ and K), total mortality coefficient (Z), natural mortality coefficient (M), length at first capture (L_c), relative yield per recruit and relative biomass per recruit were estimated by applying the FAO-ICLARM Fish Stock Assessment Tools (FiSAT) software of Gayanilo *et al.* (1997). The methods used were:

- Gulland and Holt (1959) plot to estimate the growth parameters.

- Length converted catch curve (Pauly, 1983b) to estimate "Z".

- The natural mortality coefficient (M) was calculated using the Pauly's (1980) formula as follows:

$$\text{Log } M = -0.0066 - 0.279 \text{ Log } L_\infty + 0.6543 \text{ Log } K + 0.4634 \text{ Log } T$$

Where T is the annual mean temperature of the water in which the stock lives.

The fishing mortality coefficient (F) was computed as $F = Z - M$ while the exploitation rate was computed from the ratio F/Z (Gulland, 1971).

- Catch curve analysis (Pauly, 1984) to estimate the length at first capture.

- The relative yield per recruit (Y/R)' and relative biomass per recruit (B/R)' were estimated by using the model of Beverton and Holt (1966) as modified by Pauly and Soriano (1986) and incorporated in FiSAT software package. This model is defined by:

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

$$(B/R)' = (Y/R)'/F$$

where (Y/R)' is the relative yield per recruit

(B/R)' is the relative biomass per recruit

M is the natural mortality coefficient

F is the fishing mortality coefficient

K is the growth parameter

E is the exploitation rate or the fraction of deaths caused by fishing

$m = (1-E)/(M/K) = (K/Z)$

$U = 1 - (L_c/L_\infty)$

RESULTS AND DISCUSSION

Longevity

The obtained results indicated that, the maximum life span of males *Penaeus latisulcatus* is 12 months while that of females is 15 months (Figs. 2&3). These results are in agreement with the fact that penaeid shrimp are characterized by a short life span in the order of two years, which were found also by Van Zalinge *et al.* (1981), Dredge (1990) and Somers and Kirkwood (1991).

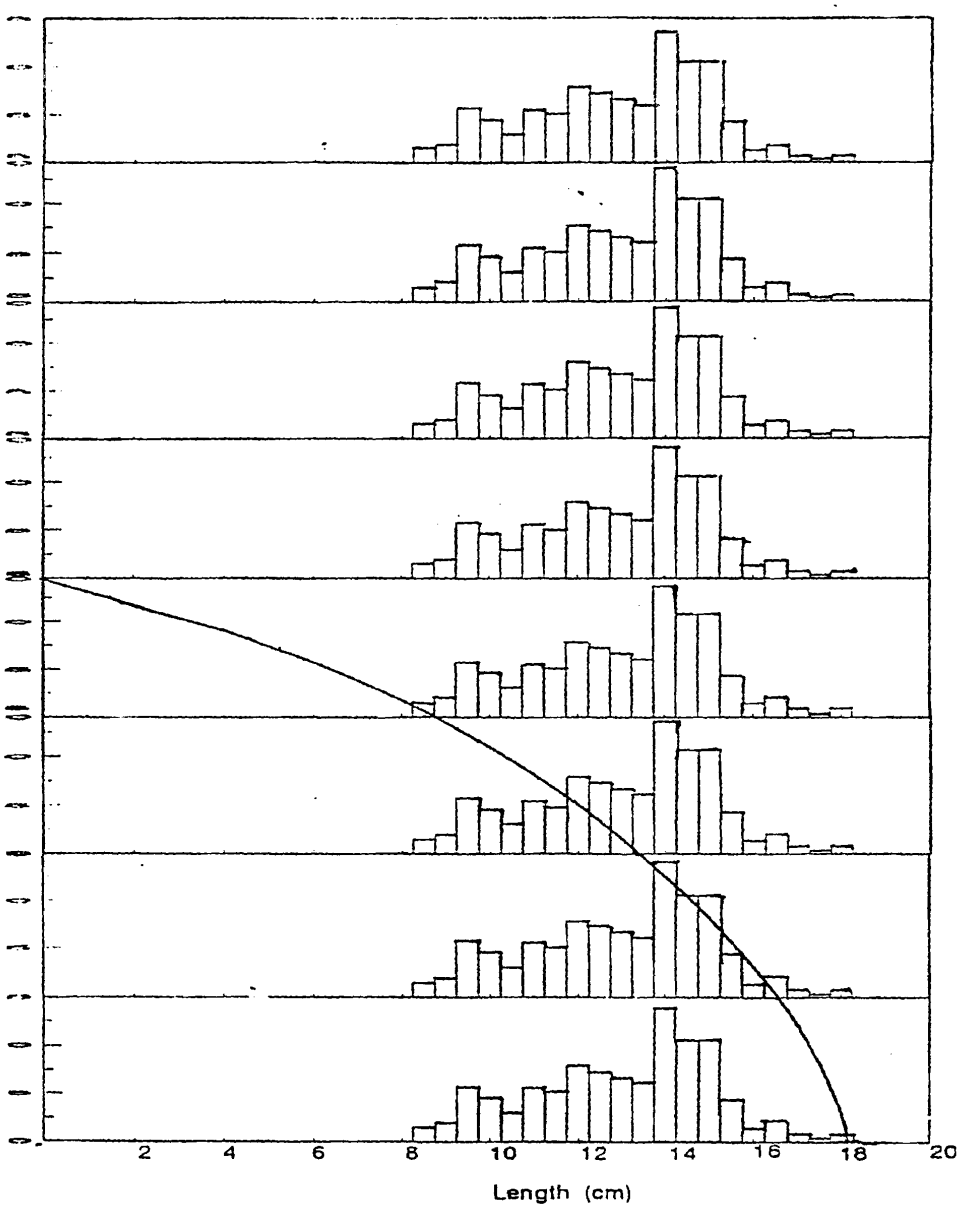

Fig. 2 : Longevity of *Penaeus latisucatus* (males) from the Gulf of Suez.

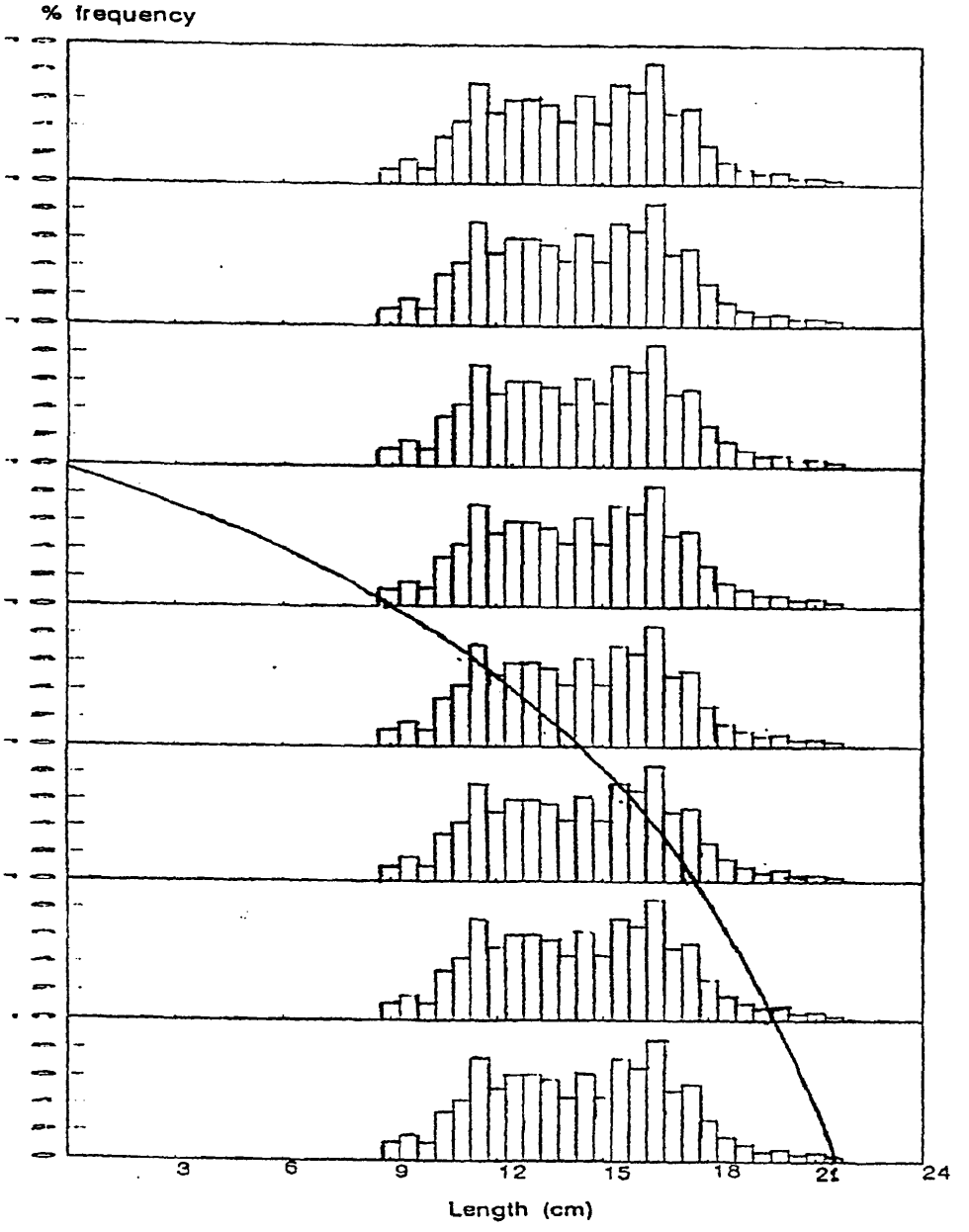

Fig. 3 : Longevity of *Penaeus latisucatus* (females) from the Gulf of Suez.

Growth in Length

The modal lengths corresponding to the various ages for males and females of *P. latisulcatus* are given in Table (1). It is found that, both males and females attain their highest increase in length during the first three months of life, after which a gradual decrease in growth increment is noticed with further increase in age. It is also noticed that females are characterized by a higher growth rate than males. These results are in close agreement with the finding of Garcia (1985). He pointed out that the typical *Penaeus* spawns at the sea and enters the inshore waters at an age of about three weeks to one month as a postlarva. It here grows for about three months before migrating back to the sea at about four months old and 80 to 100 mm total length. Imai (1977) reported that the growth rate of young and immature shrimp is much higher than that of adults, and the growth rate of females is higher than that of males.

Table 1: Estimated age and total length (cm) of *Penaeus latisulcatus* in the Gulf of Suez.

Age (year)	Estimated total length at the end of each quarter year		
	Males	Females	Sexes combined
0.25	8.5	8.9	8.7
0.50	13.4	14.2	13.9
0.75	16.4	17.7	17.6
1.00	18.3	19.7	19.9
1.25	---	21.4	21.4

Length - Weight Relationship

The length and weight measurements of 542 males and 627 females were used for the estimation of length - weight relationship of *P. latisulcatus* from the Gulf of Suez. The total length of males varied between 8 and 18.4 cm and their weights ranged between 4.1 and 43 g. The total length of females ranged between 8.6 and 21.9 cm and their weights varied between 4.5 and 78g. The obtained length – weight relationship equations were as follows:

Males $W = 0.0085\ L^{2.9447}$

Females $W = 0.0069\ L^{3.0562}$

Combined sexes $W = 0.0071\ L^{3.0457}$

Growth in Weight

The weights at the end of each quarter year of life for males and females of *P. latisulcatus* were estimated by applying the corresponding length - weight relationship to the estimated lengths. The growth in weight for both males and females is much slower in the first three months of life, and the annual increment in weight increases with the further increase in age reaches its maximum value at an age of nine months for males and one year for females. After which a decrease in growth increment was noticed (Table 2). It is evident also that, after the first three months of life, females are characterized by a higher growth rate than males.

Table 2 : Estimated age and total weight (g) of *Penaeus latisulcatus* in the Gulf of Suez.

Age (year)	Estimated total weight at the end of each quarter year		
	Males	Females	Sexes combined
0.25	4.64	5.50	5.16
0.50	17.72	22.93	21.50
0.75	32.12	44.97	44.12
1.00	44.36	62.37	64.15
1.25	---	80.33	80.04

Growth Parameters

The obtained values of K were 1.91year^{-1} for males and 1.70year^{-1} for females, while L_∞ = 21.35 cm total length for males and 24.13 cm total length for females. The value of K for males is higher than that for females indicating the faster decrease in growth rates of males than females. The rapid growth of *P. latisulcatus* implied by high values of K agrees with the fact that the short-lived animals like shrimp reach their asymptotic length in a year or two and are characterized by a high K-value (Beverton and Holt, 1957 and Garcia and Le Reste, 1981). Also, the values obtained are in agreement with those reported by other authors (Table 3).

Total Mortality Coefficient (Z)

The results (Figs. 4 and 5) indicate that the total mortality coefficient differes markedly between the two sexes (Z = 9.87 year^{-1} for males and 7.14 year^{-1} for females). These high values of Z are acceptable, because most of penaeid fisheries around the world have high fishing mortalities and thus show high Z values.

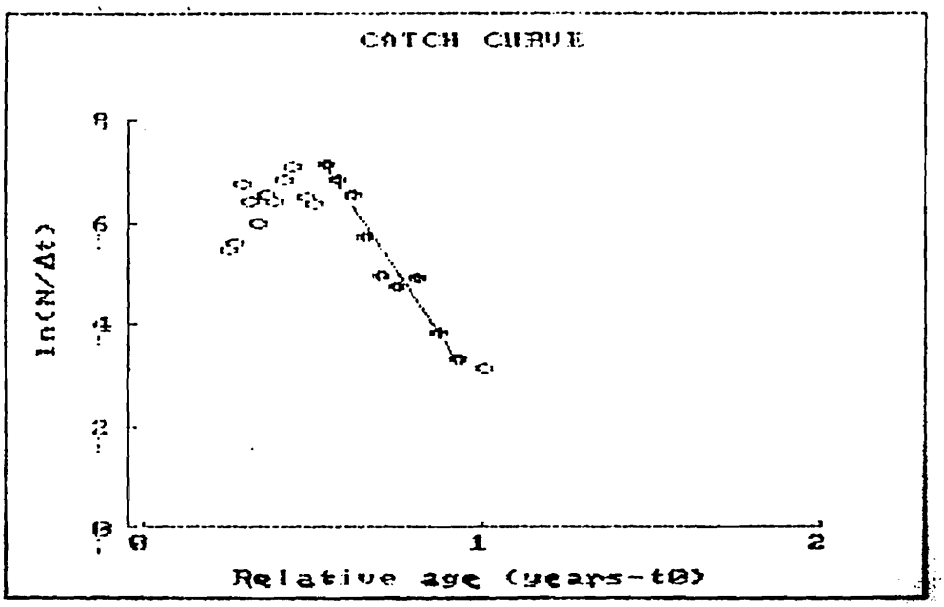

Fig. 4 : Estimation of "Z" of *Penaens latisucatus* (males) from the Gulf of Suez.

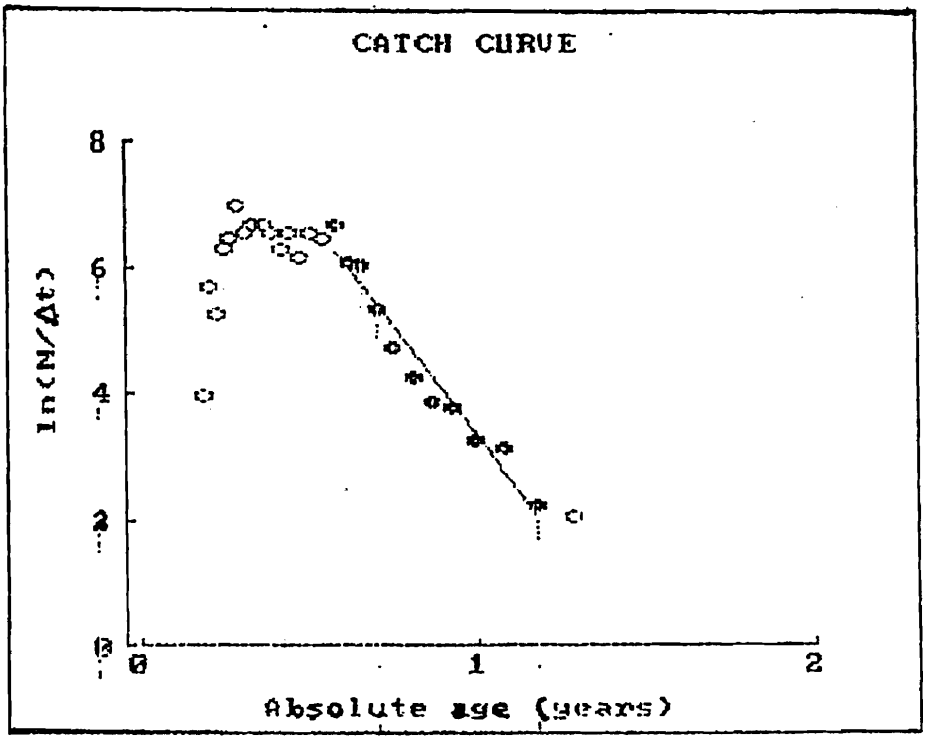

Fig. 5 : Estimation of "Z" of *Penaens latisucatus* (females) from the Gulf of Suez.

Natural Mortality Coefficient (M)

The values of M obtained were 2.74 year^{-1} for males and 2.45 year^{-1} for females. These values for M lie in the range given by Garcia and Le Reste (1981). They stated that for penaeid shrimp with a maximum life span of two years, the natural mortality should lie in the range of 2 to 3. Beverton and Holt (1959) found that fish of high growth rates have high values of natural mortality, this is also observed in shrimp populations (Table 3).

Table 3 : Summary of the growth parameter (K), natural mortality (M) and longevity available For some penaeid shrimp in different localities.

Species	K		M		Longevity (month)	Locality	Author
	♂♂	♀♀	♂♂	♀♀			
P. semisulcatus	2.15	1.44	2.7	2.9	12	Kuwait	Van Zalinge *et al.*, 1981
P. semisulcatus	3.07	1.25			…	Gulf of Carpentaria	Kirkwood & Somers, 1984
P. notialis	2.46	2.04			23	Senegal	Lhomme & Garcia, 1984
P. indicus	1.20	1.00	2.20	1.94	12	Manila Bay	Agasen & Del Mundo, 1988
P. stylifera	1.019	1.05	2.60	2.30	…	India	Suseenlan & Rajan, 1988
P. longistylus	2.05	1.12			12	Australia	Dredge, 1990
P. semisulcatus	3.22	2.24			18 – 24	Gulf of Carpentaria	Somers & Kirkwood, 1991
P. japonicus	1.82	1.65	2.73	2.44	15 – 18	Gulf of Suez	Mehanna, 1993
P. semisulcatus	1.77	1.56	2.52	2.40	18 – 18	Gulf of Suez	Mehanna, 2000
P. latisulcatus	1.91	1.70	2.74	2.45	12 – 15	Gulf of Suez	The Present study

Fishing Mortality Coefficient (F)

The values of F were 7.13 $year^{-1}$ for males and 4.69 $year^{-1}$ for females.

Exploitation Rate (E)

The exploitation rate of males is estimated to be 0.72 while that of females was found to be 0.66. The values of both fishing mortality and exploitation rates are relatively high indicating a high level of exploitation.

Length at first capture (L_c)

The length at first capture (the length at which 50% of the fish are vulnerable to capture) was estimated by FiSAT as a component of the length converted catch curve analysis. The value obtained was $L_{50\%}$ = 13.12 cm for males and 14.65 cm for females (Figs. 6 & 7).

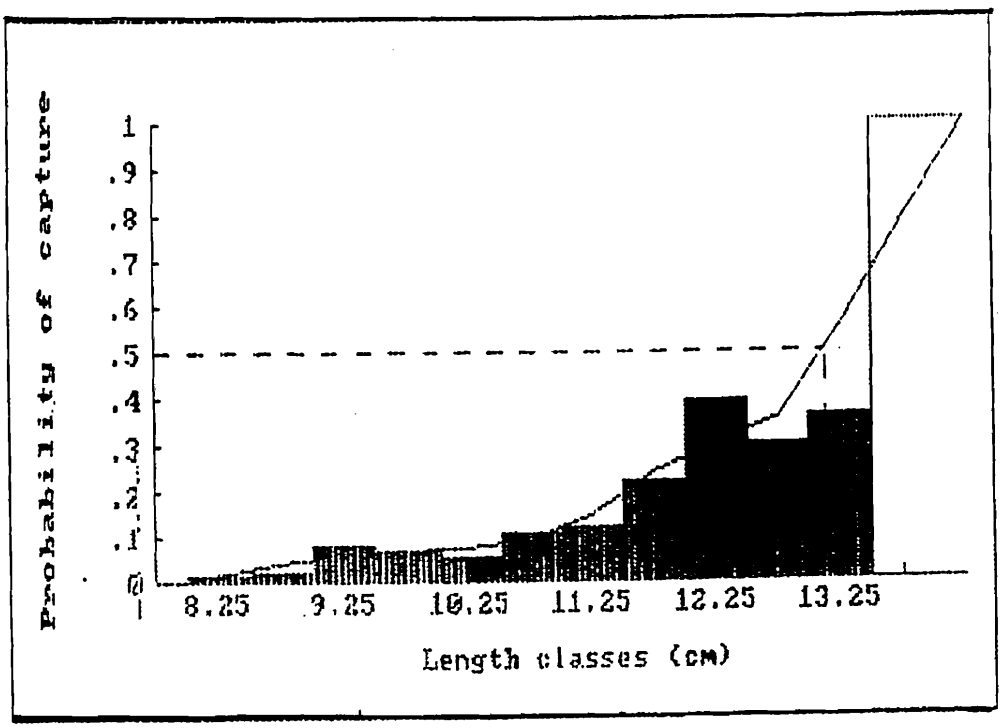

Fig. 6 : Length at first capture of *Penaens latisucatus* (males) from the Gulf of Suez.

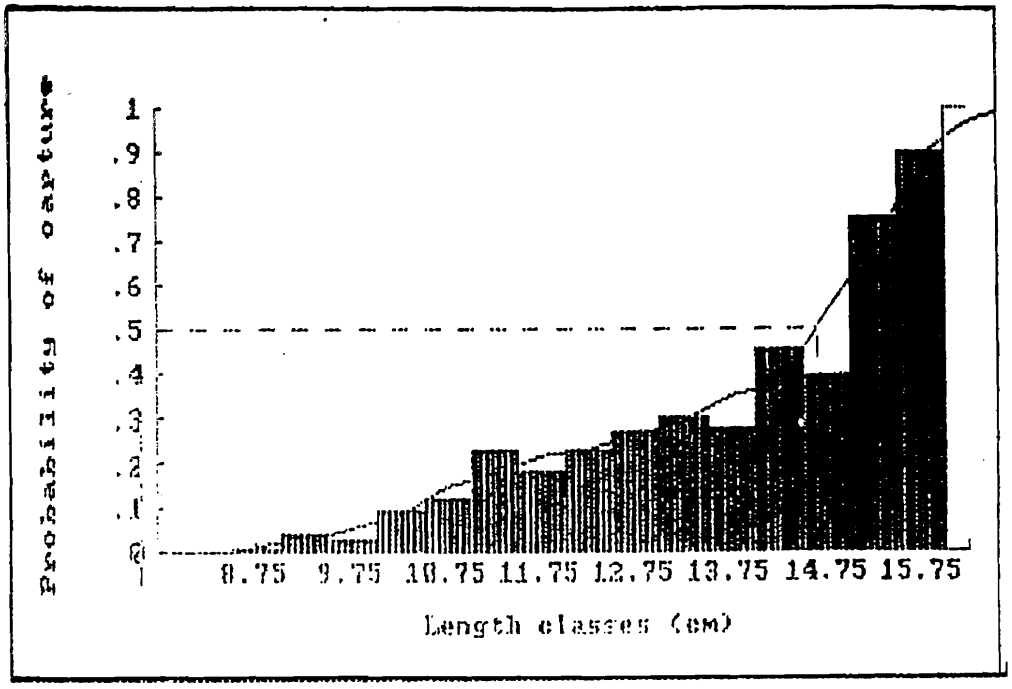

Fig. 7 : Length at first capture of *Penaens latisucatus* (females) from the Gulf of Suez.

Relative yield per recruit (Y/R)' and relative biomass per recruit (B/R)'

The input parameters used in the Beverton and Holt (1966) model are the growth and mortality parameters of the combined sexes. These parameters are as follows:

L_∞ = 24.58 cm

K = 1.62 $year^{-1}$

M = 2.36 $year^{-1}$

F = 5.32 $year^{-1}$

E = 0.69 $year^{-1}$

L_c = 12.85 cm

L_c / L_∞ = 0.52

M/K = 1.46

The plot of relative yield per recruit (Y/R)' and biomass per recruit (B/R)' against exploitation rate (E) for sexes combined of *P. latisulcatus* (Figs. 8 & 9) show that the maximum (Y/R)' was obtained at $E_{MSY} = 0.74$, as the exploitation rate increases beyond this value, relative yield per recruit decreases. Both of $E_{0.1}$ (the level of exploitation at which the marginal increase in yield per recruit reaches 1/10 of the marginal increase computed at a very low value of E) and $E_{0.5}$ (the exploitation level which will result in a reduction of the unexploited biomass by 50%) were estimated. The obtained values of $E_{0.1}$ and $E_{0.5}$ were 0.65 and 0.37 respectively. The results indicated that the present levels of E (0.69) was slightly lower than that which gives the maximum (Y/R)' but raising the exploitation rate to this value is unreasonable and for that case recruitment overfishing may occur before growth overfishing appears. The results show also that, the present level of exploitation rate (E = 0.69) is higher than the exploitation rate ($E_{0.5}$) which maintain 50% of the stock biomass ($E_{0.5} = 0.37$).

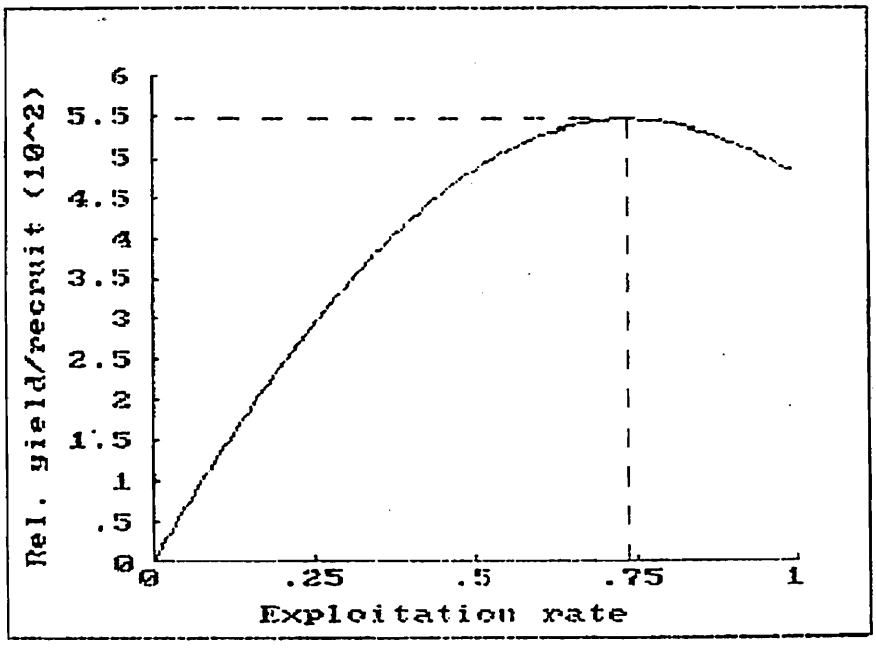

Fig. 8: Relative yield per recruit of *Penaens latisucatus* from the Gulf of Suez.

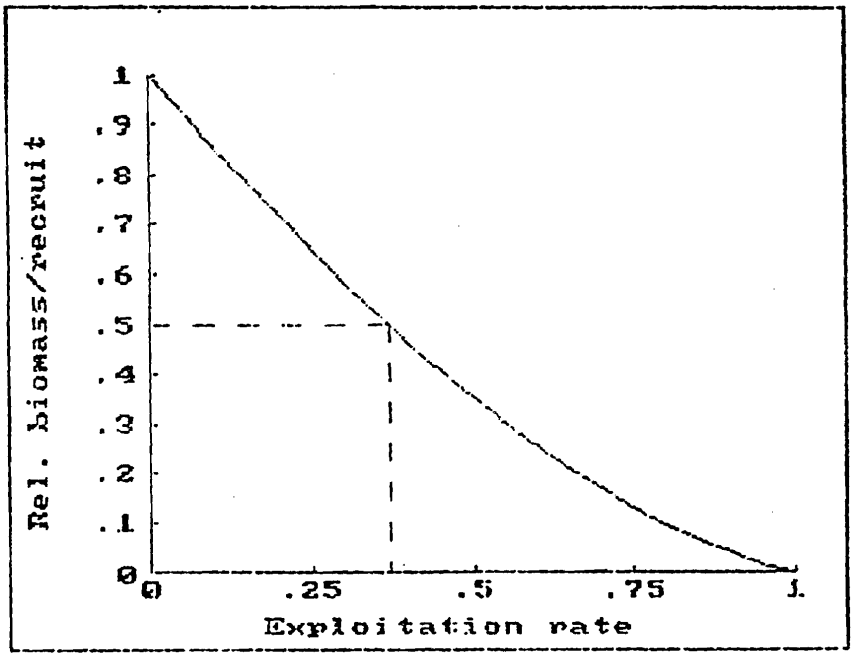

Fig. 9: Relative biomass per recruit of *Penaens latisucatus* from the Gulf of Suez.

For management purpose, the exploitation rate of *P. latisulcatus* must be reduced from 0.69 to 0.37 (46.4%) to maintain a sufficient spawning biomass. These results are in agreement with the finding of El-Gammal and Mehanna (1999). They reported, based on Schaefer model, that the shrimp fishery in the Gulf of Suez was overexploited and to obtain the maximum sustainable yield, the fishing effort represented by the number of landing must be reduced by about 30%.

The present results are also, in agreement with the finding of Garcia (1985) who pointed out that because of the high values of natural mortality (M), growth rate (K) and length at first capture (L_c) characteristic of penaeids, the yield per recruit (Y/R) curve tends to be exponential and the maximum yield per recruit is reached only at unreasonably high level of fishing effort.

It could be concluded that the *P. latisulcatus* stock in the Gulf of Suez is in a situation of economic overexploitation. To maintain this valuable fish resource the present level of exploitation rate must be reduced as well as the length at first capture must be increased.

REFERENCES

Agasen, E. V. and C. M. Del Mundo, 1988. Growth, mortality and exploitation rates of *Penaeus indicus* in Manila Bay, Philippines and south east India. In: Contributions to tropical fisheries biology (eds. S. Venema, J. M. Christensen and D. Pauly), FAO Fish. Rep., 389: 89-100.

Bertalanffy, L . von, 1938. A quantitative theory of organic growth (Inquiries on growth laws. 2). *Hum. Biol.*, 10: 181-213.

Beverton, R. J. H. and S. J. Holt, 1957. On the dynamics of exploited fish populations. *U. K. Min. Agr. Fish. Food, Ish. Invest.*, 19: 533p.

_____,1959. A review of the life spans and mortality rates of fish in nature and their relation to growth and other physiological characteristics. *Ciba Foundation Colloqia on Ageing.* 5: 142-180.

_____, 1966. Manual of methods for fish stock assessment. Tables of yield functions. *FAO Fish. Tech. Pap./ FAO Doc.* (38) Rev. 1: 67p.

Dredge, M. C. L., 1990. Movement, growth and natural mortality rate of the red spot king prawn, *Penaeus longistylus* Kubo, from the Great Barrier Reef Lagoon. *Aust. J. Mar. Freshw. Res.*, 41: 399-410.

El-Gammal, F. I. and S. F. Mehanna, 1999. Maximum sustainable yield of the demersal fish resources exploited by trawling in the Gulf of Suez with special reference to shrimp fishery . The role of Science in the Development of Egyptian Society and Environment, 23-24 October, 1999, Faculty of Science, Zagazig University, Benha Branch. 198-210.

Garcia, S. M., 1983. The stock - recruitment relationship in shrimps: reality or artifacts and misinterpretations? *Oceanographie Tropicale* 18: 25-48.

_____, 1984. A note on environmental aspects of penaeid shrimp biology and dynamics. In: Penaeid shrimp- their biology and dynamics (eds. J. A. Gulland and B. J. Rothschild) *Fishing News Books Ltd, Farnham, UK.* 268-271.

_____, 1985. Reproduction, stock assessment models and population parameters in exploited penaeid shrimp populations. In: Second Australian National Prawn Seminar (eds. P.C. Rothlisberg, B.J. Hill and D.J. Staples). 139-158.

Garcia, S. M., 1988. Tropical penaeid prawns. In: Fish population dynamics (ed. J. A. Gulland). *John Wiley & Sons Ltd.* 219-249.

_____, 1989. The management of coastal penaeid shrimp fisheries. In: Marine Invertebrate Fisheries: their assessment and management (ed. J.F.Caddy). 281-306.

Garcia, S. M. and L. Le Reste, 1981. Life cycles, dynamics, exploitation and management of coastal penaeid shrimp stocks. *FAO Fisheries Technical Paper No.* 203: 215p.

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

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

Gulland, J. A. and S. L. Holt, 1959. Estimation of growth parameters for data at unequal time intervals. *J. Cons. Perm. Int. Explor.Mer*, 25 (1): 47-49.

Imai, T., 1977. Aquaculture in shallow seas: progress in shallow sea culture. *Koseisha Koseiku Puplishers, Tokyo*. 615p.

Kirkwood, G. P. and I. F. Somers, 1984. Growth of two species of tiger prawn *Penaeus esculentus* and *P. semisulcatus* in the western Gulf of Carpentaria . *Aust. J. Mar. Freshw. Res.*, 35: 703-712.

Lhomme, F. and S. Garcia, 1984. Biologie et exploitation de la crevette penaeide, *Penaeus notialis* (Perez-Farfante, 1967) au Senegal. In: Penaeid shrimp- their biology and dynamics (eds. J. A. Gulland and B. J. Rothschild) *Fishing News Books Ltd, Farnham, UK*. 111-141.

Mehanna, S. F., 1993. Rational exploitation of *Peneaus japonicus* in the Gulf of Suez. M. Sc. Thesis, Zagazig University. 236p.

Mehanna, S. F., 2000. Population dynamics of *Penaeus semisulcatus* in the Gulf of Suez, Egypt. *Asian J. Fish.* 13: 127-137.

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.

_____, 1983a. Some simple methods for assessment of tropical fish stocks. *FAO Fish. Tech. Pap.*, 234: 52 P.

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

_____, 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 M. 'L. Soriano, 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.

Somers, I. F. and G. P. Kirkwood, 1991. Population ecology of the grooved tiger prawn *Penaeus semisulcatus* in the north- western Gulf of Carpentaria, Australia: growth, movement, age structure and infestation by the bopyrid parasite *Epipenaeon igens . Aust. J. Mar. Freshw. Res.*, 42: 349-367.

Suseelan, C and K. N. Rajan, 1988. Stock assessment of the kiddi shrimp *Parapenaeopsis stylifera* off Cochin, India. In: Contributions to tropical fish stock assessment in India (eds. S. Venema and N. P. Van Zalinge). *FI: GCP/INT/392/DEN/1*: 15-30.

Van Zalinge, N. P., M. El - Musa and A. R. El - Ghaffar, 1981. The development of Kuwait shrimp fishery and a preliminary analysis of its present status. In: Proc. int. shrimp releasing, marking and recruitment workshop. *Kuwait Bull. Mar. Sci.*, 2: 11-32.