EGYPTIAN JOURNAL OF AQUATIC RESEARCH 1687-4285
VOL. 31, SPECIAL ISSUE, 2005: 226-239.

STOCK ASSESSMENT OF THE COASTAL SHRIMP *PENAEUS SEMISULCATUS* IN THE EASTERN WATERS OF YEMEN

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Key words: Penaeus semisulcatus, Ghubbat Al-Qamar, Yemen water, mortalities, exploitation rate.

ABSTRACT

There is a lack of biological informations on shrimps in Yemeni waters. The main commercial species of shrimp is *Penaeus semisulcatus* caught from the eastern waters of Yemen and the Red Sea. Growth parameters, mortalities, biomass, and total allowable catch were estimated for this species in the eastern waters of Yemen. The calculated growth parameters were L_∞ = 51 mm, K = 1.6 year $^{-1}$ and t_o = - 0.13 for males and L_∞ = 62 mm, K = 1.5 year $^{-1}$ and t_o = - 0.11 for females. The natural mortality coefficient (M) was estimated as 2.6 year^{-1} and 2.4 year^{-1} for males and females respectively. The total mortality coefficient (Z) was 7.3 year $^{-1}$ for males and 5.6 year^{-1} for females. Total biomass was estimated using length-structured VPA as 360 tons. The exploitation rate (E) was estimated as 0.64 and 0.57 for males and females respectively. Accordingly the annual allowable catch and effort were recommended to be kept at 2003 levels of 78 tons through 151 fishing days and the fishing season was recommended to be from the 1st August to mid-October using two fishing vessels.

INTRODUCTION

Economic coastal shrimp stock is found in the eastern waters of Yemen and the Red Sea . The catch of shrimps represented 1 % by weight of the total commercial catch in the Gulf of Aden and the Yemeni Arabian Sea and 4.9 % of the total export in value (Abdul-Wahab, 2003). In 1986 biological and statistical data collection programme was implemented in Al-Mahara area east of the country for two years with the aim of studying the biology of shrimps. The main commercial species is *Penaeus semisulcatus* taken from Ghubbat Al-Qamar fishing ground area located between Tabut and Al-Ghaida (Figure 1).

Most fishing was carried out by the use of double-rigged trawlers of 750-1000 horse power in coastal waters of 8-15 meters depth. Fishing is undertaken during the period from July to November yearly.

Growth and mortality rates of shrimps in Yemeni waters are not available for stock evaluation. This study aims indicate these parameters for *P. semisulcatus* which constitutes more than 90 % of the commercial catch in the eastern waters of Yemen.

MATERIALS AND METHODS

Samples were collected through seven months during 2003 onboard the research vessel *Ibn Magid*. Shrimps were sorted according to their sizes into four grades. 4-8 kilograms of each grade were sampled daily. The carapace length, which was taken for growth in length, was measured to the nearest millimeter using a vernier caliper for both sexes

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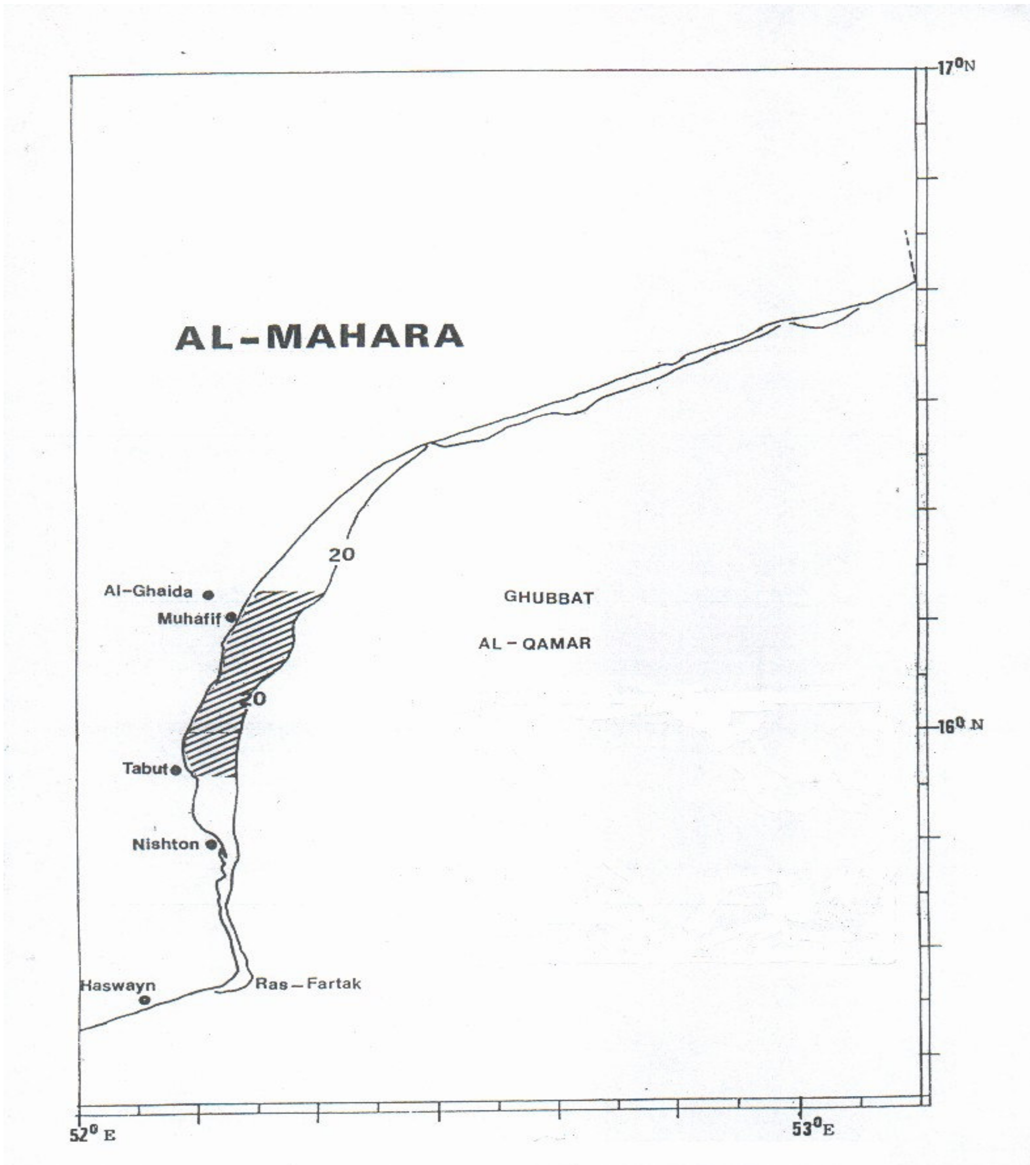


Figure 1. Location of the fishing grounds

Samples were brought to the laboratory for recording the length and weight.

The data were processed and analysed using FiSAT (FAO-ICLARM Stock Assessment Tools) package software. Bhattacharya (1967) method was used for cohorts' analysis.

The constants of von Bertalanffy growth equation in the form:

$$Lt = L_\infty [1 - e^{-K(t - to)}]$$

Were calculated, where Lt is the carapace length (mm) at age t, L_∞ is the asymptotic carapace length, K is the curvature value and t_o is the initial condition parameter.

Gulland and Holt (1959) plot was used to estimate the growth parameters L_∞ and K as follows:

$$\frac{\Delta L}{\Delta t} = K * L_\infty - K * \overline{L}$$

where ΔL is the increment in length between two times and Δt is the time needed to grow by ΔL.

The initial condition parameter, t_o, was estimated using Pauly (1983) formula:

$$\log(-t_o) = -0.3922 - 0.2752 \log L_\infty - 1.038 \log K$$

Pauly (1980) formula was used to estimate the natural mortality coefficient (M):

$$\log M = -0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4637 \log T$$

where L_∞ is the total length in centimeter and T is the annual sea water temperature.

The total mortality coefficient (Z) was estimated from the catch curve (Pauly, 1983a and 1984).

Length-structured virtual population analysis (VPA) of Jones (1981) was used to estimate the total biomass.

The exploitation rate, E, was estimated as $E = \frac{F}{Z}$ (Pauly, 1983) where F is the fishing mortality coefficient and equals to Z – M.

The FAO species identification sheets, Fischer and Bianchi (1984), were used for species identification.

RESULTS

Growth

According to Bhattacharya's method (1967) the mean length of the identified cohort was estimated. Two cohorts were identified for males and three cohorts for females. Figures 2 and 3 show the carapace length frequency of males and females respectively.

The length increment (ΔL) and the period needed for the increment (Δt) were calculated to estimate the von Bertalanffy growth parameters as given by Gulland and Holt (1959). The increments in the mean carapace length of males of the first cohorts in March-May (32.99mm, 37.34 mm), and in July and August (35.31 mm, 37.23 mm) and those of the second cohorts in March and May (42.15 mm, 44.49 mm) were taken in Gulland and Holt plot. For females the increments in mean length taken were of the first cohorts in May–July (34.64 mm, 40.98 mm), the second cohorts in May-July (42.33 mm, 46.47 mm) and in July-November (46.47 mm,52.93 mm) and the third cohorts in March-May (52.93 mm, 55.17 mm). Figures 4a and b show Gulland and Holt plots for males and females respectively. The growth parameters obtained were, L_∞ = 51 mm, K = 1.6 year $^{-1}$ and t_o = - 0.13 for males and they were L_∞ = 62 mm, K = 1.5 year $^{-1}$ and t_o = - 0.11 for females. Figure 5 shows the growth curves for each sex.

The von Bertalanffy equations with the calculated constants are $Lt = 51 [1- e^{-1.6(t+0.13)}]$ for males and $Lt = 62 [1-e^{-1.5 (t+0.11)}]$ for females.

Weight-length relationship

The form $W = aL^b$,for both sexes combined, was used to express the relation between length and weight. Where W is total body weight (g), L is carapace length (mm) and a and b are constants. The values of the constants were a = 0.0079, b = 2.3697, the correlation coefficient, r =0.989 and the total number of shrimps measured, n =146. Figure

6 shows this relationship according to the equation $W = 0.0079\ L^{2.3697}$

Total length-carapace length relationship

The linear equation $TL = a + b\ CL$ was applied to describe the total length-carapace length relationship, where *TL* is (mm) total length (rostrum included), *CL* is carapace length (mm) and *a* and *b* are constants. The obtained values of these constants for males were $a = 55.3989$, $b = 3.1749$, $r = 0.93$ and $n = 36$. For females these were $a = 44.9310$, $b = 3.3451$, $r = 0.97$ and $n = 75$. The equations for this relationship for males and females respectively are:

$TL = 55.3989 + 3.1749\ CL$

$TL = 44.9310 + 3.3451\ CL$

Natural mortality

The asymptotic total length L_∞ was estimated in centimeter for males and females. These were 21.7 cm and 24.9 cm for males and females respectively. The natural mortality coefficient, M, was estimated according to Pauly (1980), where average surface sea water temperature was 27°C, as 2.6 $year^{-1}$ and 2.4 $year^{-1}$ for males and females respectively.

Total mortality

The total mortality coefficient (Z) was estimated as 7.26 $year^{-1}$ for males and 5.64 $year^{-1}$ for females using the catch curve (Pauly, 1983b and 1984) for both sexes. Figure 7 *a* and *b* show these curves.

Exploitation

The exploitation rate (E) was estimated as 0.64 and 0.57 for males and females respectively

Biomass

Using the biological parameters of growth and mortality and the weight-length relationship, length structured VPA was used to estimate the total biomass. Tables 1 and 2 and Figures 8 and 9 give the outputs of this analysis for males and females respectively. The total biomass for both males and females was 360 tons.

CONCLUSION

There was lack of biological informations on growth and mortality for shrimps in Yemeni waters. The present study aimed to make a contribution to fill in this gap. *Penaeus semisulcatus* composed about 97 % of the total catch. However, other shrimp species found in this area were *Metapenaeus monoceros* 2 %, *P. indicus* and *P. japonicus,* the last two species were rare (Abdul-Wahab, 2003).

Table (1) gives monthly catch and effort data in 2003. The actual catch of *P. semisulcatus* was 78 ton, where the fishing effort was 151 fishing days and the average cpue was 0.5 ton/day in 2003.

Long term catch and effort statistics are not available for shrimps at this area. Table (2) gives the available catch and effort information for the years 1986-1988 (Abdul-Wahab, 1989).

Length-structured VPA gave the estimate of total biomass of males as 115.5 tons and of females as 244.8 ton (Tables 1 and 2), the total was 360.3 tons. The total catch in 2003 represents 21.6 % of the total estimated biomass. Taking into account the above estimated exploitation rates for males and females which are a bit above the optimum (Pauly, 1983), it is recommended that the total allowable catch and fishing effort to be kept at 2003 levels, i.e. 78 tons taken through 151 fishing days.

The allowable catch was predicted in 1989 as 54 tons using a direct method, i.e. taking the averages of the catches and efforts of the previous years, at 135 fishing days (Abdul-Wahab, 1989). That catch represents 15 % of the current estimated biomass. However, in 2003 the total catch of the research vessel *Ibn Magid* was 54.6 tons at 139 fishing days (Abdul-Wahab, in press).

Mature females were observed during all sampling months, but the highest percentage were observed in October and November which indicates that spawning occurs in December- January and may extend to March since no shrimps were observed in the catch during this period.

The catch and cpue declined significantly in November in 2003 (Table 3) and the shrimps disappeared in the following few months, i.e. December to April. This phenomenon was observed in 1986 and 1987 (Abdul-Wahab, 1989). There is no information on the reasons for that and it needs more study. Therefore it is recommended that fishing season to be from the 1st of August to mid-October.

ACKNOWLEDGEMENT

I would like to thank Mr. Abdulla Hammadi, Director General of Marine Science and Resources Research Center, for his support and all the researchers and technicians who involved in data collection.

Table 1. Length-structured VPA output for male *P. semisulcatus*

Mid-length (mm)	Catch (in number)	Population (in number)	Fishing mortality (F)	Steady-state Biomass (ton)
25	228	14692369	0.0007	5.56
26	152	13801877	0.0005	5.95
27	687	12933031	0.0021	6.34
28	1368	12085562	0.0043	6.73
29	1845	11259711	0.0060	7.12
30	3774	10456090	0.0126	7.49
31	3427	9673729	0.0118	7.85
32	15223	8915381	0.0542	8.18
33	74202	8169835	0.2748	8.46
34	129326	7393523	0.5033	8.64
35	432213	6596107	1.8261	8.53
36	644954	5548507	3.1353	7.92
37	1088241	4368716	6.8348	6.54
38	751301	2866505	6.7685	4.86
39	441988	1826608	5.7226	3.60
40	267844	1183811	4.8861	2.71
41	116629	773443	2.8444	2.15
42	102825	550207	3.2745	1.74
43	50739	365739	2.1210	1.40
44	44262	252802	2.4309	1.13
45	29146	161201	2.2019	0.87
46	23638	97640	2.6324	0.62
47	6374	50655	1.0528	0.44
48	401	28540	0.0875	0.35
49	5181	16218	1.8816	0.22
50	277	3878	0.2000 (Ft)	0.12
Total				115.52

Table 2. Length-structured VPA output for female *P. semisulcatus*

Mid-length (mm)	Catch (in number)	Population (in number)	Fishing mortality (F)	Steady-state Biomass (ton)
25	198	19659864	0.0006	5.63
26	395	18827584	0.0012	6.08
27	363	18008686	0.0011	6.53
28	532	17203556	0.0016	7.00
29	854	16412155	0.0026	7.47
30	1655	15634506	0.0052	7.94
31	1952	14870328	0.0063	8.42
32	2717	14120331	0.0089	8.90
33	3010	13384266	0.0101	9.38
34	8314	12662828	0.0284	9.85
35	57642	11951373	0.2017	10.30
36	86564	11207693	0.3118	10.69
37	157167	10454778	0.5864	11.02
38	191470	9654372	0.7455	11.24
39	201777	8846509	0.8241	11.40
40	293722	8057115	1.2410	11.43
41	223846	7208747	1.0322	11.37
42	363846	6464434	1.8094	11.16
43	400946	5617982	2.2022	10.68
44	326496	4780072	1.9980	10.13
45	365556	4061388	2.5232	9.47
46	330954	3348129	2.6288	8.67
47	396197	2715023	3.7514	7.65
48	235961	2065357	2.7014	6.65
49	254489	1619759	3.5537	5.73
50	229898	1193401	4.1328	4.67
51	112413	829996	2.5880	3.82
52	108059	613335	3.1606	3.15
53	89828	423222	3.5387	2.44
54	88727	272472	5.2869	1.69
55	32611	143469	3.0563	1.12
56	7655	85250	0.9669	0.87
57	5361	58594	0.8430	0.73
58	4231	37969	0.8634	0.58
59	2164	21978	0.6033	0.45
60	1898	11205	0.8189	0.30
61	288	3744	0.2000 (Ft)	0.19
Total				244.80

Table 3. Catch and effort of *P. semisulcatus* in 2003.

Month	Catch (ton)	Fishing days	cpue (t/day)
March	4.138	15	0.3
May	3.640	10	0.4
July	15.915	36	0.4
August	6.662	20	0.3
September	15.479	19	0.8
October	28.788	28	1.0
November	3.502	23	0.2
Total	78.124	151	0.5

Table 4. Catch and effort of *P. semisulcatus* during 1986-1988 period.

Year	Catch (t)	Effort (number of shots)	cpue (t/shot)
1986	65.5	1529	0.043
1987	49.4	1672	0.030
1988	31.4	446	0.070

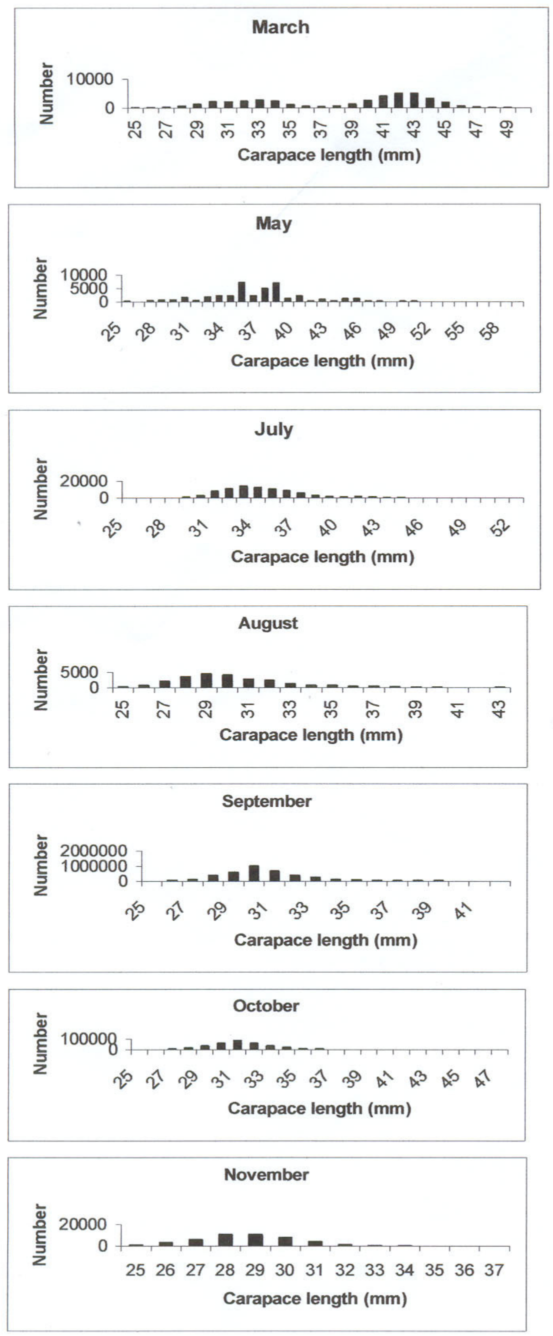


Figure 2. Carapace length frequency of male *P. semisulcatus*

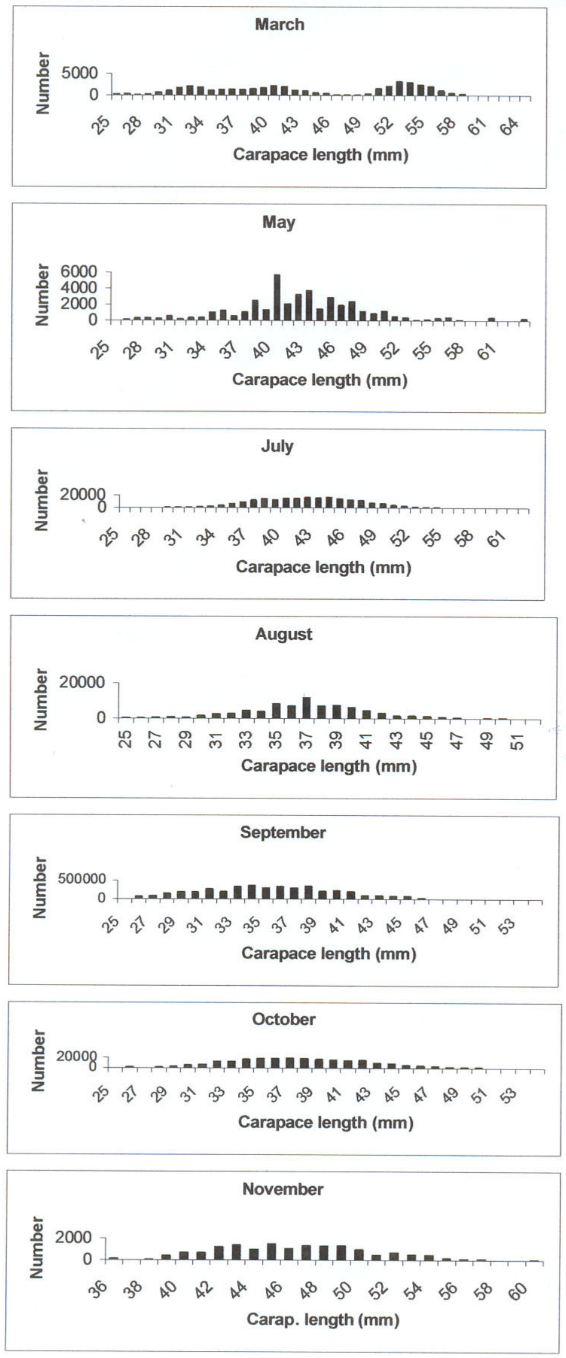
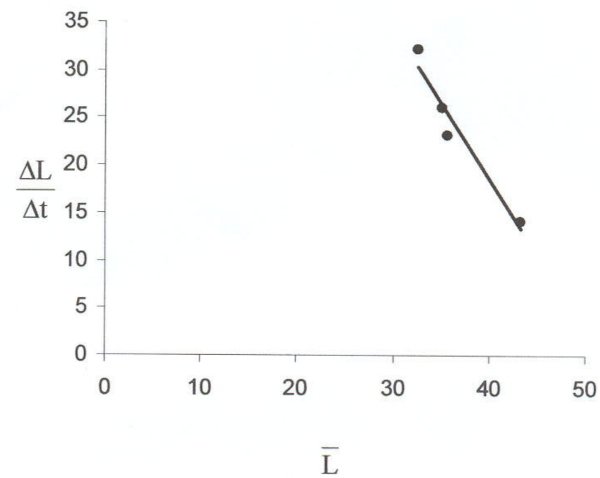


Figure 3. Carapace length frequency of female *P. semisulcatus*

a) Males



b) Females

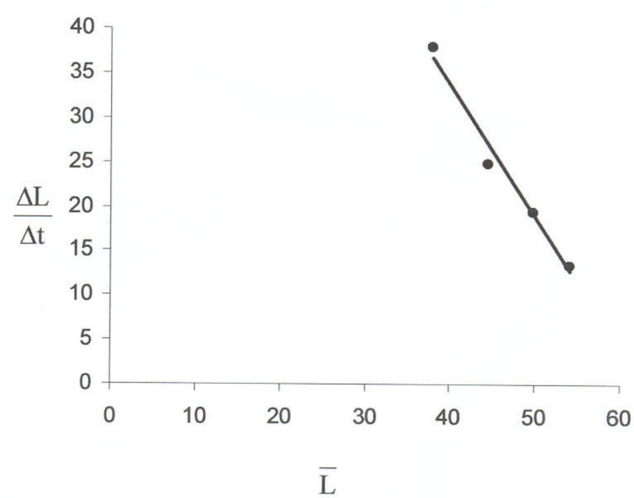


Figure 4. Gulland and Holt plot for *P. semisulcatus*

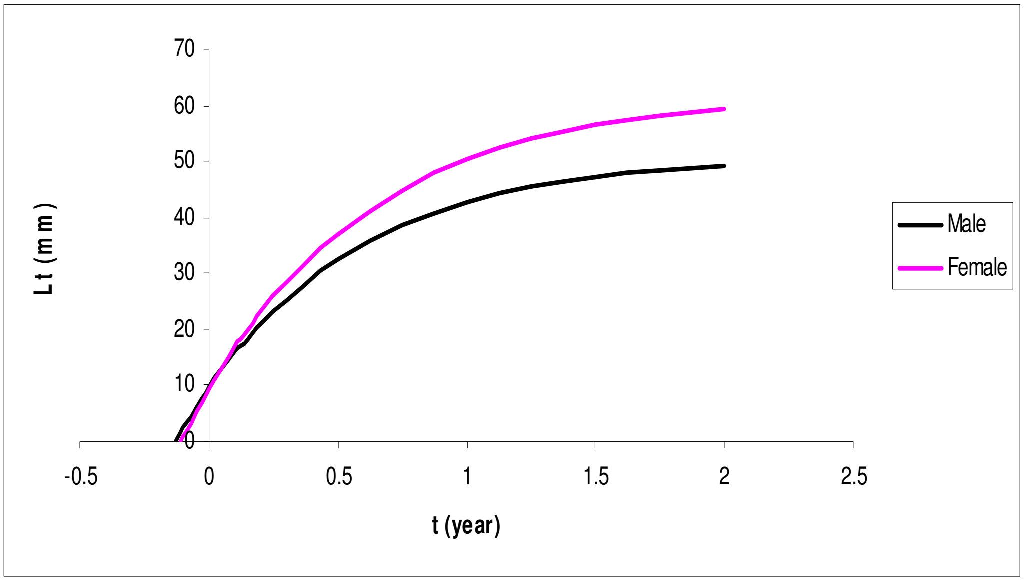


Figure 5. Growth curves of male and female *P. semisulcatus*,(*t* age, *Lt* length at *t*)

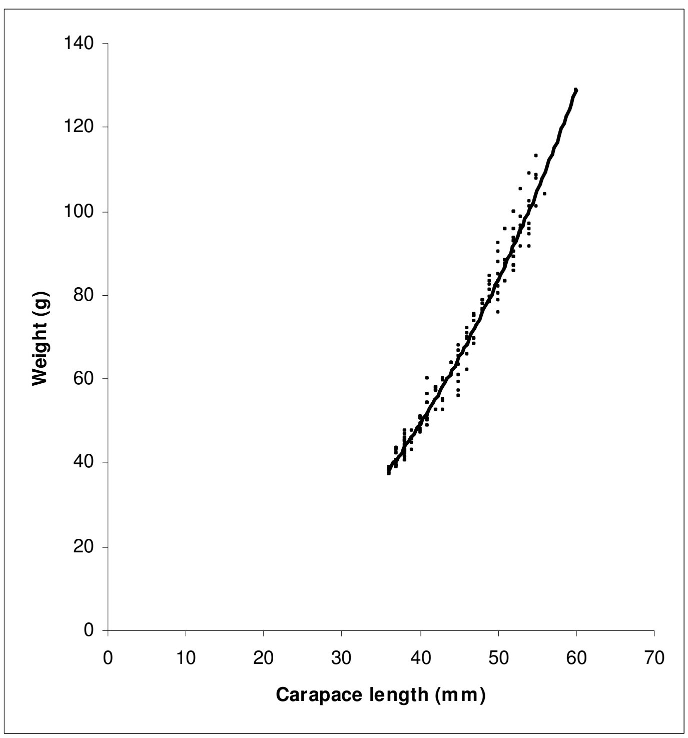
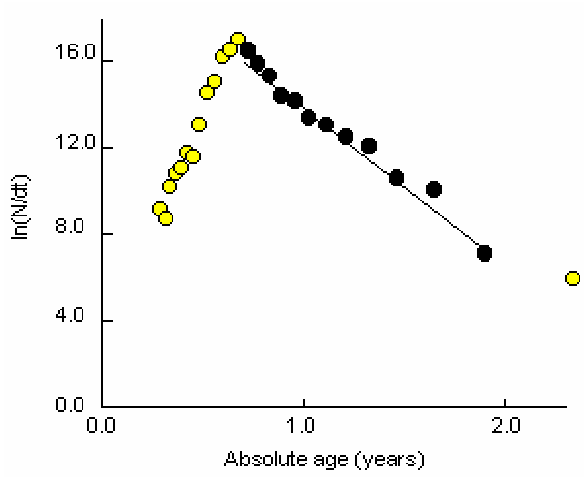


Figure 6. Weight-length relationship of male and female *P. semisulcatus*

a) Male



b) Female

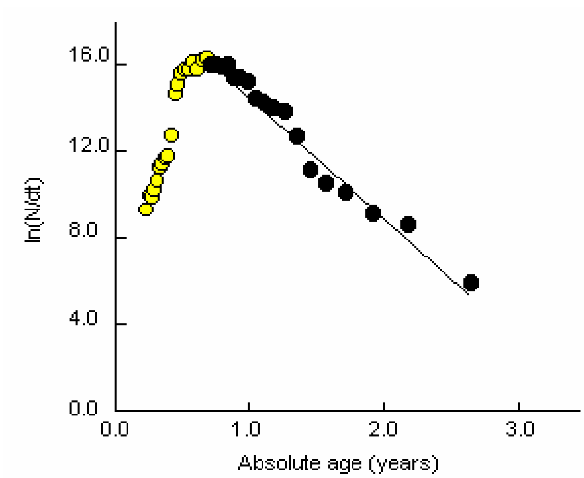


Figure 7. Catch curves for males and females of *Penaeus semisulcatus*.

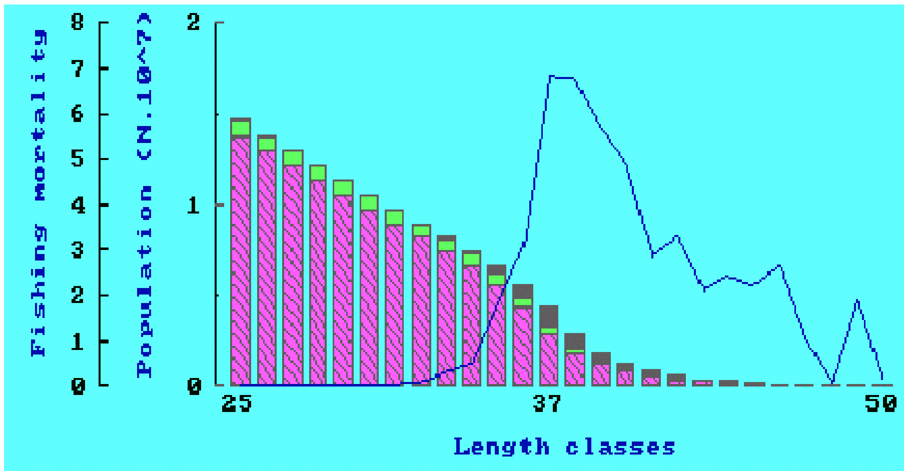


Figure 8. VPA output based on Table 1 for male ***P. semisulcatus.***

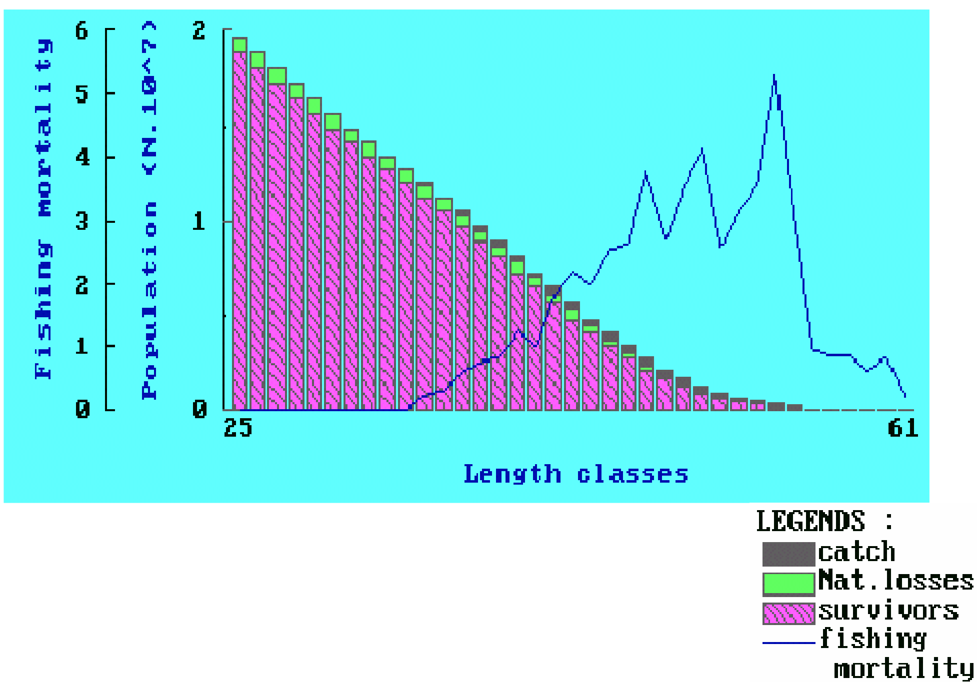


Figure 9. VPA outputs based on Table 2 for female *P. semisulcatus*.

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